EDUCATIONAL MULTIFUNCTIONAL
ELECTRONIC ROBOTIC KIT

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SEMERN KEBANGSAAN
PENDIDIKAN TEKNIK DAN VOKASIONAL
KALI KE 3 2009
9-10 DESEMBER 2009
DEWAN SENAT
UNIVERSITI TEKNOLOGI MALAYSIA
EDUCATIONAL MULTIFUNCTIONAL ELECTRONIC ROBOTIC KIT (E.M.E.R.K)

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ABSTRACT

The idea of design and building the Educational Multifunctional Electronic Robotic Kit (E.M.E.R.K) as teaching aids is to enhance the process of teaching and learning easily and practically for each subtopic in the introduction to robotic topic of Electrical and Electronic Engineering Studies Form 5 subject in Technical Secondary School. The produce of this kit can be seen as the initiative to enhance activities based on hands on method of teaching and learning. The purpose of this project is to build a teaching aid called the Educational Multifunctional Electronic Robotic Kit (E.M.E.R.K) that can help and motivate students toward learning the introduction to robotic topic during the lesson in class. Secondly, it is to evaluate the design of the robotic kit and furthermore to test the functionality of this educational robotic kit. Moreover, with the complete and explicit content of lab sheets on how the robot and the programming of PLC works, it can help teachers deliver the process of teaching and learning in the systematic way. In the process of designing kit, researcher selected the ADDIE Model as the elements towards developing product design that contain analysis phase, design phase, development phase, implementation phase and evaluation phase. The effectiveness of using E.M.E.R.K is tested toward teacher that teach PLC topic in Technical Secondary School with the teacher test using it along with answering questionnaire. The results and feedback are positive and teacher loves using it and it actually help them in the process of teaching and learning. As a conclusion, E.M.E.R.K that involve PLC and robotics successfully developed and built as a teaching kit to help the process of teaching and learning for teachers and students for the topic introduction to robotic in the Electrical and Electronic Engineering Studies subject.
1.0 Introduction

The Malaysia 'Vision 2020' to be fully developed country by the year 2020, economically, politically, intellectually, socially, spiritually, psychologically and culturally. The achievement of sustained and equitable development remains the greatest challenge facing humanity today. As for today, education plays an important role in fulfill the challenge towards reaching the Vision 2020 and therefore the Ministry of Education (MOE) has formulated a five year action plan called the National Education Blueprint (2006-2010) or better known as PIPP.

Technical and Vocational Education and Training (TVET) programs can play an instrument role in developing a new generation of individuals who will face the challenge of achieving sustainable socio-economic development (Majumdar, 2006). TVET as “the acquisition of knowledge and skills for the world of work.” As such, one of the key objectives of TVET is to prepare and equip students for immediate work upon graduation especially in technical (Kane et al, 2007).

With rapid transformation of societies in social, political, economic, technological and education spheres, the Ministry of Education work hard in making the big changes to Technical and Vocational Education and Training according to the plan and strategies that have been made in PIPP (2006-2010) which has six strategic thrust areas that will contribute directly towards the achievement Vision 2020 through educational sustainability. Under the thrust of National Education Blueprint, 2006-2010, Developing Human Capital, the ministry will give attention to value systems, disciplinary aspect, character, morals and resilience of students. This is to produce students who are competent in Science and Technology, innovative and creative and marketable as mention in the journal of Aris et al (2007).

Greater effort would be made to nurture creativity and innovativeness among students such as enhance a lot of activities on literacy and hands on and developed new curriculum along with competent towards 2010. Moreover, in developing the science and technology culture through the development and integration of Information and Communication Technology (ICT), provide for an efficient, effective, and world-class quality education system, such in teaching and learning, teachers can variety the teaching
methods more to students-centered strategies. As for example, multiple the activities like experimenting, discussion, simulation, problem solving, and outdoors activities (National Education Blueprint, 2006-2010).

