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Problem-Based Learning in Malaysian Technical School

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ABSTRACT*: The purpose of this action research was to identify the problems faced by electrical and electronic engineering or PKEE (Pelajaran Kejuruteraan Elektronik dan Elektrik) students studying a difficult topic – transistor. This study was also aimed at examining students' attitude towards Problem-Based Learning (PBL). PBL is said to enhance students' understanding and make the learning more meaningful. This action research was based on Kemmis and McTaggart (1998) model. Jigsaw technique was also used in the first and second rounds of the study whereas the discussion technique was used in the third round. A sample of 30 form 5 students from a Technical School Melaka, Malaysia was selected. The treatment was given for a nine-weeks duration. Data were obtained from peer assessment, observation, and pre- and post-tests. Descriptive statistics used in this study, include frequency, mean, and standard deviation. The study found that the collaboration skill of the students increases in each round and their achievements also show better results. Students' attitude became more positive with regard to PBL. In the open-ended questions, the respondents said that they like collaborative and problem-solving activities. Thus, teachers are suggested to use this method. However, for those who are not confident or do not have the skills to use the PBL method, it is advised that training and guidance be given to them. PBL workshops and short courses should be offered to them.*
KEY WORDS*: Action research, problem-based learning, jigsaw technique, electrical and electronic engineering, and technical school.*

Introduction

The electrical and electronic subject or PKEE (*Pelajaran Kejuruteraan Elektronik dan Elektrik*) is one of the courses offered in Technical Schools. The subject is taught four (4) periods per week, with the duration of 40 minutes for each period. The timetable can be arranged in a four-blocked periods as it involves theories and practical works (KPM, 2003). The subject is offered at the Technical Schools for students who are interested in Electrical and Electronic Engineering. The subject was designed to suit the capabilities of Form 4 and Form 5 students whereby it has some continuity from the lower secondary level subject – the Living Skills. The subject is also related to Mathematics and Science, especially Physics (KPM, 2001).

The teaching of this subject is relatively challenging due to the nature of the subject which is perceived as "difficult subject" by the students. In addition, most

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teachers who teach this subject use traditional teaching method. The traditional teaching method is still preferred by the majority of teachers in the exam-oriented system. According to D.P. Diaz and R.B. Cartnal (1999), substantial number of teachers thought that traditional teaching method was more suitable than the student-centred method when the focus is on the examination and the class size is large.

However, the Malaysian Curriculum Development Centre (*Pusat Perkembangan Kurikulum*, 1991) has identified among the weaknesses of the traditional teaching method was the failure (of the students) to make connection between new information and what they had already known and between what they learnt at school and the real life situation. An effective teacher should be able to use various teaching strategies to ensure his or her class is interesting and meaningful. Among the student-oriented techniques that a teacher can use are discussion, brain-storming, role-play, simulation, games, and problem-solving activities. These teaching techniques are more interactive than the lecture mode (Burden & Byrd, 1994).

Problem-Based Learning (PBL) is one of the learning methods using relevant and meaningful real-life problems as its foundation. Literature has indicated the strengths of PBL in terms of active learning and group dynamics. According to L. Torp and S. Sage (2002), PBL is focusing on active learning involving mind and hands. In PBL, students are given a real problem or actual situation in which they are asked to find the solutions by gathering various inputs from books, journals, newspapers, brochures, internet, and so on. Teachers only act as guides or catalysts to the students.

Statement of the Problem

Based on the analysis of the SPM (*Sijil Pelajaran Malaysia* or Malaysia Certificate of Education) Examination results in 2003, it was stated that students had shown moderate achievements in the paper 2 of the electrical and electronic subject (LPM, 2004). Mistakes in simplifying the formula have caused some high-achievers to provide the wrong answers. For the moderate achievers, only a few of them were able to answer completely based on the instruction. For examples, most candidates only wrote the formulae without showing the calculation. Mistakes also occurred when they wrote the wrong units of the calculation. For the low achievers, their main problem was that they did not how to solve the problem and the majority would just guess the answer.

