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Analysis of students' mathematical reflective thinking on problem based learning (PBL) based from learning styles

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Abstract

Reflective thinking is one of the high-level thinking skills that learners must possess. This study aimed to determine the effectiveness of Problem Based Learning (PBL) model and to describe the students' reflective mathematical thinking ability for each type of learning styles (visual, auditory, and kinesthetic). This research used a mixed method. The research class was taken with cluster random sampling. The subjects of this study were 6 students of class in one of junior high school in Purworejo which were selected by purposive sampling by selecting 2 students from each type of learning style. The data collection by using tests, questionnaires, and interviews. The results showed (1) PBL was effective in achieving students' reflective mathematical thinking ability; (2) mathematical reflective thinking ability of visual subject was unable to draw the analogy of the problems and the visual subject was unable to identify relevant data. The auditory subject was unable to explain correctly the concept used in drawing sketches and unable to understand and identify the concepts. In addition, the auditory subject was less able to identify relevant data. Whether the kinesthetic subject made a mistake in drawing the analogy but he was unable to mention the problems that existed and could not identify the relevant data. In addition, the kinesthetic subject was less able in doing proof by using the concept involved in the proof of argument.

1. Introduction

Learning in the 21st century is directed to prepare students in the direction of the global economy. So in the learning, especially learning mathematics students are expected to have the ability to understand and apply the concept well. According to Noer (2008) "on the process of learning mathematics, students need to be accustomed to solving problems, finding something useful for themselves, and working with ideas". So that learners are expected to be able to construct knowledge in their own minds.

The results of observation suggest that the ability of children in solving non-routine problems is not optimal, students prefer to solve routine problems rather than problems in the form of stories. Based on Trends in International Mathematics and Science Study (TIMSS), students are still weak on the problem in the form of applications. According to TIMSS, Indonesia ranked 45 out of 50 countries participating TIMSS (Puspendik Kemdikbud, 2015). Meanwhile, according to the Program or International Student Assessment (PISA) in 2015 as quoted by Kemendikbud (2016), Indonesia's position is still below the average of OECD countries (Organization and Economic and Development). The result of TIMSS and PISA achievement shows that the ability to think high level of mathematics subject is low. While the 2013 curriculum requires students to have higher order thinking skills (HOTS) when using a scientific approach.

According to King (1998), higher order thinking skills include critical, logical, reflective thinking, metacognitive, and creative thinking. In this case, one of the higher-order thinking skills is reflective thinking. According to Nindiasari, as quoted by Lutfiananda et al (2016), reflective thinking is one of the necessary abilities in mathematics learning. This is because the targets

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of learning mathematics such as understanding, problem solving, connections, and mathematical communication, as well as other capabilities will be owned by students well. Reflective thinking ability is formed when individuals experience confusion, obstacles or doubts in solving complicated math problems such as problems non routine (Sabandar, 2013).

From the results of interviews with math teachers, it informed that mathematical ability of the students had not been optimal. This is shown from the students learning outcomes which were not optimal when solving non-routine problems. The main cause was still low ability reflective mathematical thinking of students, so that students got difficulty in reflecting their knowledge when faced with non routine problem. In line with the results of Nindiasari (2013), the students' reflective ability is still low. Almost 60% of students have not been able to achieve indicators of reflective mathematical thinking ability.

According to Nindiasari (2013) the indicators of mathematical reflective thinking ability are as follows: students are able (1) to interpret a case based on the mathematical concepts involved; (2) to identify mathematical concepts or formulas involved in math problems that are not simple; (3) to evaluate / verify the truth of an argument based on the concept / nature used; (4) to draw the analogy of two similar cases; (5) to generalize and analyze generalizations; and (6) to differentiate between relevant and irrelevant data. In relation to the above problems, a learning model is needed in order to improve the ability to reflect mathematically reflective students. PBL is a constructive approach that is believed can support the students' reflective thinking ability (Lim, 2011).