In the implementation of developing and strengthen the curriculum, it is provision in enrichment programmes cater for all the students in a class, regardless whether they bright, average or slow learners. An enrichment programmes consist of additional activities to reciprocate the basic learning activities. Students often use different learning styles in studying, operating either as an activist, a theorist, a pragmatist or a reflector (Aris et al, 2006). Therefore, knowledge of their preferred learning methods that provide for a variety of learning styles will help towards achieving the learning objectives, since they will automatically cater for different types of learners.

Related to that, learning becomes effective when students are actively involved in the process. To extent his different senses are related, his learning becomes successful to that extent. For using various senses in the teaching and learning process, different materials are utilized in the classrooms. The learning experiences are thus made quite relevant, meaningful and effective (Bagulia, 2005). Teaching and learning materials (teaching aids) are prepared to fulfill curriculum and teaching-learning requirements, including critical and creative thinking, motivate learning, and active participation.

These teaching and learning materials are prepared to fulfill curriculum and teaching and learning requirements, including critical and creative thinking, motivate learning, and active participation and teaching and learning material also a network-based, teacher-based and materials-based, which include both conventional and electronic materials. (Mok, 2003). Refers to the journal of Khan et al, (2003), Nicholls (2000); Raw (2003), stated that education has become wide spread and exclusively oral teaching cannot be the key to successful pedagogy. To make the teaching learning interesting the teacher has to use teaching aids. Learning process can be enhanced if aids are used.

The idea of design and building the Educational Multifunctional Electronic Robotic Kits (E.M.E.R.K) as teaching aids is to enhanced the process of teaching and learning easily and practically for each subtopic in the last topic of Electric and Electronics Engineering Study Form 5 in Technical Secondary School. The produce of this kit can be seen as the initiative to enhance activities based on hands on methods of
teaching and learning. The use of kit can be used as a teaching mod that can help teachers practically apply lab activities with the help of teaching aids that can help in the construct of the teaching concept perfectly and more systematic.

2.0 Problem Statement

From the previous research and observations it is proved that teaching aids play an important role in the process of teaching and learning. In the other case, not all teachers in school use teaching aids especially the one that applied hands on activities.

According to an interview (refer to APPENDIX C) between the researcher with Encik Abdul Rahim Bin Md Sab and Puan Norihan Binti Yusof which are both are teachers of EEES subject in Johor Bahru Secondary High School found that many students understand this topic with many exercises from handouts given by teachers and memorize mostly of the facts that involve robots and Programmable Logic Controller (PLC).

Encik Abdul Rahim Bin Md Sab explain that he needs to explain more than twice to make the students see what PLC can do to robotic in the basic programming such as ladder diagram and mnemonic code works. Puan Norihan Binti Yusof actually supports this statement and further states that there are no specific teaching tools that can show how the robot actually works with the program of PLC in the real situation. Puan Norihan Binti Yusof even explained that even though the suggestion activities exist at the end of each subtopic in the topic of Introduction to Robotic, teachers seldom carry out the activities itself due to teachers facing problems such as lack of tools and instruments, time constraint and problems in managing and sorting out the lab tools.

Cost for mostly lab instruments are expensive, fragile, and difficult to do maintenances on it. Additionally, only 40 minutes of time in teaching and learning are qualified for each session. While, students takes a lot of time moving around and handle practical activities with separate and unattached instrument that available in laboratory. In spite of that, students need times to makes robot and handle the PLC alone for practical works because not all student can easily make progress in handling the robot and write
the PLC program in such a real situation. Therefore, teachers try to avoid carry out the practical activities for the topic Introduction to Robotic.

According to the problems above, researcher initatively want to carry out a project title Educational Multifunctional Electronic Robotic Kit (E.M.E.R.K) in practical activities for the Electric and Electronics Engineering Study (EEES) Form 5 subject in Secondary Technical School to help students comprehend this topic in more practical and effective way. The development of this kit takes count on the factors of organizing material, instruments and time taken to handle the kit as what the teachers emphasize on about during the interview session before this.

By constructing and building this kit, students can emphasize on their psychomotor skills and create more literal and exact understanding concept and simultaneously arouse the students interest and have more positive attitudes towards this topic. Other than that, hopefully this kit can give the benefits and the pleasant to the teachers for them to carry out the practical activities related and at the same time can run the process of teaching and learning more efficient and in a better way.