Similarly, for the paper 1 of the electrical and electronic subject, most moderate achievers failed to provide complete answers for the structural questions. There were candidates who tried to guess the answers, especially names of the gadgets and components. The low achievers, on the other hand, failed to answer multiple choice questions and to list down components. For the structural questions, majority of them failed to do the calculation and they drew the circuits wrongly. There were few students who did not attempt to answer at all. Table 1 shows that only a few technical school students obtained excellent results (A1 and A2) in the electrical and electronic subject. SPM analysis for five consecutive years (for this particular

subject) has shown that there were fewer than 6% of the students obtained excellent result (A1) in the subject for each year.

Table 1
SPM Results Analysis for the Electrical and Electronic Subject from 2001 to 2005

SPM	A1	A2	B3	B4	C5	C6	D7	E8	G9	No of Passes	Average Grade Point
2005	189	499	968	1110	1357	1284	865	309	79	6581	4.84
	(2.84)	(7.49)	(14.53)	(16.67)	(20.38)	(19.28)	(12.99)	(4.64)	(1.19)	98.81%	
2004	267	414	776	1003	973	719	554	121	43	4827	4.49
	(5.48)	(8.50)	(15.93)	(20.60)	(19.98)	(14.76)	(11.38)	(2.48)	(0.88)	99.12%	
2003	241	361	694	858	964	874	688	250	70	4930	4.80
	(4.82)	(7.22)	(13.88)	(17.16)	(19.28)	(17.58)	(13.76)	(5.00)	(1.40)	98.60%	
2002	183	408	734	967	1368	1239	1182	420	97	6501	5.13
	(2.77)	(6.18)	(11.12)	(14.66)	(20.73)	(18.78)	(17.91)	(6.37)	(1.47)	98.53%	
2001	170	200	368	510	592	662	680	368	115	3550	5.29
	(4.64)	(5.46)	(10.04)	(13.92)	(16.15)	(18.06)	(18.55)	(10.04)	(3.14)	96.86%	

Source: JPT [*Jabatan Pendidikan Teknikal*] (2006).

If the candidates were given the choices, they would not choose to answer questions about transistor. Only those who were really confident and skillful would choose to answer these questions. SPM analysis (2003) for the electrical and electronic subject (LPM, 2004) showed that only a few candidates chose to answer questions about transistor. Among these candidates, some were unable to use the formula correctly, they did not know how to change the miliampere to ampere units, some thought Ic = Ie, few of them used wrong formula, did not label the load line, and labeled the saturation and divert points wrongly.

Purpose and Objectives of the Study

This action research was conducted to identify the students' understanding about transistor in the electrical and electronic subject, using the PBL (Problem-Based Learning) method. The study was also designed to identify students' attitudes towards Problem-Based Learning.

Specifically, the research objectives were to: (1) Identify the students' misconception in learning about transistor in the electrical and electronic subject; (2) Examine the students' achievements in the subject after undergoing PBL process; (3) Investigate how well the group members work together to solve the problem; and (4) Assess the students' attitudes towards PBL in learning a topic about transistor in the electrical and electronic subject.

Literature Review

On the Problem-Based Learning. Problem-Based Learning (PBL) is a learning method that uses relevant and meaningful problem in the learning process (UTM,

2005). According to E. Graaff and A. Kolmos (2003), PBL is based on various theories such as constructivism and social learning theory. Based on those theories, PBL was formed. In the PBL, students were given an authentic problem or situation. They were asked to solve it using various inputs from books, journals, newspapers, brochures, or internet. Teachers only functioned as guides or facilitators for the students.

Boud and Felitti stated that PBL is a new philosophy in teaching and learning (cited by Ousey, 2003). It means that teachers are no more the sole source of knowledge or reference for the students. Thus, they can obtain information from other sources. They further stated that PBL helps students achieve specific learning in order to make them skillful and knowledgeable. For example, students should solve the problem critically and creatively, as well as finding causes and effects of certain phenomena. In addition, students can identify their strengths and weaknesses and work cooperatively in groups. Consequently, PBL can help improving their learning more effectively. According to Finley and Torp, PBL is a teaching and learning system which simultaneously builds the students' problem-solving skills (cited by Barrows, 1999). In PBL, students are given ill-structured problems taken from real life problems.