The difficulties occurrence of students' mathematical reflective thinking while learning among others was influenced by learning styles. In Brueckner's opinion in Widdiharto (2008: 6), learning styles are one of the intellectual factors that causes learning difficulties to students. According to Lestari et al (2012), not all students have the same learning style, where each student has a natural and comfortable learning style for themselves. This difference in learning style causes different students ability in processing and solving math problems (Indrawati, 2017). In addition, Hartati (2015) states that there are differences in learning outcomes between the three groups of students who have visual, auditory, and kinesthetic learning styles. So students mathematical reflective ability differs for each learning style. According to DePorter & Hernacki (2008), the classification of learning styles is visual, auditory, and kinaesthetic. The sharing of learning styles is based on the tendency of students to utilize the sense devices they have to receive, absorb, and process information.

Regarding to preliminary explanation, there are several formulation of problems in this research as follows (1) does the model of PBL effectively support the achievement of mathematical reflective ability of students? (2) how to reflect mathematical ability of students for each type of learning style? Considering to the research problems above, the purposes of this research are (1) to describe the effectiveness of the implementation of PBL on the achievement of students' mathematical reflective thinking ability, and (2) to describe the mathematical reflective thinking ability of students for each type of learning style.

2. Methods

The research method used was a mixed method with concurrent embedded model (mixture of quantitative and qualitative). The research design used was posttest-only control design. In this design, two groups were selected with cluster random sampling. The first group was treated (X) called as the experimental class (VIII A) and the second group was the untreated group or called as the control class (VIII B). Then the two groups were given a mathematical reflection ability test (post-test).

The subjects of this study were 6 students from the experimental class (VIII A) selected by purposive sampling technique. The subjects of this study consisted of 2 students from each type of learning style (visual, auditory, and kinesthetics). The methods used to collect data were questionnaires, tests, and interviews. The learning style questionnaire instrument used in this study was adopted from a learning style questionnaire created by Rosmaiyadi (2015).

The collected data were then analyzed. The data were analyzed by quantitative and qualitative analysis. The quantitative data analysis was conducted to know the effectiveness of PBL in achieving the ability of reflective mathematical thinking. Particularly, the quantitative analysis was divided into two parts, namely the analysis of initial data and analysis of final data. Analysis of preliminary data was using the value of final exams class VIII A and VIII B. While the analysis of final data was using the value of mathematical reflective thinking ability test. The qualitative analysis was performed to determine the description of students' mathematical reflective ability based on the learning styles. The qualitative data analysis was done by data reduction phase, data presentation, and conclusion (Sugiyono, 2015: 337).

3. Results & Discussions

Based on the classification of learning styles, it is found that each students had a different type of learning style. This is in accordance with the research of Ramlah et al (2014), that everyone has a tendency of different learning styles. Based on the learning style questionnaire, it is seen that the auditory learning style dominated the type of learning style of students in VIII A. This is proven because half of the students of class VIII A had the auditory learning style. The results of research conducted by Apipah & Kartono (2017) indicate that the auditory learning style dominates the class of research. Students prefer to the auditory learning styles (Abidin et al, 2011).

3.1. Effectiveness of PBL on Achieving Mathematical Reflective Thinking Skill

The results of mathematical reflective thinking ability tests were used for final data analysis. The data of mathematical reflective thinking ability of students from both research classes are presented in table 1.1.

Table 1. The Data of Mathematical Reflective Thinking Skills

Class	N	**Σ**	Standard	Max	Min
Experimental Class	32	79	12.32	97	47
Control Class	32	68	11.43	88	47

Prior to hypothesis testing, a normality test was performed first. Based on the results of the calculation of normality test by using Kolmogorov Smirnov test, the value obtained $Sig = 0.810 > \alpha = 0.05$. So based on the test criteria, H_0 was accepted. This means the data were normally distributed population, so statistics was used parametric statistics. This is in line with Sugiyono's opinion (2015: 75) that the use of parametric statistics works with the assumption that the data of each research variable to be analyzed is normally distributed. Based on the homogeneity test, the mathematical reflection thinking test of the experimental and control classes has the same variance.

