The Effectiveness of Problem – Based Learning Methods in Improving High-Order Thinking Skills

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ABSTRACT: Problem based Learning (PBL) methods is a teaching approach based on real life problems, which involves the utilization of various skills in solving the issue. The purpose of this quasi-experimental research is to study the effectiveness of PBL technique in increasing students’ high order thinking skill. The research took a period of eight weeks to be completed. The instruments used in this research are pre-post test questions and survey. The research involved 71 respondents from Sekolah Menengah Kebangsaan Tun Ismail who were divided into two groups, which are the treatment and controlled groups. All of the respondents were a group of students undertaking the form four Science subject. The acquired data was analysed descriptively and inferentially using the Statistical packages for Social Science Version 21.0 (SPSS) software. The findings of this research have proven that PBL method is successful in increasing students’ high order thinking skill. A similar finding was also obtained regarding students’ perceptions in using PBL to help in their achievements, showing a high mean score of 4.00. In conclusion, the use of PBL shows positive response from students and the findings illustrate that different, interesting and effective teaching and learning methods are more capable of increasing students’ high order thinking skill compared to traditional methods.

1. Introduction

High order thinking skill, HOTS is the ability to apply knowledge, skills and values in making induction and reflection in solving problems, making decisions, being innovative and having the capabilities to create something (Buletin Transformasi Pendidikan Malaysia, 2015). According to Zainuddin et al., (2006), thinking skills are nurtured in students through the use of high level questions, activities that encourage thinking and problem solving along with teaching methods. Mansor (2009), has defined high order thinking skill as the mastery level of the cognitive domain in Bloom’s Taxonomy which is applying, analyzing, evaluating and creating. HOTS required us to do something with the information, facts, and ideas that we received by giving meaning and implications different from what usually are. HOTS allows us to understand, combine and link one knowledge with another, to categorize and manipulate them to acquire new meaning and understanding (Malaysian Examination Council, 2014).

High Order Thinking Skill (HOTS) also stresses on the application of critical thinking, creative thinking, logical thinking, reflective thinking and meta cognitive (Buletin Transformasi Pendidikan Malaysia, 2015). To put it plainly, students analyse a data or information which will be processed in their minds and later, re-presented in different forms. By having this skill, students are free to compare, differentiate, organize, classify and identify causes and effects according to their own opinions and points of views. Students can give several answers for one question. HOTS’ questions are open-ended questions that can result in more than one answer (Zakaria et al., 2014). Therefore,
high order thinking skill is created, which consequently encourages creativity, innovativeness and inventiveness among students. HOTS also has another advantage, which is its ability to increase students’ already existing capabilities and skills. They will be able to control, drive and measure the lessons that they have mastered. These skills will make them more productive and competitive. From here, their level of understanding will be increased and their learning will be strengthened in whatever subject that they will learn.

In Malaysia, the science field has been acquiring a large amount of attention. This has put a great deal of importance towards education as the leader in achieving the aim of becoming a developed country capable of facing challenges and economic demands lead by Science, Technology, Engineering and Mathematics (STEM) by the year of 2020 (Pelan Pembangunan Pendidikan Malaysia (2013-2025). Science is one of the most important subjects that has been taught since the primary school level. The teaching methods of this subject have been strengthened towards the combination of theory and practical usage. Science process skills are skills contained in the field of science (Ismail, 2001). Other than science process skills, high order thinking skill is another skill that has to be mastered within the field of science.

Problem – based learning (PBL) is one of the active learning methods based one the social constructivism theory. PBL is a learning process that begins with a problem and students will construct new ideas using support materials, information and their own existing knowledge (Saaid, 2011). Hall (2006) stated that PBL is a technique that is shaped by events that occur subconsciously in our daily lives. For Torp and Sage (2002), on the other hand, PBL focuses on learning experiences that involve mind – on and hands – on events occurring through investigations and results from real life problems. According to Subadrah and Malar (2005), PBL is an effective method in encouraging high order thinking skill. Thus, students must be exposed to teaching and learning methods that encourage high order thinking skill.

