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EXPLORING THE PROBLEMS FACED BY TECHNICAL SCHOOL STUDENTS IN LEARNING ENGINEERING COURSES

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Abstract

The teaching of engineering courses is relatively challenging due to the nature of the courses that are perceived as "difficult courses" by a number of students. Thus, the purpose of this action research was to explore the problems faced by electrical and electronic engineering (PKEE) students studying a difficult topic–transistor. This research was also aimed at identifying the students' attitude towards Problem-based Learning (PBL). Literature has shown that PBL could enhance students' understanding and make the learning more meaningful. The theoretical framework of this study was based on Kemmis and Mc Taggart model. Cooperative learning method was also utilised in this study consisted of Jigsaw technique in the first and second rounds of the study. In the final round, the discussion method was used. In an action research design, a classroom is a usual research site. Thus, an engineering class of 30 Form 5 students in a Technical School was selected. The PBL method was applied in the class for a nine-week duration. Empirical data were gathered from peer assessment, observation, and pre- and post-tests. The data were described descriptively using frequency, mean and standard deviation. The main results show that the students were more interactive and their post-test result shows significant increases. In terms of the attitude towards PBL, the participants rated PBL highly. The participants also assert that the main benefits of PBL include enhancing their collaborative and problem-solving skills.

Keywords: Technical school, Electrical and electronic engineering, Action research, Jigsaw technique, Malaysia.

1. Introduction

Problem-based Learning and Project-based Learning are new methodologies in teaching. In Malaysia, previous field research in teaching engineering courses using these methodologies have been conducted by several researchers including Al-Atabi and Al-Obaidi [1], Puteh et al. [2], Rahman et al. [3], Mohd Yusof et al. [4], Mohd Salleh et al. [5], and Abu Hassan et al. [6]. However, the present research focuses on Problem-based Learning among technical school students. Technical School offers the electrical and electronic subject (PKEE) as one of the courses. The course 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 [7]. The course is offered at the technical schools for upper secondary students who are interested in Electrical and Electronic Engineering. The basics of this course has been taught at the lower secondary level − in the Living Skills course. PKEE is an applied course which mainly derived from Physics [8].

The implementation of Problem-based Learning (PBL) specifically in engineering classes is relatively new. Traditionally, PBL has been implemented in medical schools and has shown considerable success. PBL was introduced because of the ineffectiveness of the traditional lecture method. However, the traditional teaching method is still preferred by the majority of teachers in the exam-oriented system including Malaysia. According to Diaz and Cartnal [9], 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. Nevertheless, the Malaysian Curriculum Development Centre [10] has recognised 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 apply varied teaching techniques to ensure his or her class is appealing 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 student-centred teaching techniques are more interactive than the lecture mode [11].

Solving meaningful real-life problems is the basic principle of the Problem-based Learning (PBL). The philosophy of active learning and group dynamics is embedded in PBL. According to Torp and Sage [12], PBL involves 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.

2. Statement of the Problem

In the Malaysian Technical Schools, the electrical and electronic subject (PKEE) is offered as one of the courses. Based on examination results, this course is considered relatively "difficult subject" for the students to grasp. Based on the analysis of the SPM − *Sijil Pelajaran Malaysia* (Malaysian Certificate of Education) Examination (2003) results, 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. In the paper 2 of the electrical and electronic subject, 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 they did not know how to solve the problem and the majority would just guess the answer [13]. Table 1 illustrates 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 results (A1) in the subject for each year.

Table 1. SPM Results Analysis for the Electrical and Electronic Subject from 2001 to 2005 [14].

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	49309	4.80
	(4.82)	(7.22)	(13.88)	(17.16)	(19.28)	(17.58)	(13.76)	(5.00)	(1.40)	8.60%	
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: Jabatan Pendidikan Teknikal [14]

3. Purpose and Objectives of the Study

This study was conducted to explore the students' understanding about transistor in the electrical and electronic subject, using the PBL method. Specifically, the research objectives were to identify the students' misconception in learning about transistor in the electrical and electronic subject, examine the students' achievements in the subject after undergoing PBL process, investigate how well the group members work together to solve the problem.

4. Concepts of Problem Based Learning

There are many interpretations of Problem-Based Learning (PBL). Basically, PBL is an active learning where unstructured problems are used as the starting point or anchor for the inquiry and learning process. In the nutshell, PBL method uses relevant and meaningful problem in the learning process [15]. According to Graaff and Kolmos [16], 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.

Ousey [17] stated that PBL is a new philosophy in teaching and learning. 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 skilful 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 Barrows [18], PBL is a teaching and learning system which simultaneously builds the students' problem-solving skills. In PBL, students are given ill-structured problems taken from real life problems.

