The effectiveness of problem based learning with authentic assessment towards students' mathematical problem solving ability at 11th grade of Tran Nhan Tong Senior High School in Ho Chi Minh City, Vietnam

Sela Mawarti[a,*], Masrukan[a], Mohammad Asikin[a]

[a] Mathematics Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang, Indonesia

* E-mail address: selamawarti@students.unnes.ac.id

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Abstract

The purpose of this research was to find out whether Problem Based Learning (PBL) learning with authentic assessment affects the students' mathematical problem solving ability. The method of this research was quantitative research method. Its population was 11th grade of Tran Nhan Tong Senior High School Ho Chi Minh City, Vietnam in academic year 2017/2018. By using the cluster random sampling, class 11A1 was selected as a control class that gained conventional learning in Vietnam, class 11A2 as an experiment class 1 that obtained PBL learning with authentic assessment, and class 11A3 as experiment 2 class that obtained PBL learning. The data collection techniques were documentation and test method. The result of the research showed that the result of mathematical problem solving test at the experiment class 1 successfully reached classical completeness more than or equal to 75% of the students in the class, and students' mathematical problem solving ability at the experiment class 1 was better than at the experiment class 2, while students' mathematical problem solving ability at the experiment class 2 was better than at the control class.

1. Introduction

Mathematics is one of the main subjects in formal education in Vietnam. According to Gravemeijer et al. (2017), the purpose of mathematics education is to prepare students to apply mathematics to all types of work and daily life situation. According to Asikin (2012), learning mathematics in schools has several objectives: (1) organizing the logic of students' reasoning and building their personality and (2) making students be able to solve mathematical problems and apply mathematics. Thus, problem solving ability is the basic ability that each student must possess and master. The importance of mastery in problem solving in Vietnam is underscored by Dunga & Baob (2017) who state that one of the ten core competencies to be a comprehensive mathematics subject program in Vietnam is problem solving ability. So, in other words, problem solving ability is highly important and useful for students' daily life.

Problem solving is an important aspect, but most students in Vietnam are still weak in terms of mathematical problem solving. The weakness of students' problem solving ability can be seen from the results of the PISA (Program for International Student Assessment) survey organized by OECD (Organization for Economic Cooperation and Development), Vietnam has decreased the average PISA score on mathematical literacy from 2012 to 2015. In PISA studies (OECD, 2009), one of competencies measured in the cognitive domain is the problem solving.

Then, from the data summarized by Scopus in 2013 on the understanding of the mathematical concepts of ASEAN countries especially in the problem solving sector originating from the International Mathematics Union reports that Vietnam is fifth rank in ASEAN. Hence, Vietnam

cannot yet be categorized in the high level of problem solving. It is also affirmed by Dunga & Baob (2017), on the formation and development of problem solving and a deep understanding are in the terms of major knowledge.

In line with the importance of mathematical problem solving in mathematics education, then educators must certainly attempt that students can achieve the optimal results in mastering problem solving ability. Duong (2016) explains that roblem solving efficiency is predicated influenced by academic learning. There are various efforts which can be attempted by teachers, including by providing a good learning media or an appropriate teaching method for students. The appropriate learning model can encourage students to be more active and able to solve problems well. Vuong & Duong (2013) say that to improve students' problem solving abilitys is by using experiment learning. Additionally, they have to be active in this experiment learning. For more, one of the learning models that can develop students' creativity and activeness to achieve problem solving indicator is PBL.

PBL is a learning that uses real-world problems as a context for students to learn about critical thinking and problem solving ability, and to acquire knowledge and essential concepts of knowledge. As Michael argues as quoted in Argaw et al. (2017) who explains that PBL is a method in which the relevant problems are introduced early in the instruction cycle and used to provide context and motivation for learning. Therefore, PBL is effective to improve students' problem solving ability. PBL is a learning model that involves students to solve problems through the stages of scientific method so that they can learn the knowledge related to the problem and also have the ability to solve the problem. According to Barber et al. (2015), there are several characteristics of PBL, namely using real-world problems, working in group, teachers guide the discovery of solutions and concepts, and students are able to find concepts and present results.

One of the lessons connected with the PBL model is learning with authentic assessment. Authentic assessment enables teachers to evaluate the performance and ability of students on the basis of reality or the origin. It is an effective strategy to increase students' involvement in learning, creativity, and self confidence (Hodgman, 2014).