3.0 Objective Research

To make the project clear and on the right track, researcher determined the objectives below as a target to be achieve by the end of the project.

(i) To build an educational robotic kit as teaching aid that includes 5 lab sheets based on robot PLC programming elements.
(ii) To evaluate the design of educational robotic kit that has been build.
(iii) To test the functionality of the educational robotic kit that has been build.

4.0 Research Question

According to the problems and objectives stated, researcher has identified the research question as the elements of the project:
(i) What is the suitable design to be developed so it can be able to function as a teaching aid for Introduction to Robotic in the EEES Form 5 subject at Technical Secondary School?

(ii) What are the important aspects that need to be evaluate in the build of design the product that are based on teaching aid?

(iii) Can the robotic kit that has been design be use as the teaching aid for Introduction to Robotic in the EEES Form 5 subject.

5.0 Scope Project

The project mainly focus on the subtopic of manipulator, controller, power source, gripper, sensor, D.C motor, and gear, and using the Programmable Logic Controller (PLC) which can be divided under the subtopic of main part on PLC system, basic programming, programming console, procedure to develop PLC programme, developing a programme, and application of PLC system to control robot mechanism. This project focus mostly in proving the input entered that can delivers the correct output for lab activity. Additionally, this project is for the student to be familiar with the electronic circuit on robot and how the robots actually work.

6.0 Methodology

The purpose of carry out this project is to design and to explore or study the various value of the Education Multifunctional Electronic Robotic Kit (E.M.E.R.K) for the EEES Form 5 subject to assist or aid the process of teaching and learning towards teachers and students especially in the chapter six for the EEES Form 5 subject in Technical Secondary School. In the process of designing kit, researcher selected the ADDIE Model as shown in Figure 1 as the elements towards developing product design.
7.0 Engineering Analysis

Analysis has been carried out on E.M.E.R.K. to find out the functionality of each input and output to make sure this teaching kit product work as it commanded. Simulation process was carry out using Cx Programmer convenient to the analysis that is done to simulate input voltage using contact and coil as terminal from Cx Programmer between Push Button (contact) that is as input to the coil as output (hardware).

Additionally, this analysis is carried out to test the coding of contact if it match or synchronize with the coding of the coil. Testing with multi meter kit on PLC(OMRON) is to test whether there is close circuit between the contact and coil that had been programme in Cx Programmer that had been transferred to PLC(OMRON) using
OMRON USB cable for the system to function when the output (hardware) such as robotic arm, Light Emitting Diode (L.E.D), and conveyor belt connected to PLC (OMRON) output (OC211) to work as it command in Cx programmer (ladder diagram) or using console in form of mnemonic codes.

The analysis procedure for this teaching kit is started with the connection of wires from Push Button 1 (PB 1) until Push Button 7 (PB 7) to the input (ID211) of PLC (OMRON). Then proceed with the connection of wires from the output (hardware) to the output (OC211) of PLC (OMRON). There is also a connection wires from input and output devices to Command (COM) of PLC (OMRON) as for it to link to the Cx Programmer. After that researcher created a programme coding that give command to each contact to coil that has it own coding in Cx Programmer and linked to the PLC (OMRON).

Then press every Push Button that had been linked to the PLC (OMRON) to see the connection between Cx Programmer and the PLC (OMRON). The light will appear at the number input (ID211) synchronize with number of the output (OC211) of PLC (OMRON) if there is current flow between the contact and the coil. If it test with the multi meter, the value of voltage read by the meter will be 0 V if the Push Button is pressed. This means that the circuit is close and the system proven works as in theory.

Moreover, each of every circuits differ with its own coding as an input and output that had been programmed by researcher in Cx Programmer. For analysis, only serial circuit is appropriate to test the input and the output of the circuit developed. For example, just by edit contact and edit coil researcher can have the next analysis in testing every input for every output of this product circuit as shown in Figure 4.1. Then the push button is pressed to see if there is a connection from Cx Programmer to PLC (OMRON) and to test if the coding set for input can linked to the coding of the output. If there is a connection, the line will turn green to show simulation of current flows in the Cx Programmer. As shown in the figure 4.2.
As a conclusion, E.M.E.R.K that involve PLC and robotics successfully developed and built as a teaching to help the process of teaching and learning for teachers and students for the topic introduction to robotic in the Electrical and Electronic Engineering Studies subject.