Then, the hypothesis test was conducted in this study including the average test, one-party proportion test, and the difference of two averages test. The average test was used to determine the average of students' mathematical reflective thinking ability to achieve individual completeness or not. Based on the calculation, obtained that $t_{count} = 6.430468$ and $t_{table} = 1.698$. Because $t_{count} = 6.430468 > t_{table} = 1.698$, then H_0 was rejected. In conclusion, the average of the students' mathematical reflective thinking ability of was more than 65, so that it can be expressed completely individually.

For more, one-party proportion test was conducted to find out whether the average of mathematical reflective thinking ability of experimental class students achieved classical completeness. Based on the calculation, it is obtained that $Z_{count} = 2.041241$ and $Z_{table} = 1.64$. Since $Z_{count} = 2.041241 > Z_{table} = 1.64$, then H_0 was rejected. In brief, the result of the students mathematical reflection ability test with PBL which got value more than or equal to 65 more than 75%. In other words, the PBL class had fulfilled the classical mastery in way. This is in line with Nuriana et al (2017) that the results of mathematical reflection thinking ability test using PBL is completely classical.

This two-averaging difference test was used to test the average of students mathematical reflective thinking ability in the experimental class was higher than students' in the control class. Based on the calculation assisted by ms.excel, obtained t_{count} = 3.609391 and t_{table} = 1.9993. Because $-t_{table}$ = -1.9993 $< t_{count} = 3.609391$, and t_{count}= 3.609391> t_{tabel} = 1.9993, then H_0 was rejected and H_1 was accepted. So the students' mathematical reflective thinking ability in PBL class was more than students' mathematical reflective thinking ability students in the classroom with the learning that took a place in school. As Veno et al (2013), explain that the application of PBL is better than the learning that takes place in school, the average experimental class learning outcomes are more than the average control class. In addition, according to Fadillah in Happy (2014), the learning by using open problems is better than ordinary learning. This is supported by the opinion of Herman (2007), that PBL is significantly better in improving the ability of high-level mathematical thinking students than ordinary learning.

Based on the criteria of effectiveness, the students' reflective thinking ability with PBL was completed individually and classically. In addition, the average mathematical reflective thinking ability of students in the experimental class was more than the control class. So that PBL was considered to be effective in supporting the achievement of reflective mathematical thinking ability. This is in line with the opinion of Lim (2011), that PBL indeed promotes the development of reflective thinking ability. In addition, the results of research Angkotasan (2013) inform that PBL was effective to improve the mathematical reflective thinking ability and mathematical problem solving ability

3.2. Analysis of Students Mathematical Reflective Thinking Ability Based From Visual Learning Styles

The visual subjects were capable of interpreting a case based on the mathematical concepts involved. The visual subject understood the problem well by mentioning information that was known and asked in the question correctly and completely. In addition, they were able to sketch neatly and detail along with explaining how to sketch properly. According to DePorter & Hernacki (2008: 116) that a person with a visual learning style prefers art rather than music. So that students with visual learning styles are usually cleverer in drawing.

In the second indicator of identifying mathematical concepts or formulas involved in math problems that are not simple, the visual subjects were able to meet these indicators. They were able to understand and explain what concepts which were involved in the problem. In explaining, they were less able to tell stories at length. Students with their visual learning styles are not very good at speaking, but actually they know what should be said (DePorter & Hernacki, 2008: 118). The visual subject was able to use the concepts involved to solve the problem and the problem-solving steps in detail and systematic. According to Apipah & Kartono (2017), the visual learning style can write down the problem solving steps systematically and clearly.

In the third indicator that is evaluating / checking the truth of an argument based on the concept / properties used, the visual subjects were able to meet these indicators. This is in accordance with the results of research Mentari et al (2018), the visual students are able to evaluate / check the truth of the argument correctly, clearly, and complete. Visual project is appropriate in choosing the steps and formulas / concepts in conducting argument proof.

In the fourth indicator that is interesting to draw an analogy from two similar cases, the visual subjects had not been able to meet these indicators. They were unable to understand the problems that exist on the item correctly. Moreover, the visual subjects were unable to draw analogies so wrong in making final conclusions. This is in accordance with a study conducted by Jaenudin et al (2017), that visual students can't draw an analogy from two similar cases.