Based on the description above, authentic assessment aims to evaluate students' ability in a real world context. In other words, students learn how to apply their knowledge and ability to authentic tasks. In addition, it makes them become more active in planning solutions and gathering information (Azim & Khan, 2012). The characteristics of Barber's authentic assessment are real-world tasks, holistic judgments, and produce products or artifacts. Masrukan (2014) groups authentic assessment into several types, as follows performance assessment, product assessment, and project assessment. Performance assessment is done by observing when students do activities in class or create a work in accordance with the purpose of learning (Munawaroh et al., 2017). Product assessment is the assessment of students in controlling processes and utilizing or using material tools to produce something, practical work or aesthetic quality of something they produce (Ulya, 2012). While project assessment by Masrukan (2014) is an assessment that not only focuses on the product but also on the process of project work.

Owing to the preliminary explanation, then the formulation of the problem in this research are (1) Does the problem solving ability of mathematical students through learning PBL with authentic assessment to achieve classical completeness?; and (2) Is there any differences in students' mathematical problem solving ability among students who have received PBL learning with authentic assessment and students who have received PBL lessons?

2. Methods

The method of this research was quantitative method. The researcher used post-test only control design by Sugiyono (2010). The research design is picturized on Table 1.

Table 1. Research design

Class	Treatment	Post-test
Experiment 1	PBL with authentic assessment	Test
Experiment 2	PBL	Test
Control	Conventional learning in Vietnam	Test

The, the population of this research was students' 11th grade of Tran Nhan Tong High School in the academic year of 2017/2018. By using cluster random sampling, class 11A1 was selected as control class using conventional learning in Vietnam, class 11A2 as an experiment

class 1 using PBL with authentic assessment, dan class 11A3 as an experiment class 1 using PBL.

The variables of this research were independent and dependent variable. The independent variable was learning model and the dependent variable was mathematics problem solving ability. The method of data collection was documentation and test method. The documentation method was used to obtain initial data of midterm test scores of 11th grade of Tran Nhan Tong High School in the academic year of 2017/2018. While the test method was used to obtain final data of mathematics problem solving ability. The test questions was in the form of essay. Technique of mathematics problem solving test was given after treated in experiment class 1, experiment class 2, and control class, to find final data. After that, the data were analysis then continued by reporting the results.

3. Results & Discussions

The result of normality test of initial data which were analyzed by SPSS 16.0 with Kolmogorov-Smirnov shows that the value of significant is $0,557 > \propto = 0,05$. It means that H_0 is accepted and H_1 is rejected, so the data come from normal population. The result of homogeneity test of initial data which were analyzed by SPSS 16.0 with Levene test reports that the value of significant is $0,802 > \propto = 0,05$. It means H_0 is accepted and H_1 is rejected, in other words the data are homogenous population. Meanwhile, the result of average equality of initial data which were analyzed by SPSS 16.0 with Analysis of Variance (Anova) highlights that $F_{count} = 0,292$ and $Sig = 0,748$, so $F_{count} < Sig$. It means H_0 is accepted and $H_{1\ is}$ rejected, so the data have no average different. Thus, it can be concluded that the sample class came from the same conditions or circumstances and has the same ability or knowledge.

Further, the lesson applied to the experiment class 1 was PBL research with authentic assessment, the experiment class 2 was the PBL learning, and the control class was the conventional learning in Vietnamese. The indicators of mathematical problem solving of this research are from NCTM, as follows: (1) students are able to identify known, questioned, and adequacy of required elements, (2) students are able to formulate mathematical problems or develop mathematical models, (3) students are able

to apply the strategies to solve problems inside or outside mathematics, and (4) students are able to explain the results according to the original problem.

After being treated differently for each class, the test results of the mathematical problem solving ability were obtained and then analyzed to get the final data. The result of mathematical problem solving ability can be seen in Figure 1.