PBL can train students to become more responsible and active in learning as well as more independent. Teachers are only guides or facilitators. In PBL, students have to realize that they must be active in thinking of how to solve the problems and should not depend on their teacher to provide the solution (Barrows, 1999). E. Graaff and A. Kolmos (2003) said that PBL is a teaching and learning method using problems as the basic of the learning process itself. Generally, the problems chosen are real life problems and adjustments are made to suit the teaching objectives. In the nutshell, PBL can be a philosophy, a theory, a model, a concept, an approach, or a strategy that improves learning process. In PBL, students are given problems, and they must conduct research, explore, and find information relevant to the problems and solve them using various tools.

On the Models of Problem-Based Learning. According to E. Graaff and A. Kolmos (2003), the PBL principles include: (1) PBL is a learning approach which uses problems as the basic in the learning process; (2) Student-centered learning, students are only given guidance by the teacher to solve the problems, no direct teaching; (3) Teachers should be ingenious in creating problems relevance to the topic taught; (4) Use real-life problems; (5) Students use prior knowledge and experiences during the teaching and learning processes; (6) Learning activities are the basics of the processes in PBL; (7) Involve "deep" learning; (8) Cooperative learning in the groups; and (9) PBL is an active and reflective learning process.

According to K.N. Lynda Wee (2004), there are various models which can be used in carrying out the PBL process. Table 2 shows examples of PBL models used by selected learning institutions:

Table 2
Models of Problem-Based Learning

Institution	PBL Process
Temasek Polytechnics, Singapore.	1. Select the learning groups. 2. Identify the problems. 3. Brainstorm the ideas. 4. Identify learning issues. 5. Self-learning process. 6. Synthesize the knowledge. 7. Reflect and receive feedback.
Republic Polytechnics, Singapore.	1. Select ill-structured problems. 2. Activate students mind to generate ideas. 3. Identify what is known and what had already known. 4. Facilitators guide students on important questions and learning objectives. Then, students learn on their own. 5. Share information among the group members. 6. Enhance understanding to solve the problems. 7. Conduct reflection.
Medicine School, University of Southern Illinois, USA.	1. Introduce the group members. 2. Set the scenario. 3. Select objectives. 4. Identify problems. 5. Identify facts. 6. Explore the ideas. 7. Identify learning issues. 8. Propose action plan. 9. Focus on learning outcomes. 10. Identify resources. 11. Self-learning process. 12. Assess the resources. 13. Assess the problems based on new knowledge obtained. 14. Suggest problem solutions. 15. Self and peer evaluation.
University of Samford, USA.	1. Identify problems 2. In groups, students identify existing knowledge and determine the nature of the problems. 3. Students raise questions on what they do not know. 4. Students suggest actions to solve the problems and identify the resources needed. 5. Students gather information to solve the problems. 6. Facilitators guide by asking questions.
Chemical Engineering School, University of McMaster, Canada.	1. Explore the problems, make hypotheses, and identify learning issues. 2. Attempt to solve the problems based on what the students know. 3. Identify knowledge gap to solve the problems. 4. Determine learning needs, select learning targets and identify resources for self-learning. 5. Sharing knowledge among group members. 6. Apply knowledge to solve the problems. 7. Receive feedback.