2. Background Of The Problem

Science is a field that covers knowledge, skills, scientific attitude and moral values (Aziz & Wee, 2008). Science is also a process that combines the concept of discovery inquiries in problem solving. Students perceive the science subject as one of the most difficult to pass and can jeopardize their chances of furthering their studies to universities (Mahizer et al., 2012). The decrease of the number of students in the science field is caused by three main factors which are lack of interest, perception that science is a tough subject and limited career prospects (Abdullah et al., 2013). Malaysia’s achievement in the international test, Programme for International Students Assessment, PISA shows that Malaysia is at a lower rank compared to neighbouring counties such as Vietnam and Thailand. According to Zabani (2012), the factor that contributed to Malaysia’s weak achievement in PISA 2009 is the format of the questions which used High Order Thinking Skill (HOTS).

The transformation of Malaysia’s education system also witnesses changes in the assessment and evaluation systems. Elements of HOTS is also incorporated in all examination papers measured by the suitability of students’ thinking levels based on their age (Pelan Pembangunan Pendidikan Malaysia (2013-2025). Students’ true achievements can be measured through transparent and efficient evaluation. However, the transition of the evaluation system from Lower Secondary Assessment, PMR to Form Three Assessment, PT3 has seen a result drop for almost all subjects. In 2014, PT3 results for science subject at the national level is 39.94 percent (Malaysian Examination Council, 2015). This low passing percentage has caused an alarm among Science teachers. Among the changes identified in PT3’s evaluation system was the change of question format and addition of High Order Thinking Skill, HOTS questions. For the upper secondary level as well, questions in the Malaysian Certificate of Education, SPM contains a section of HOTS questions. High Order Thinking Skill, HOTS is a skill element that must be mastered in order to answer PT3 and SPM questions.

According to Ngasiman (2014), teachers who are not creative in conducting their lessons will cause students to quickly become bored and this will reduce their interest and motivation. Therefore, it is the teachers’ role to make classrooms more lively. A set of lesson plans must be planned by considering many factors. Every person has different capabilities and tendencies in receiving and processing
information (Razak & Azman, 2012). The currently observed teaching and learning situations lean more towards traditional methods where teachers deliver information to students with little support from reinforcement activities (Samsuddeen et al., 2005). Teachers also seem to dominate the class when using this method. Less effective learning is also caused by material (book) based learning technique. Students are only focused on available concepts and limited to solving certain problems only.

High order thinking skill is one of the most important skills in ensuring students’ marketability. There are several definitions of ‘employability’ skill and most of them are related to the aspects of personal image, attitude, habits, behaviour, communication skills, problem solving, decision making skill and organization management process (Buck and Barrick 1987). According to Hasyamuddin (2008), Malaysia is now known as NIC (New Industrial Country). Therefore, in this globalisation era, the country is in need of skilled and semi-skilled labour force that can fulfill the requirements of workers as demanded by the industry to compete with other countries. Problems occur when employers complain that hired graduates still lack the necessary skills and have to be re-trained by the company (Kasiran, 2004). According to Hamid (2006), students’ capabilities in giving criticism, presenting ideas and providing relevant suggestions also do not achieve the levels desired by employers. This statement is in tandem with Hassan’s (2002) opinion, who stated that the reason why graduates cannot find their place in the job market is because of their lack of soft skills or generic skills such as high level thinking skill, which has become the main agenda in today’s education environment. Thus, this research is conducted in order to study the application of problem based learning method or better known as PBL in increasing students’ high order thinking skill in the Science subject.

3. Research Objectives

- To study the effects of PBL on students’ high order thinking skill for form four science subject.
- To study students’ perceptions after being exposed to PBL method for form four science subject.

4. Research Methodology

4.1. Research Design

The study has used quasi-experimental design. Experimental research design is used for the purposes of descriptive, explanatory and exploratory research (Earl, 2013). Table 1 displays the variables involved in this study.

| Group       | Independent Variable | Dependent Variable     |
|-------------|----------------------|------------------------|
| Treatment   | PBL Method           | Problem-solving Skills |
| Control     | Traditional Method   | Problem-solving Skills |

Quasi-experimental design is chosen because experiment is a good research design that can be used in measuring the effectiveness. The above statement is parallel to Chua (2011) who stated that quasi-experimental design is normally used to evaluate the effectiveness of certain program when the research respondents were not able to be divided randomly. PBL method was run for a group of form four students in science subject. PBL method questions were designed to be applied in the teaching and learning run in the class. According to Masek (2012), a few controlled factors should be taken into consideration in running the quasi-experimental research such as the teachers, subjects, topics, duration of the research and outer input. All of the factors concerned should be the same for both treatment and control groups. For quasi-experimental design, there are few threats towards the validity of the experiment. According to Chua (2013), there are some effects on the dependent variables that need to be reduced. The effects concerned are history effect, maturity effect, research instruments
effect, testing effect, regression statistics effect, choices effect and also the effect of losing participants. In order to obtain good results, all of the effects mentioned should be controlled and reduced at the minimum level.