From the development of this product, concept of learning PLC and robotic is easily to be deliver and explain towards students. As for that, along side with the design concept that is being abroad up successfully can face the problems in time constraint and lack of instrument before this that are the main causes for the teachers to carry out practical activities in the process of teaching and learning in introduction to robotic topic.

Moreover the E.M.E.R.K. that has been built by the researcher also suitable and appropriate with the objective of EEES subject as in the EEES syllabus that highlight for student to identified, acknowledge and use the electrical and electronic component with tools related. Other than that, E.M.E.R.K. also can develop student won positive characteristic such as patient, responsibility and others. This is support from the Mick Lalopa, 2006 that strategies in teaching and learning should be engaging and interactive while incorporating sharing, trusting, teambuilding, reflecting, helping and coaching (Pitas, 2000)

In the aspect of applying this kit, E.M.E.R.K. that is built are suitable in constructivism learning method as supported by that constructivism is an environment that allows for the learner-centered activities to take place where the teacher provides the students with the experiences that allow them to develop problem solving, critical thinking and creative thinking skills, and apply them in a meaningful manner. Neo & Neo, 2009. Hopefully, E.M.E.R.K. that has been built can motivate students, and make them become more creative and innovative in the area of electrical and electronic engineering.
9.0 Discussion

The kit product entitled Educational Multifunctional Electronic Robotic Kit (E.M.E.R.K) for the subject of Electrical and Electronics Engineering Studies which is the experimental type of research that focus on the three main matters:

(i) Kit development process
(ii) Kit design
(iii) Kit functionality

9.1 Kit Development Process

Basically, researcher used teachers experienced in the process of teaching and learning based on the topic on introduction to robotic as an input to this research. Research input attained from the interview process session on two teachers that are involved in the process of teaching and learning in the subject of Electrical and Electronics Engineering Studies in Secondary Technical School. Included in the information gained from the interview session are on the information about the main problems faced by the teachers during the process of teaching and learning in the introduction to robotic topic.

The outcomes of the interview are that teachers faces the difficulty in explaining the concept of program developing in PLC that are causes from:

(i) There is no specific teaching kit to help teachers in the process of teaching and learning.
(ii) There is lack of practical learning (hands on) in class because of:
   (a) Problem in time constraint
   (b) Problem in managing and sorting out the lab tools
   (c) Lack of tools and instrument.

Therefore, researcher had made a conclusion that the need to emphasizes on the practical teaching method aspect have to be stress on in the process of teaching and learning in the topic of introduction to robotic. This is realistic to the proposal made by
the Minister Of Education in the National Education Blueprint (2006-2010) that encouraged in using hands on and visual activities concept. Hands on method are constructivist approach to science education, which emphasizes the importance of concrete physical experiences in learning science concepts and principles (Brooks and Brooks, 1993; Frensham, 1992) in the journal of Johnson(1997)

On the other hand, by developing teaching and learning kit for the introduction to robotic topic is the best solution to solve the problem in teaching and learning process. This is suitable from the journal of Yen, 1999 for the teaching and learning kit concept that is practical activities provides a chance for students to practice future skills and develop logical thought by trial and error.

Moreover, researcher has identified few important aspects in designing the teaching kit. All the aspect are from the researcher analysis towards the outcomes of the interview session and teachers suggestion that involve the process of the interview.

The aspects are:
(i) Can assist teacher in explaining how to develop PLC programming.
(ii) Easy to use by the students.
(iii) Does not involve complicated programming.
(iv) Parallel towards developing student cognitive in class.
(v) The use of tools and instrument that is easy to be handle.
(vi) Does not take a very long time using it.

ADDIE model was chosen as a kit development model for a greater systematic work development. This is support the ADDIE model for this research that said ADDIE model is a systematic which the steps are carefully prescribed and follow a logical order and it is also empirical where the data gathering is built into the process and decisions are made on the basic of data (Aris et al, 2006).