University of Maasrticht, Netherlands.	1. Identify unknown terminologies associated with the problems. 2. Define the problems. 3. Analyze problems, provide explanation and activate existing knowledge. 4. Evaluate proposed explanation and describe processes involved in the problems. 5. Determine learning issues. 6. Self-learning process. 7. Share findings among group members to form comprehensive explanation.
Newcastle University, Australia.	1. Seek the problems. 2. Gather information via on-line resources. 3. Identify the problems. 4. Identify the learning issues. 5. Self-learning process. 6. Apply knowledge and submit written report. 7. Generate self-evaluation checklists. 8. Feedback from facilitators. 9. Students submit the report based on feedback received.
University of Technology Queensland, Australia.	1. Analyse problems by identifying early responses towards the problems, determining the terminologies and concepts, defining the problems, and confirming the scope of the problems. 2. Activate prior knowledge. 3. Identify learning objectives. 4. Conduct self-learning. 5. Synthesize the information obtained. 6. Analyze additional issues. 7. Analyze, synthesize, and summarize.
Gimmer University, United Kingdom.	1. Two groups are given similar problem. 2. First group acts as a consultant and the other group acts as a problem solver. 3. Third group acts as a client and use criteria to assess the problem. 4. The clients and the consultants produce their own critics. 5. Meeting between the client and the consultant.
Stanage University, United Kingdom (Diploma in Social Works).	1. Students are given real-life problems. 2. Analyze the problems. 3. Identify learning issues. 4. Self-learning process. 5. Discussion. 6. Solve the problem.
University of Lambert, United Kingdom.	1. Introduce PBL – students write about their learning in journal. 2. Assign tasks to the students. 3. Deal with the problems in group and individually. 4. Present orally and submit report. 5. Provide self and peer evaluation.

Table 2 shows that most of the models possess similar conceptual framework, which is focusing on problems. However, the PBL practised at Temasek Polytechnics Singapore, Medicine School University of Southern Illinois USA, and Gimmer University United Kingdom put focus on learning groups identification prior to formulating the problem itself. Uniquely, University of Lambert has PBL introduced at the beginning of the class.

On the Action Research. J. McNiff (1998) defined "action research" as an approach to improve or enhance education through changes which make teachers more alert about themselves. They should also become more critical with those practices and ready to change any ineffective practices. Meanwhile, P. Lomax (1994) has come out with the similar concept when he stressed that an action research is an educational research and it is different with research in education. This is because the researcher is the teacher herself, who aims to improve herself and her profession. P. Lomax also stressed that action research is very important for educational innovation as it is a way which enables the teachers to make improvement in education. Action research is a research on social situation involving teachers as researchers, with the aim of improving the quality of teaching practices. In doing the research, the teachers do innovation and changes by reflection and inquiries. In this study, the Kemmis and McTaggart (1998) model was selected because it is among the simplest models and it embeds self-reflection mechanism (Zailah Zainuddin, 2005).

On the Conceptual Framework. The conceptual framework for this study in figure 1 is formed based on the PBL model developed by K.N. Lynda Wee and Y.C. Megan Kek (2002) and an action research model by Kemmis and McTaggart (1998). The conceptual framework begins with finding a problem. After identifying the problem, a pre-test was carried out to measure the students' understanding. Using the PBL method, six heterogeneous small groups (selection was based on the pre-test result and gender) were formed in the first round of the study. The problem-based learning was implemented for 3 weeks in the first round, using the PBL module. After the 3-weeks duration, the students took the post-test. In addition, reflection, planning, implementing, and observation were conducted in the first round (such as looking at students' results in a test on transistor, students' collaboration, observation on competency and students' interaction) for the betterment in the next rounds.

The re-evaluation process in the second and the third rounds was conducted until the students' achievement in the post-test has reached the saturation point. Students' attitudes towards PBL were measured through the questionnaire prepared. The dependent variables in this study were the students' attitudes in solving the problems, their attitudes towards the PBL, and their perception towards the facilitator whereas the independent variable was the PBL method itself. The problem-based learning also includes collaborative learning. Collaborative learning encourages students to discuss, communicate, and integrate new ideas with existing ideas in order to enable students to learn new ideas in depths using conceptual exploitation and their existing knowledge (Khoo Yin Yin & Zakaria Kassim, 2005).