Among the benefits of PBL include it can train students to take responsibility of their own learning, as well as to be more independent. Teachers are only guides or facilitators. In PBL, students have to realise that they must be active in thinking of how to solve the problems and should not depend on their teacher to provide the solution [18]. Graaff and Kolmos [16] 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 brief, 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.

According to Graaff and Kolmos [16], the PBL principles include:

(i) PBL is a learning approach which uses problems as the basic in the learning process.
(ii) Student-centred learning. Students are only given guidance by the teacher to solve the problems. No direct teaching.
(iii) Teachers should be ingenious in creating problems relevance to the topic taught.
(iv) Use real-life problems.
(v) Students use prior knowledge and experiences during the teaching and learning processes.
(vi) Learning activities are the basics of the processes in PBL.
(vii) Involve "deep" learning.
(viii) Cooperative learning in the groups.
(ix) PBL is an active and reflective learning process.

According to Wee [19], 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. Many institutions that employed PBL have used "problem" as a stimulus for learning. However, the PBL practiced at Temasek Polytechnics Singapore, Medicine School University of Southern Illinois USA, and Gimmer University United Kingdom put more focus on learning group identification prior to formulating the problem itself. Uniquely, University of Lambert has PBL introduced at the beginning of the class.

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
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
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
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.
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

5. Action Research

Action research is a form of enquiry that enables teachers or practitioners to evaluate their practices. Mc Niff [20] 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. Lomax [21] 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. 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 Mc Taggart [22] model was selected because it is among the simplest models and it embeds self-reflection mechanism [23].

6. Conceptual Framework

A precise conceptual framework is critical in any scientific research. Conceptual framework shows the relationship of variables that provides a focus for inquiry. The conceptual framework for this study in Fig. 1. is formed based on the PBL model developed by Wee and Kek [24] and an action research model by Kemmis and Mc Taggart [22]. 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-week 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 [25].