Based on the result of the research, the result of the average score of mathematical problem solving ability of the experiment class 1 students is 83,42, the experiment class 2 is 81,5, and the control class is 75,61. The data obtained were then analyzed by using the proportion test, Anava and Scheffe Test. After the statistical test was conducted, the result was obtained which is picturized on the following figure.
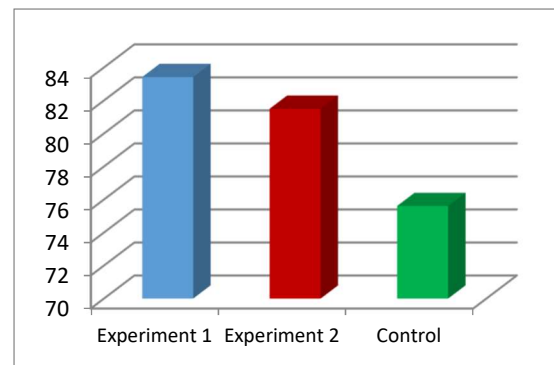

Figure 1. The Mean of Data Test Mathematical Problem Solving Ability

Based on the proportion test, many students in experiment 1 who achieved the highest learning achievement among the other classes, 95% with 23 of 24 students successfully achieved the learning mastery. Then, in the experiment class 2 is 91% with 22 of the 24 students reached learning mastery. While, in the control class, 16 of 23 students achieved learning mastery with percentage of 69%.

The final data in this research is the posttest value of mathematical problem solving ability in the three sample classes. The result of normality test and homogeneity test of the final data reports that the final data in the three classes were normally distributed and had homogeneous variance. The classical completion test of experiment class 1 was analyzed by using one-party proportion test (right side test). Based on calculations, $z_{count} = 2.36$, with a = 5% obtained $z_{table} = 1.64$. So, $z_{count} > z_{table}$. Thus, it can be concluded that the mathematical problem solving

ability of the experiment class 1 that obtained PBL learning model with authentic assessment successfully achieved classical completeness. Particularly, the result of mathematical problem solving test at the experiment class 1 reached classical completeness more than or equal to 75% of the students in the class. PBL has led students' problem solving ability to achieve completeness learning since it provides learning experiences for students to learn through problem solving activities in which students can construct new knowledge by linking the old knowledge (Maretasani et al., 2016).

Furthermore, the mean difference test in learning outcomes in terms of mathematical problem solving ability between experiment class 1, experiment 2 class, and control class began with the average equality test analysis. The result of the average equality test of final data with program of SPSS 16.0 shows that $F_{count} = 6,674$ and Sig = 0,002, because $F_{count} < $ Sig then H_0 is rejected. It suggests that there is an average difference in mathematical problem solving ability between experiment 1 classes, experiment 2 classes, and control classes. Therefore, further test was conducted namely Scheffe test which aims to find out which class that has the best mathematical problem solving ability. The results can be seen in the following table.

Table 2. The Result of Scheffe Test

Class Comparison	Mean Difference	Sig.	Conclusion
Experiment 1 > Experiment 2	1,92	0,39	Not Significant
Experiment 1 > Kontrol	7,8	0,001	Significant
Experiment 2 > Kontrol	5,9	0,01	Significant

Based on Table 2, it can be seen that the mathematical problem solving ability of experiment class 2 and control class has a significant difference, the ability of solving mathematical problems of experiment class 2 and control class also has significant difference, while the problem solving ability of students' experiment class 1 and class experiment 2 has no significant difference. From the comparison of the mean result of the students' mathematical problem solving ability in each class, the average of students'

experiment problem solving ability of the experiment class 1 is more than in the experiment class 2 more than in the control class. Thus, it can be concluded that the ability of the problem solving ability of the students 'experiment class 1 is better than the experiment class 2. Meanwhile, students' mathematical problem solving ability of experimental class 2 is better than the control class.

The students' mathematical problem solving ability of the experiment class 1 which obtained PBL learning with authentic assessment is better than the experiment class and control class. This is because in the experiment class, students were given a problem related to daily life. After that, they were given instructions on how to solve the problem. In this lesson, the teacher acted as a facilitator who always guided them in concept discovery, presenting data, or creating a work. At the end of the lesson, teachers and students reflected on the results of the problem solving. With this confirmation, students' understanding of the material became stronger and in order to avoid any difference in understanding.

The control class which was as conventional learning in Vietnam was teacher-centered learning. Students in Vietnam were a very active type of student, yet in this learning the students' activity is not utilized by teachers for improvement of their mathematical problem solving ability. Thus, they felt bored and less enthusiastic in learning. During the learning activities, they looked for other things to eliminate boredom, such as sleep and play gadgets, consequently their concentration was not maximal. In learning, the students were less active as well as their creativity to bring up new ideas in problem solving was still low.