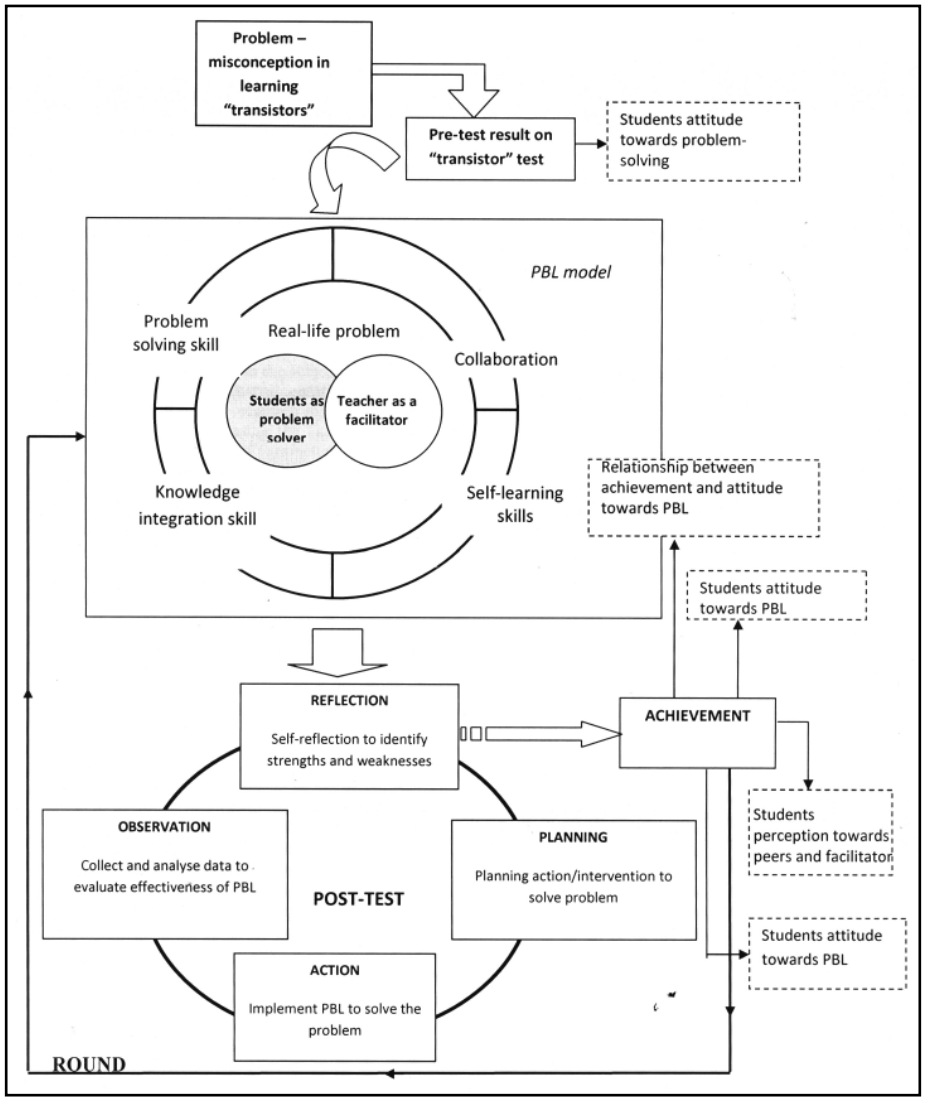

Figure 1. Conceptual Framework

Research Methodology

On the Research Design. This study utilized an action research design to rectify students' misconception regarding transistor in the electrical and electronic subject, using Problem-Based Learning. Pre- and post-test, observation, and interviews were used in the data gathering process for each round. The processes involved in each

round follow the model developed by Kemmis and McTaggart (1998). According to this model, action research moves in a continuous cycle involving four levels or steps, which are Level 1: Reflection, Level 2 : Planning, Level 3: Action, and Level 4: Observation.

On the Sample. The sample for this study were the Form 5 students from one of the Technical Schools in Melaka, Malaysia. There were 30 students, comprising 21 male and 9 female students. According to P. Lomax (1994), an action research is not designed to make generalization but just to solve the problem they face. These students were selected because of their low achievement in the subject.