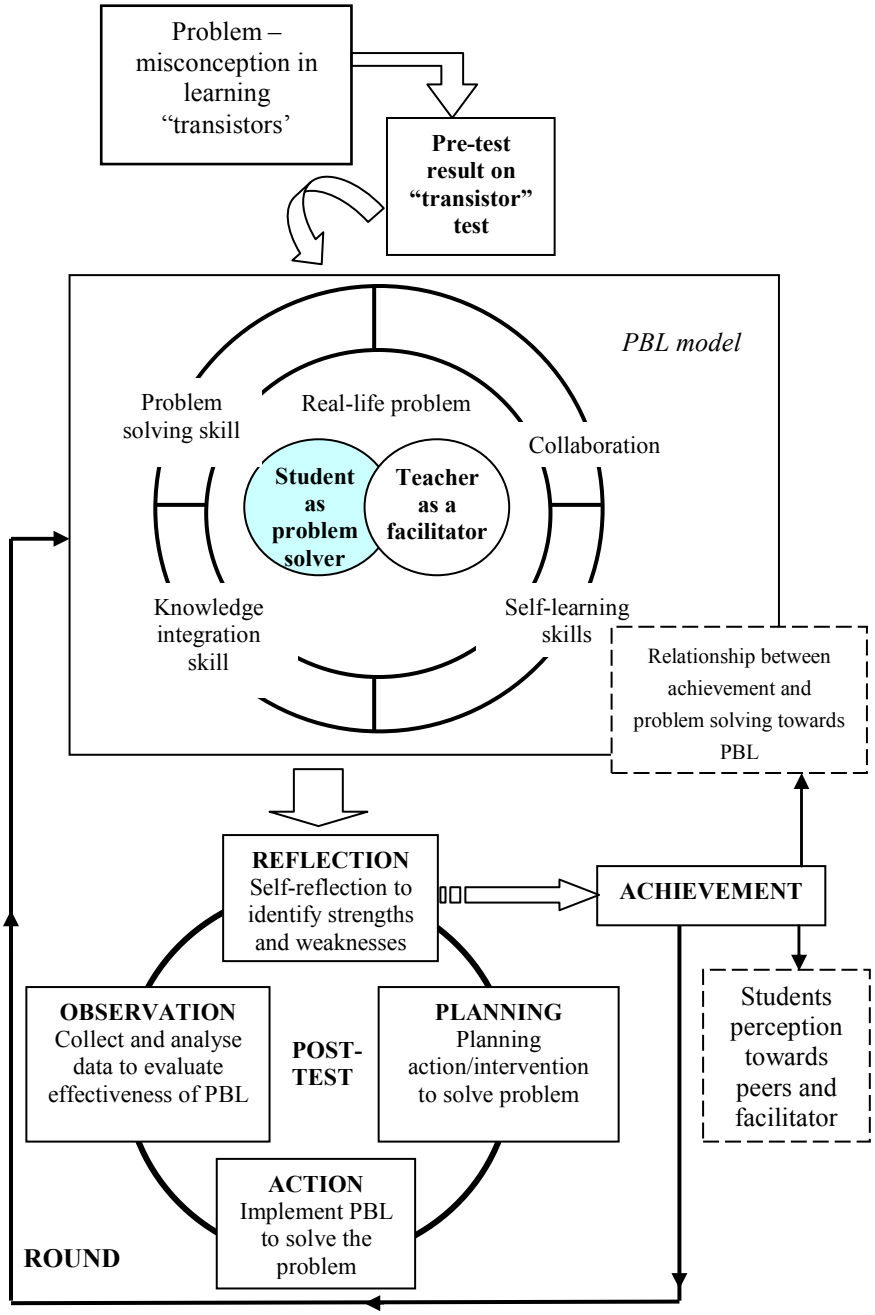

Fig. 1. Conceptual Framework.

7. Methodology

Consistent with the objectives of the study, this research has employed an action research design. The research was designed to identify students' misconception regarding transistor in the electrical and electronic course, 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 Mc Taggart [22]. 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

Level 4 : Observation

The samples for this study were the 30 students with low achievement in the subject (electrical and electronic) from one of the Technical Schools in Melaka. According to Lomax [21], an action research is not designed to make generalisation but to solve a different set of circumstances appear with different problems. A valid and reliable research instrument is essential for data collection [26]. 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' opinion regarding their facilitator and questionnaires on their attitudes towards problem solving.

8. Findings

The total duration of the study took nine weeks, which involved 36 teaching sessions, 80 minutes for each session. The study was designed to enhance the students' understanding of the topic transistor in the electrical and electronic course, using the PBL method. Apart from that, the study was also conducted to determine the students' perception on the effectiveness of the teacher as a "facilitator". The study has reached its saturation point in the third round, based on the post-test mean score.

8.1. 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.

8.2. Research Finding 1: Students' difficulties to master the topic transistor in the electrical and electronic subject

Assessment of students' achievement in the course was determined through tests. The pre-test results show 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 Lembaga Peperiksaan Malaysia [13]. 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; they failed to identify correctly the load line, saturation and divert points.

The teacher has recorded the students' responses on their difficulty in mastery the topic. Based on students' personal notes, they had given some reasons for these failures (arranged according to the highest frequency) which were (a) did not understand the concept, (b) teachers were being too fast in the teachings, (c) difficulties to memorize the formulae, (d) lack of communication and interaction in the learning sessions, (e) difficulties in understanding the topic transistor, (f) did not know how to solve the problems given, (g) lack of practice and did not do the assignments.

8.3. 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 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.

The result of the post-test shows 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 [27] on proximal development zone, which indicates that collaboration between a student with a smarter peer may enable him to solve difficult and complicated questions. 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.

8.4. Research Finding 3: The extent of group members' cooperative work in order to achieve collaborative skills

Observations were made 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 has 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 empirical studies conducted by Barrows [18], Torp and Sage [12], Wee [19] and Lambros [28].

In the middle of the research, there were students who could not stay in a particular group as they were either hyperactive 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 Tan [29] who says that less effective discussion may take place if the group members are unskilful, immature and lack knowledge. Though, during open-ended questioning to test students' abilities to answering questions without teacher's 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. In this process, students adapt new information they receive with their existing knowledge, to build new knowledge in their minds. According to Savery and Duffy [30], problem-based learning is based on constructivism approach.

9. Conclusion

This research has found several main findings. Difficulties in memorising 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 show positive attitudes towards PBL and they also have positive opinions on the teacher and the PBL itself. Open-ended questions show 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 results reached their saturation point in the third round.

Nevertheless, there were some challenges arose during the research. First, the teacher had to deal with few students who refused to participate during the group presentation. Second, time constraint was a critical factor where the lesson must be stopped when the time was up; even though the students were in the middle of doing PBL activities. In this case, the teacher had to ask 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 teacher 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.

10. Recommendations

Several recommendations can be derived from this study. Based on the findings and limitations of the study, it was shown that PBL approach has a positive impact on students' learning process. Thus, the classroom teachers are suggested to use this method. In addition, it is suggested that the 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 poor learning. 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. Further, PBL course should be included as one of the compulsory subjects in the teachers' training program. Finally, lecturers at teachers' training institutes and universities should be exposed to PBL.

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