The experiment class 2 was a PBL learning class, student centered learning, active students, and teachers as facilitators. With this model students were given the freedom to be active. Student activeness was used in group discussion activities, presentation in front of class, so that student enthusiasted as well as learning could be well understood. In this learning, the students were actively involved, as the result their creativity to bring up new ideas in the mathematical problem solving of the students developed.

In the experiment class 1, the PBL learning class with authentic assessment, the student were more active than the experiment class 2. They were not only given the discussion and presentation activities, but also the activities outside the classroom and computer activity in

which the use of computers on learning mathematics in Vietnam was something new. Thus, they were able to follow the learning steps ad understand the material as well as their mathematical problem solving ability was improved. This result is in line with the opinion of Vuong & Duong (2013) who argue that to improve problem solving ability, it needs to use a learning which uses experiments and students activeness involves in it. The higher level of student activity will be followed by the achievement of high problem-solving ability (Rusyida et al., 2013).

The problem solving ability of students in experiment class 1 which obtained the PBL learning with authentic assessment was the best among the other two classes. In this class, students were given the opportunity to play an active role in finding solutions of problems. As Asikin & Junaedi (2013) explain that students' problem solving ability will increase, if they are given the opportunity to take an active role in finding their own solutions to the problems presented by integrating the concepts, theorems, and knowledge they have. Above all, the authentic assessments provided a great opportunity for students to take an active role in finding their own solutions to the problems presented by integrating the concepts, theories, and the knowledge they possess rather than just using student worksheets such as experiments class 2 did.

Additionally, the Scheffe advanced test shows that the mean value of students' mathematical problem solving ability of experiment class 1 and experiment 2 was not significantly different. The learning model in both classes was same, yet the difference was the medium. Experiment 1 class used authentic and worksheet assessment, while experiment class 2 only used worksheets. In the discovery of concepts, the two classes were equally through discussion. Although the media used were different, but both had essentially was same that was problem solving.
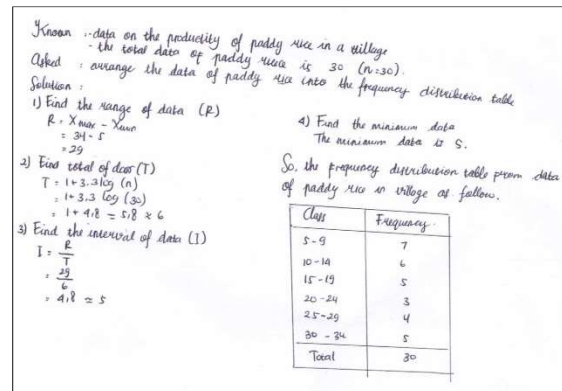

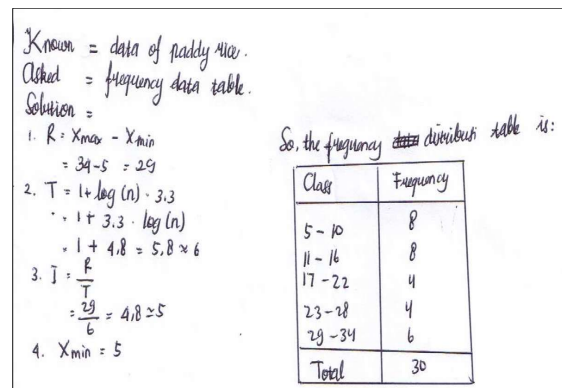**Figure 2.** Student Experiment Class 1's Work

Figure 3. Student Control Class' Work

Problem Based Learning is a learning that focuses on problem solving activities. The problem has not been so or ill-structured problem (ill-structured problem), so that it can challenge students to think and conduct discussions in groups. Meanwhile, Problem Based Learning with authentic assessment is a learning that confronts students on the problems that are close to the student's daily life. The problem are presented in the form of facts, circumstances, situations that contrast the structure of student's cognition. In this situation there is a conflict between the knowledge that students have with a deliberately provided real situation.

In the classes that applied Problem Based Learning, students worked in team to solve real life problems. The problems in Problem Based Learning are unstructured, contextual and engaging problems. Therefore, it stimulates students to ask from various perspectives. Mathematics learning must also be connected to real and meaningful life for students. In this case, the role of authentic assessment is needed to improve students' attractiveness that certainly impact on their problem solving skills on statistical materials.