In the fifth indicator, which is generalizing and analyzing generalizations, the visual subjects were able to meet these indicators. They were unable to write a formula in doing a proper generalization even though he is able to explain the process of generalization done correctly. This is in line with Jaenudin et al's (2017) study that the visual students are less fluent in formulating one to the next.

In the sixth indicator, distinguishing between relevant and irrelevant data, the V1 subject was unable to identify the relevant data that can facilitate problem solving. But subject V2 was able to use and explain relevant data to solve problems.

3.3. Analysis of Mathematical Reflective Thinking Ability Students based from Auditory Learning Styles

The Auditory subjects had not been able to interpret indicators of a case based on the mathematical concepts involved. The auditory subject was unable to write down and explain the information known to the item. In addition, they were unable to explain correctly the concept used in drawing sketches, so that the results obtained were not yet complete. The concept used was different from the intention desired by the question. It was caused by a person with an auditory style of learning style had visualization problems as well as opinions conveyed by DePorter & Hernacki (2008: 118), someone with an auditory learning style has problems with work involving visualization.

In the second indicator, that is identifying the concepts or mathematical formulas involved in math problems that are not simple, the auditory subject had not been able to indicate. They were unable to understand and explain the concepts involved in the problem correctly. They were still experiencing errors in finding the building area to be painted. They conducted in a systematic and unstructured manner in performing the settlement steps. In addition, they tend to write the formula briefly and not detail. Jaenudin et al (2017) say that auditory students are able to write the formula correctly but tend to be short. This is also supported by DePorter & Hernacki's (2008: 118) opinion, that the subject of auditory learning style has difficulty writing but is great at telling stories.

In the third indicator, that is evaluating / checking the truth of an argument based on the concept / properties used, the auditory subjectd completed it well. They were able to write proof correctly and tell the process of proof at length. This is in the opinion of Mentari et al (2018), in examining the truth of an argument, the auditory subject was able to give the right answer and the correct reason. Although there were several auditory subjects proved in a longer way that was when finding the length by using the volume of the beam. In other words, one characteristic of the auditory learning style that likes to talk, discuss, and explain something at length (DePorter & Hernacki, 2008: 118).

In the fourth indicator which is drawing the analogy of two similar cases, the auditory subjects completed well. They were able to mention the length of the problems that existed and its relevance correctly. In addition, auditory subjects were able to explain the process of analogical withdrawal done in detail and clear. As mentioned before, they could explain well due to their characteristics who like to speak, discuss, and explain something at length (DePorter & Hernacki, 2008: 118).

In the fifth indicator, which is generalizing and analyzing generalizations, the auditory subjects were able to meet these indicators. They had not been able to write a formula in doing a proper generalization and some even wrote down the final result without resorting to a solution. However, they understood and were able to explain the process of generalization correctly. According to De Porter and Hernacki, a person with the type of auditory learning style has a tendency to find it difficult to write but is great at telling stories (DePorter & Hernacki, 2008: 118).

In the sixth indicator, distinguishing between relevant and irrelevant data, the auditory subjects were less able to meet these indicators. They were able to distinguish between relevant and irrelevant data used to solve the problem, yet there were some mistakes in the calculation, and must be told in advance to realize the mistakes made. While other auditory subjects were still unsure of relevant data even though the ones mentioned are correct.

3.4. Analysis of Mathematical Reflective Thinking Ability Students Based From Kinesthetic Learning Styles

The kinesthetic subject was capable of interpreting a case based on the mathematical concepts involved. The kinesthetic subject was unable to write down the information on the problem completely, but able to confirm at the time of the interview. This happened because the kinesthetic subjects were less thorough when performing tests of mathematical reflective thinking ability. This is in Nurul's opinion, as cited by Jaenudin et al (2017) that kinesthetic subjects with high, medium, and low ability tend to be less precise and hasty in counting. The kinesthetic subject was able to draw the sketch correctly according to the desired concept on the problem, but not too neat and detailed, because they had not included the size on the sketch made.