4.2. Sample and Population
The population of research was the students in Sekolah Menengah Kebangsaan Tun Ismail, Batu Pahat, Johor. The students involved were form four students. According to Azizi et. al., (2007), the purpose of sampling is in terms of the selection of respondents with the aim of obtaining the data and information required in responding the research questions given. Two classes which are equivalent were chosen to undergo this experimental based research. In one of the classes with 35 students altogether, the students were taught using traditional method while the other class with 36 students, the students were taught using Problem based Learning (PBL).

4.3. Research Instrument
There were few instruments used in this research. All of the instruments were used in stages and this was very important to aid in the findings results of this research.

i. Pre-Post Test Question
These pre and post tests questions were to test the first research question which is whether the problem-based learning (PBL) method affects students' high thinking skills for form four science subject or not. This experimental method which was done for eight weeks has involved the traditional method of teaching for the first class and PBL method for the second class.

ii. Questionnaire
The instrument used to answer the second and third research questions was a set of questionnaire. The questionnaire contains two sections which are section A and section B. Section A was referring to the students’ demography in the aspects of gender and race. Section B contains the items used to collect data and answer the research question stated in chapter one.

iii. Data Analysis
Data were analyzed according to the set of questionnaire answered by the respondents. The software used to analyze data is the version 21.0 software as demonstrated in the Table 2.

| Table 2 : Type of Data Analysis |
|---------------------------------|
| Research Question | Type of Analysis |
| a) To study the effect of Problem based Learning methods towards students’ achievement in form four science subjects. | independent t-test, pair t-test |
| a) To study students’ perceptions after being exposed to Problem based Learning methods in form four science subjects. | Mean and standard division |

5. Results and Discussion
Before the data analysis were done, the exploratory data analysis (EDA) process was run to clean up the data obtained. During the pre-test and post-test were executed, all of the respondents have attended school and there were 71 of the respondents who returned the set of questions for the pre-test and post-test. However, when the questionnaires were distributed, 3 of the respondents from the treatment group were absent, leading to the number of questionnaire forms received to be only 33 sets.

5.1. Respondent Demographics
This study has involved two groups of students which are the treatment group and the controlled group. The number of respondents for the treatment group was 36 students while the controlled group was 35 students. Table 3 shows the division of respondents according to the gender and race.

| Division      | Male | Female | Malay | Chinese | Indian | Others | Total |
|---------------|------|--------|-------|---------|--------|--------|-------|
| Treatment     | 13   | 23     | 33    | 3       | -      | -      | 36    |
| Control Group | 19   | 16     | 35    | -       | -      | -      | 35    |

5.2. Normality Test
Normality test was conducted to see if the data obtained in in normal distribution or not. Normality test is supported by looking at the Skewness and Kurtosis values. According to George and Mallery (2003), if the Skewness and Kurtosis values are in between value of 1.0 until -1.0, where it shows that the data is in normal distribution. Table 4 shows the skewness value and Kurtosis.

| Post-test     | Skewness | Kurtosis |
|---------------|----------|----------|
| HOTS Test     | 0.377    | -0.637   |

The normality test is supported with the skewness value which is 0.3777 (1.00 > 0.377 > -1.00). Findings of the skewness value have demonstrated that the data are in normal distribution. Therefore the parametric test can be conducted.