There are five main parts involve in the ADDIE model that are analysis phase, design phase, development phase, implementation phase, and evaluation phase. Researcher had included the new phase that can help the flow of developing this kit product that is improvement phase. At the primary stage, researcher did not label the kit
properly and need to include more interactive output as it is proven of why improvement phase is important to this research. An improvement to this teaching kit are that more interactive output is better and can apply lots more activities after referring this teaching kit product to the peculiar expertise. Hence, researcher made a decision that improvement phase is convenient to make a room of improvement in developing better teaching and learning kit and can contribute great benefits to teachers and students.

9.2 Kit Design

The teaching kit that developed by researcher refers to exceptional design instrument and it is place in a mobile casing that can be easily use in the process of teaching and learning by teachers and students specifically in carry out many activities that involve practical learning in introduction to robotic topic. Wherefore it is defined as a teaching and learning kit where teaching and learning kit tool being developed and provide help in many ways for the teaching process. (Alexandra Cristea et al, 1997).

Additionally, creating teaching kit is purposely to help teachers that facing difficulty in explaining the concept of developing PLC programming in teaching and learning process for the topic introduction to robotic as stated in the interview session carry out by the researcher to the teachers themselves. Building concepts by making connections of abstract symbols to concrete materials with the use of five senses that involve kinesthetic activity in learning. Engaging as many of the five senses as possible helps make the abstract more concrete for the learner. Yetkin, 2003-Jennifer R. Bradley et al, 2008)-this statement also supported from the journal of Nader Nada et al, 2007 stated that with many student being visual and kinesthetic learners, this approach makes the teaching more enjoyable and effective and the learning more successful and fun.

Generally, there are two main parts that involved in the process of developing E.M.E.R.K that are at the part of circuit designing and part where the designing the casing product development. In the circuit design part involved the process of developing the electronic circuit on the PCB, on the other hand casing design part involved developing casing product that can place in the complete PCB with electronic circuit and the output of the teaching kit.
The circuit designed required connection from within and outer of the casing. Connection from within means that, it needed a connection from components leg to the track that is developed on the PCB and from outer means that it needed the use of the kit to make a complete circuit such as with push button and clip wires. Therefore, students can use the kit depends on their knowledge on the topic introduction to robotic. Hence this teaching and learning kit is very effective according to what it is Lee & Yeap, 2003 stated that it is generally recognized that good technology helps student to learn effectively. Indeed the uses of appropriate educational technology tools will enable teachers to implement a greater variety of strategies and new ways of doing teaching learning.

There are about more than five PLC programming that student need to develop in the Cx Programmer adapted from Daud et al (2006) to see the output of the programme that students have develop. The use of PLC programming with the help of computer technologies are suitable with the syllabus content from the subject of Electrical and Electronic Engineering Studies for the introduction to robotic topic. As for that, this is supported by Lee & Yeap, 2003 that lecturer should know how to integrate the correct sequence of activities with good technology into an effective part of the teaching and learning process that not only leads to student motivation and engagement in the subject but also to student understanding of the subject matter.

All of the circuit and output (hardware) are being integrated to one kit that is solidified to fit in the mobile character kit. Mobility character is very suitable for the teaching and learning properties that is effective as suggested by Aris et al, 2000 stated that teaching tools need to have mobility characteristic that can be brings to different places depends on the process of teaching and learning that had been process.

At the first stage of circuit combination, researcher needed to carry out simulation using Proteus Software to prove the combination of the circuit function well. All of the circuit that have been combine and test its functionality can be transferred to the Proteus Software also to scheme in the schematic circuit and the PCB layout design for it to carry on the next process to developed a printed circuit PCB to fit in the component that can make the whole circuit functions as it command to be.
Casing product is built to fit in the electronic circuit that had been developed. First of all, casing initial development need to be design in the software called SolidWork to match the operation of the circuit with the product display interface. Rectangle shape alike a suites case are used in this teaching kit design for it to be easy to carry around and to make it into wider space for the student to explore. The size of this case are 510mm x 435mm for the student to easily carry out an experiments and interact among them in groups. Colored acrylics is used in building the case to give a properties of attractive and colorful display which the use of colorful properties, showing images of the various to subject matters does look lively and conducive to student learning according to Lee & Yeap, 2003.