In the second indicator, that is identifying the concepts or mathematical formulas involved in math problems which are not simple, the kinesthetic subjects were able to meet these indicators. They had not written the complete information but were able to confirm at the time of the interview correctly. The kinesthetic subject read the question while pointing at the writing. This is in accordance with the characteristics of the kinesthetic learning style. According to DePorter & Hernacki (2008: 118), a person with a kinesthetic learning style type uses a finger as a guide when reading. The kinesthetic subject is able to explain the identification process which is done slowly but clearly. In addition, a person with a kinesthetic learning style tends to speak slowly.

In the third indicator, that is evaluating / checking the truth of an argument based on the concept / properties used, the subject K1 was less able to complete this indicator, but K2 able to this indicator. Subject K1 was unable to prove properly, that was mistakes in finding the height of the beam. This caused a miscalculation when looking for beam surface area. But the steps or concepts used to verify it were correct.

In the fourth indicator, which is drawing the analogy of two similar cases. The kinesthetic subject had not been able to meet the indicator. Kinesthetic was unable to mention the problems that exist on the problem correctly. But the kinesthetic subject was unable to explain the meaning of the matter correctly, so that the kinesthetic subject makes a mistake in the withdrawal of the analogy. This is demonstrated by the final answer of kinesthetic subjects who were only looking for the second surface of the wall shelf. This is consistent with research conducted by Mentari et al (2018), that kinesthetic students do not answer in their entirety so as not yet able to attract analogies. Kinesthetic subjects need to read repeatedly the questions in the question in order to be able to understand the purpose of the matter. As well as Anintya (2016), students with kinesthetic learning style tends not to understand to read the problem only once, so it needs repetition.

In the fifth indicator, which is generalizing and analyzing generalizations. Kinesthetic subjects were able to meet these indicators. They had not been able to write a formula in doing a proper generalization and some even wrote the final result without using the solution. This is in the opinion of Jaenudin et al (2017), kinesthetic students tend to write only the end result. But the kinesthetic subject understands and is able to explain the generalization process correctly.

In the sixth indicator, that is distinguishing between relevant data and irrelevant data. The kinesthetic subject had not been able to meet the indicator. This is in line with the research of Mentari et al (2018), that kinesthetic students are unable to distinguish relevant and irrelevant data. It can be seen from the answers of kinesthetic subjects who seek long perfume place first, but this was definitely unnecessary. Thus in search of the beam volume, kinesthetic subjects used the formula $V = p \times l \times t$. Based on the results of interview, subject kinestethics stated that all information obtained from the question was relevant data.

4. Conclusion

Based on the result of the research, it can be concluded that: (1) PBL is effective in achieving students' reflective mathematical thinking ability. Students' mathematical reflective thinking ability with PBL achieves individual and classical mastery. In addition, the ability to think in relational students of the class with PBL is more than the classroom with the learning that took place at school; (2) Mathematical reflective thinking ability of subject visual was able to fulfil 4 indicators of mathematical reflective thinking ability, that is indicator 1,2,3, and 5. For indicator 4, the subject visual was unable to draw an analogy from the problems that exist on the problem although it was able to mention the existing problems. As for indicator 6, subject V1 is unable identify the relevant data but subject V2 is able to use and explain relevant data to solve problems. The mathematical reflective thinking ability of subject auditory was able to meet 3 indicators of mathematical reflective thinking ability ie indicators 3, 4, and 5. For indicators 1 and 2, subject auditory is unable to explain correctly the concept used in drawing sketches so they got incorrect conclusion and they are not yet able to understand and identify any concepts involved in the problem to solve the problem. In addition, for an indicator of 6 auditory subjects are less able to identify relevant data that can assist in solving the problem. Mathematical reflective thinking ability of kinesthetic subjects are able to meet the 3 indicators of mathematical reflective thinking ability that are indicator 1, 2, and 5. For indicators 4 and 6, the kinaesthetic subjects make a mistake in interesting analogies but are able to mention the problems that exist and unable to identify relevant data that can help them to solve the problem. In addition to indicator 3, subject K1 is less able to prove by using the concept involved in proof argument. But K2 is able to use concept to prove.

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