On the Instrumentation. According to Mohd Majid Konting (2004), a valid and reliable research instrument is essential for data collection. It is also a tool used to measure the variables studied. He added that a good measuring tool measures the parameters accurately. In this research, the instrument used include the group members' evaluation form, observation checklist on students' interaction, unstructured interviews, pre- and post-tests (on the topic transistor in the electrical and electronic subject), questionnaires on students' attitudes towards problem-based learning, questionnaires on students' opinion regarding their facilitator, and questionnaires on their attitudes towards problem solving.

Research Findings

The action research was conducted at one of the Technical Schools in Melaka, Malaysia. It took the total duration of nine weeks, which involved 36 teaching sessions, 80 minutes for each session. The research was designed to enhance the students' understanding of the topic transistor in the electrical and electronic subject, using the PBL (Problem-Based Learning) method. Apart from that, the research was also conducted to determine the students' attitudes towards problem-based learning and their perception on the facilitator. The study has reached its saturation point in the third round, based on the post-test mean score.

On the Respondents' Profiles. A total of 30 form 5 students were selected as research subjects. They consisted of 21 (70%) male and 9 (30%) female students. Almost half (53%) of the students (8 males and 8 females) stayed at the school hostel.

Research Finding 1: Students' difficulties to master the topic transistor in the electrical and electronic subject. The pre-test results showed that among the reasons why students had difficulties in mastering the topic transistor in the electrical and electronic subject were their failure to understand the concept of electronic circuit; failure to remember the formulae; inability to apply the formulae with the questions; limited knowledge of the topic; confusion with the values and symbols of microampere (μ), miliampere (m) and misunderstanding of the concept of I_c where most of the time they thought $I_c=I_e$.

These results supported the findings of the *Laporan Prestasi SPM 2003* (for the topic transistor) which were released by the LPM (*Lembaga Peperiksaan Malaysia*) in 2004. According to the report, majority of the students did not remember the

formulae; they failed to use them correctly; they did not know how to change miliampere to ampere; they also thought that $I_c=I_e$; they used wrong formulae; and they failed to identify correctly the load line, saturation, and divert points (LPM, 2004).

Based on students' personal notes, they had given some reasons for these failures (arranged according to the highest frequency) which were (1) did not understand the concept; (2) teachers were being too fast in the teachings; (3) difficulties to memorize the formulae; (4) lack of communication and interaction in the learning sessions; (5) difficulties in understanding the topic transistor; (6) did not know how to solve the problems given; and (7) lack of practice and did not do the assignments.

Research Finding 2: Students' achievements after undergoing problem-based learning for the topic transistor in the electronic and electronic subject. Before the students underwent the PBL (Problem-Based Learning) process, they had only obtained 19% the mean score in the pre-test, with an average grade of 8.93. After participating in PBL, the students sat for the post-test and the achievement had improved to 34% with an average point of 7.67 (in the first round), 64% with an average point 4.20 in the second round, and 62% with an average point 4.37 in the final round. The findings show that there were significant achievements between the pre-test with the post-tests of the first and the second rounds of the PBL. The post-tests results of the second and third rounds did not show much improvement which indicated a saturation point.

Analysis on students' answers in the tests has shown that the students have made significant improvements in the subject from round one to round two and the number of those making mistakes were fewer. This shows that problem-based learning is effective as students have shown significant achievements in the subject. The findings can also be associated with Vygotsky's theory on proximal development zone, which indicates that collaboration between a student with a smarter peer may enable him to solve difficult and complicated questions (as cited by Savery & Duffy, 1995; Tan, 2003; Lambros, 2004; Khairiyah Mohd Yusof; 2005; and Hall, 2006). The results of this study have shown that students' involvement in team work and active group members' interaction has improved their mastery of the subject matter.