5.3. Identifying whether Problem – based Learning (PBL) method Gives Effect on Students’ High Order Thinking Skills.
The pre and post-tests were used to answer the first research question which is whether Problem – based Learning (PBL) method gives effect on students’ high order thinking skills in form four science subject. The findings results of these pre and post tests were analyzed using t-test to see the effect before and after treatment. These comparisons were conducted for the two groups (treatment and controlled groups). The marks obtained by the students in the pre and post-tests are shown in Table 5 for treatment group and Table 6 for controlled group.

| No. | Respondent | Pre Test (%) | Post-test (%) | Difference (%) |
|-----|------------|--------------|---------------|----------------|
| 1.  | R1         | 30           | 35            | 5              |
| 2.  | R2         | 28           | 58            | 30             |
| 3.  | R3         | 23           | 33            | 10             |
| 4.  | R4         | 20           | 48            | 28             |
| No. | Respondent | Pre Test (%) | Post-test (%) | Difference (%) |
|-----|-------------|--------------|---------------|----------------|
| 1.  | R1          | 13           | 23            | 10             |
| 2.  | R2          | 20           | 48            | 28             |
| 3.  | R3          | 6            | 28            | 22             |
| 4.  | R4          | 10           | 25            | 15             |
| 5.  | R5          | 28           | 15            | -13            |
| 6.  | R6          | 13           | 8             | -5             |
| 7.  | R7          | 10           | 18            | 8              |
| 8.  | R8          | 33           | 45            | 12             |
| 9.  | R9          | 24           | 30            | 6              |
| 10. | R10         | 24           | 35            | 11             |
| 11. | R11         | 33           | 20            | -13            |
| 12. | R12         | 8            | 13            | 5              |
| 13. | R13         | 18           | 25            | 7              |
| 14. | R14         | 18           | 35            | 17             |
| 15. | R15         | 20           | 33            | 13             |
| 16. | R16         | 20           | 30            | 10             |
| 17. | R17         | 28           | 28            | 0              |
| 18. | R18         | 10           | 28            | 18             |
| 19. | R19         | 10           | 45            | 35             |
| 20. | R20         | 8            | 10            | 2              |
| 21. | R21         | 25           | 15            | 10             |

Table 6: Marks of Controlled Group Test
Based on the differences in the percentage marks obtained before and after treatment, a greater difference can be perceived from the treatment group. According to the respondents (R28) from the treatment group, the disparity of the pre-test marks and post-test marks are about 60% while for respondent (R19) from the controlled group, the difference shown from both of the tests are only 35%. These results have demonstrated that the difference of post-test marks and pre-test marks obtained are greater for the treatment group. These findings have proven that Problem–based Learning (PBL) has given positive effect on the students’ high order thinking skills.

5.3.1. Independent T-Test for Pre-test
The data obtained were analyzed to prove that both groups have almost similar level of in terms of high order thinking skills. The form of analysis conducted was independent t-test or t-free test. Therefore, the data of pre-test for treatment group were compared with the controlled group. The results of analysis displays that both groups are insignificant with the reading, 0.135 (> 0.05). Hence, there is no difference between both treatment and controlled groups based on the findings of the pre-test. Table 7 has shown the significant value of the pre-test done.

| Controlled Group and Treatment Group | Independent T-test |
|--------------------------------------|--------------------|
| Equal Variances Assumed              | Significant (2-tailed) | Mean of Differences | Std. Error Different |
|                                      | 0.135              | 3.423               | 2.144                |

5.3.2. Independent T-Test for Post-test
In order to answer the first research question, the post-test data were analyzed to compare the post-test marks obtained between the treatment group and the controlled group. The form of analysis conducted was also independent t-test. The results of analysis obtained using the Statistical Package for Social Science Version 21.0 for Windows (SPSS) software has demonstrated the significant value of 0.00 (<0.05). Hence, there are differences shown between both controlled and treatment groups based on the post-test marks. This has proven that there is improvement in the marks of the students from treatment group. Table 8 has shown significant value for the post-test.

| Table 8 : Significant Value for Post-test of the Controlled Group and Treatment Group |
5.3.3. Paired T-test for Treatment Group

Paired T-test was also conducted to prove the first research question which is whether Problem – based Learning (PBL) gives effect on the students’ high order thinking skills. Therefore, the comparison of the pre-test and post-test marks for the treatment group was conducted. The results of analysis from the paired t-test have displayed significant relationship where there are differences of marks between the pre-test and post-test for treatment group. The significant value obtained is 0.00 (<0.05). Table 9 demonstrates the significant value for pre-test and post-test of the treatment group.

| Pre-test and Post-test for Treatment Group | Paired T-test |
|----------------------------------------|--------------|
| Significant (2-tailed) | Mean | Standard Division |
| Paired Different | 0.00 | -26.722 | 16.503 |