9.3 Kit Functionality

E.M.E.R.K is built with the concept of PLC system that uses PLC OMRON with the help of Cx Programmer to make this kit function with the theory that are related with theory used by Salwani Mohd Daud et al, 2003. The use of PLC symbols and its code for E.M.E.R.K are shown in the Table 1.

Table 1: PLC and Robotic System, Coding

<table>
<thead>
<tr>
<th>Data</th>
<th>Input Device</th>
<th>Data</th>
<th>Output Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>PB 1</td>
<td>100</td>
<td>L.E.D 1</td>
</tr>
<tr>
<td>001</td>
<td>PB 2</td>
<td>101</td>
<td>L.E.D 2</td>
</tr>
<tr>
<td>002</td>
<td>PB 3</td>
<td>102</td>
<td>L.E.D 3</td>
</tr>
<tr>
<td>003</td>
<td>PB 4</td>
<td>103</td>
<td>Conveyor Belt</td>
</tr>
<tr>
<td>004</td>
<td>PB 5</td>
<td>104</td>
<td>Servo Motor 1</td>
</tr>
<tr>
<td>005</td>
<td>PB 6</td>
<td>105</td>
<td>Servo Motor 2</td>
</tr>
<tr>
<td>006</td>
<td>PB 7</td>
<td>106</td>
<td>Servo Motor 3</td>
</tr>
</tbody>
</table>
The codes that are entered in the Cx Programmer are the manipulative for the system to change according to what the ladder diagram looks like with its own command made by the user. The maximum voltage that are used in this product is 24 V and it is from the power supply set. The push button used required +24 V for it to function while the rest of the components and instrument only need +5 V to function.

E.M.E.R.K. that is built was able to test the code that are entered in Cx Programmer for every input given. Every input represent the PLC ladder diagram code from Cx programmer or mnemonic code from the console such as basic code like normally open contact and normally close contact symbol. Every output for E.M.E.R.K represent with the L.E.D, conveyor belt and servo motors in robotic arm as it light up or move according to the programme developed in Cx Programmer.

### 10.0 Researcher Recommendation

According to the analysis, discussion and the result achieved from the whole of the research process in developing E.M.E.R.K, there are several recommendations that needed to be brought up by the researcher to add more concepts from the original concepts in the kit developing process, kit designing and kit functionality.

### 10.1 Kit Developing Process

Product specification that has been built referred to the source of interview with the teacher along side with the process of teaching and learning in topic of introduction to robotic. Based on the evaluation and the questionnaire in the APPENDIX D done by the peculiar expertise shows that E.M.E.R.K that has been built fulfill the biggest part of teaching kit needs in the topic of introduction to robotic. It is proven that in developing design based on the teaching kit, it is appropriate to take opinion form the expertise appointed that involve in the process if teaching and learning for the topic related because its play a great role in designing according to criteria that is suitable to be develop.
10.2 Kit Designing

The research carried out proven that E.M.E.R.K are capable to be a teaching kit for the introduction to robotic topic that was successfully design and developed. The kit that has been built suitable for teachers and students to use especially in EEES subject in technical secondary school because it is complete with learning the concept of PLC from the basic to higher level as shown in the questionnaire answered by the peculiar expertise in the APPENDIX D On the other hand, E.M.E.R.K. are suitable to be use as one of alternative in the teaching and learning from teachers and students instead of technical secondary school such as in ordinary school, polytechnic, and other institution that have others skills that are involve in teaching and learning robotic and PLC.

10.2 Kit Functionality

The data achieve from the questionnaire from the Appendix ...that answered by the peculiar expertise are appointed to prove that E.M.E.R.K that has been built can excelently functions. The design that has been built also suitable for activity in group and have the properties of easy to keep. This result shows that in building product, it is very important that researcher identified the target client or user for the product that need to be develop.

11.0 References


Cleveland: Cleveland State University.