Research Finding 3: The extent of group members' cooperative work in order to achieve collaborative skills. Researchers have made observation in each round focusing on aspects such as sharing of the ideas, listening to others' opinions, managing time, supporting the group, carrying out tasks, and contributing knowledge or information to the groups. Overall, the findings show that there was 70% improvement for the cooperative work in the first round, 84% in the second round, and 88% in the final (third) round. It is clear that there were improvements from the first to the second and the third rounds. In the first round, it had been at a positive level and became even better in the second and third rounds. This means that PBL helps students to improve their collaborative skills in learning. The finding is supported by studies conducted by H. Barrows (1999), L. Torp and S. Sage (2002), A. Lambros (2004), and K.N. Lynda Wee (2004).

Since there were students who could not stay in a particular group as they were either hyper active or passive, they were then allowed to change group members. This was to ease the collaboration process among the members. They also could discuss better. This situation is supported by O.S. Tan (2003) who says that less effective discussion may take place if the group members are unskillful, immature, and lack knowledge. Though, during open-ended questioning to test students' abilities to answering questions without teachers' assistance, the findings indicated that despite of their "protest" for not being helped by the teacher in the first round, the students could actually discuss and learn together. This supports the constructivism theory which states that knowledge is actively developed by one's existing knowledge and experiences (as cited by PPK, 1991). In this process, students adapt new information they receive with their existing knowledge, to build new knowledge in their minds. According to J.R. Savery and T.M. Duffy (1995), problem-based learning is based on constructivism approach.

Research Finding 4: Students' attitudes towards problem-based learning for the topic transistor in the electrical and electronic subject. The study found that most participants have positive attitudes towards the PBL for the topic transistor in the electrical and electronic subject. In fact, few weak students also had shown active participation in the team work. This finding supports the result of research conducted by Khairiyah Mohd Yusof (2005) that shows students have positive attitudes towards problem-based learning. Norsyahidan Mohd Yusof (2004) also found that there is a significant difference between the achievement of those who used PBL and those who used conventional learning method. Mohd Khairuddin Abdul Karim (2004), in his research, found also that the students who used PBL could solve problems better that those students who attended lecture method.

Conclusion and Recommendations

Difficulties in memorizing the formulae; failure to understand the concept of electronic circuit; inability to apply the formulae with the questions; limited knowledge of the topic; confusion with the values and symbols of microampere (μ), miliampere (m); and misunderstanding of the concept of I_c where most of the time they thought I_c=I_e were the main weaknesses of the students in mastering the topic transistor in the electrical and electronic subject. The study also found that students' collaborative skills improved in each round, their achievement became better, they showed positive attitudes towards PBL (Problem-Based Learning), and they also had positive opinions on the facilitator and PBL itself. Open-ended questions showed that cooperative and problem solution aspects were the most preferred aspects in the PBL. There was a significant difference of students' achievements between the first and second rounds and the research reached its saturation point in the third round. There was also significant difference of students' attitudes towards problem solution, as shown in the mean scores of the pre- and post-test results.

However, there were some challenges arose during the research. *First*, the researcher had to deal with few students who refuse to give full commitment to the other group members during the group presentation. *Second*, time constraint whereby the lesson must be stopped (following the class timetable) although during that time, students were really enthusiastic to learn in the PBL environment. In this case, the researchers had asked the students to continue group discussion after the school hours. *Third*, differences in IQ levels had given advantage to more intelligent students to dominate group activities. For this situation, the researchers had identified less active students and they were given supports to do the activities as well. Active students were encouraged to motivate those students to participate in the activities.

Based on researchers' experiences as a teacher who has used the PBL approach, it is suggested that teachers should be active in constructing problems according to the objectives of the lesson. If they are not active, the students might not be excited to learn, which can result in ineffective learning.

Based on the findings and limitations of the study, it was shown that PBL approach had given positive impact on students' learning process. Thus, teachers are suggested to use this method. However, for those who are not confident or do not have the skills to use the PBL method, it is advised that training and guidance be given to them. PBL workshops and short courses should be offered to them. In addition, the teachers' training sector is advised to include PBL as one of subjects in the teachers' training programme. Further, lecturers at teachers' training institutes and universities should be exposed to PBL.

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