5.3.4. Identifying Students’ Perceptions After Being Exposed with Problem – based Learning (PBL) Method

Students’ perceptions on Problem – based Learning (PBL) method were identified after the period of eight weeks they were exposed with the method. In order to answer the third research question, questionnaires on the perceptions were distributed to the respondents from treatment group. Respondents marked the answer based on Likert scale options from the questions given. 24 items were used and given to 33 students from the treatment group. Item 24 has displayed the highest mean which is 4.33. This shows that students prefer to do presentations of the group work task in front of the class. Item 10 and item 16 were the items demonstrating average mean values of 2.85 and 2.06 respectively. Both of the statements in the items are negative. Therefore, the items have supported the research questions. As the statement for item 10 which is “student feel very stressed to study science because often asked questions that challenge the mind.”, with the lowest mean value, it has proven that students do not feel stress when they learn science. On the other hand, the statement for item 16 which is “group study has made students to feel bored because they prefer self-study.”, with the lowest mean value also has proven that students prefer to study in a group more than self-study. Table 10 shows the standard deviation and mean scores for each item.

| No. | Item | Mean Score | Standard Division | Level |
|-----|------|------------|-------------------|-------|
| 1.  | I enjoy learning using Problem – based Learning method. | 4.09 | 0.58 | High |
| 2.  | I think science subject is easier to be understood using Problem – based Learning method. | 4.03 | 0.47 | High |
3. Problem – based Learning method helps me in solving problem in science subject. 4.09 0.59 High
4. Problem – based Learning method increases my high order thinking skills in science subject. 4.06 0.56 High
5. I enjoy learning in group using the learning session. 4.24 0.50 High
6. I prefer the teaching to be conducted through ‘chalk and talk’ because it is more time-consuming. 4.00 0.64 High
7. I am very happy to be able to assist my friends when doing all the activities and work of the group. 4.30 0.59 High
8. Problem – based Learning method improves the effectiveness of my work. 3.97 0.53 High
9. I am very excited to be actively involved during the teaching and learning session. 4.09 0.58 High
10. I feel very stressed to study science because often asked questions that challenge the mind. 2.85 0.67 Moderate
11. I am more interested in learning science after being exposed to Problem – based Learning method. 4.03 0.59 High
12. I am more motivated to learn science. 4.09 0.52 High
13. I feel happy when I'm studying because I am often guided and given the opportunity to solve a problem. 4.24 0.50 High
14. I would be frustrated if I could not share my own opinion during the discussion session. 3.67 0.74 High
15. I am more confident to help my friends in solving problems in their assignments. 4.03 4.03 High
16. Group learning makes me feel bored because I like to study by myself. 2.06 0.90 Moderate
17. I have high self-confidence after learning to use Problem – based Learning method. 3.94 0.66 High
18. I want to continue studying science using the Problem – based Learning method. 4.18 0.53 High
19. I enjoy learning because Problem – based Learning method relates the issues learned with daily life. 4.30 0.53 High
20. I hope the Problem – based Learning method is implemented in all subjects. 4.15 0.71 High
21. I became braver to answer science questions. 4.06 0.61 High
22. If I were given the choice, I would like to use the Problem – based Learning method. 4.15 0.62 High
6. Conclusion
To conclude, the findings of the research show that all research questions have been answered with support from the literature review and explanations. For the first research question, it is proven that Problem – based Learning (PBL) boosts students’ problem solving skill. This is proven by the achievement of the post-test for the treatment group. The independent t-test analysis results have found that there are differences in the post-test marks of the treatment and controlled groups. These findings are supported by paired t-test analysis displaying that there is an improvement in the post-test marks compared to pre-test marks for treatment group. For the second research question on the other hand, Problem based Learning method is able to improve the level of high order thinking skills among the students and proven by the analysis on each item in the questionnaire showing the mean and standard deviation to be at the highest level. As for the third research question, students have shown the positive perceptions and interest towards Problem – based Learning method. Mean score for each positive item is at a high level while mean score for negative item is at the low and average levels. As a whole, Problem – based Learning method should be continued and applied to be a culture in the teaching and learning in the class. Students especially will benefit more from this Problem – based Learning method. Other than developing students’ potential and synergizing all skills needed to become well – balanced students. The parties concerned such as the school administer and Malaysia Education Ministry can also make this research to be as the framework guidelines in designing future programs for the purpose of developing better teachers’ skills.

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