The authentic assessment of this study consisted of performance assessments, product assessments, and project assessments. The performance assessment assigned students the task of comparing the mean, mode, and median values of data obtained through microsoft excel and the values obtained through manual work, then they were asked to conclude whether the results obtained through the two paths were the same or different. Based on the results, it can be seen that students were able to find the mean, median, and mode either by using computer aids or manually. Afterwards, students concluded that the results obtained in two ways were the same. They also concluded that by using the computer in finding the mean, median, and mode was easier and faster.

In addition to performance assessment, product assessment was also used in this study. Product assessment is one type of authentic assessment which aims to realize an idea or plan of outer form, such as making diagrams, tables, and props. It will help students to easily find the problem-solving strategy. The task in product assessment asks students to create a diagram according to the problems provided with the help of the computer. Students are able to create various types of diagrams on demand and according to the problem. This product assessment aims to connect mathematics with daily life or in the sense of providing contextual problems as Mattew (2014) says that contextual problems can improve students' problem solving skills.

Then, project assessment aims to train students in solving an intellectual difficulty, such as solving problems related to frequency distribution tables and diagrams as well as mean, median, and fashion in daily life. In general, the more students experience in solving math problems, the more creative the students in preparing the settlement plan and solve the problem.

Based on Figure 2 which is the student work of the experiment class 1 on one of the criteria of problem solving ability, it shows that student was able to write down the mathematical concepts that underlied the answers, the steps with coherence, complete, and correct. This means that student could understand the problem well and they were familiar with the settlement. In the experiment class 2, students were able to understand the problem well and write down the correct completion steps such as the experiment class 1, but not as complete as the experiment class 1. In addition, they did not write the complete conclusions in accordance with the initial problem.

Meanwhile, students' work of the control class on one of the criteria of problem solving ability shows that they were able to understand the problem well, but the information written on known things were incomplete. Then, student were mistaken in understanding the concept so work results were wrong.

In brief, PBL with authentic assessment in eksperiment class 1 was more effective than learning with PBL in experiment class 2 which was more effective than control class which used conventional learning in material of Statistic student 11th grade of Tran Nhan Tong High School in Ho Chi Minh City Vietnam that academic year 2017/2018.

With PBL learning, students used triggers derived from a problem or a decisive scenario that determines their own learning goals. After that, students completed independently which was self-centered learning, before returning to the group to discuss and sort out the knowledge they had. With a range of issues done individually and in group, students could help each other to gain new knowledge and improve problem solving skills. As Purnomo et al. (2015) say that through PBL, students use triggers from the problem case or scenario to define their own learning objective. Subsequently, they do independent, self directed learning before returning to the group to discuss and refine their acquired knowledge.

Authentic assessment aims to improve students' ability to understand concepts, because by presenting cognitive conflicts during the learning process students were accustomed to deal with an unexpected mathematical problem. Students would use their memory and understanding on a mathematical concept to make the right decisions. In situations of cognitive conflict, they could obtain clarity from the environment, among others from teachers or students who were more clever (Scaffolding). With the increased ability to understand students' concepts, students' problem solving skills will also increase.

Authentic tasks consisting of product and project tasks were given since students needed to be involved in problem-solving tasks and specialized learning on how to find and solve problems. The research results of Akinoglu (2008) mention that project-based learning environment makes students become more active and solve complex problems. Additionally, every constructivist concept, based on inquiry learning, problem solving, and design discussed in vocational and industrial education as well as in

other areas of American education, "products and projects" are considered as one of the best and most appropriate teaching methods. This is because during the course of a project that produces a product the students are faced with daily problems that must be solved in group so that they prepare plans, implement plans, and discuss which can develop problem-solving skills.

At the time students do authentic tasks in group, the interaction between learners helps the cognitive development of learners in which the cognitive repertoire of learners will be enriched with various points of view and alternative actions (Rifa'i & Anni, 2012). It makes them get experience in analyzing a problem and communicating it to a friend in a team as well it can improve in-depth understanding which is an important element in problem solving.

Factors that cause the problem solving ability of the learners in the learning of PBL with authentic assessment is better than in the lesson of PBL and the expository learning as follows: (1) in the PBL's learning with authentic assessment, the learning is done in small group so that the participants can discuss in solving the problem. This is in accordance with the statement of Suryati et al. (2013) that the cooperative model of evidence can improve critical thinking and improve the ability of problem solving. While expository learning tends to be passive and the learning is still centered by a teacher, (2) on PBL's learning with authentics assessment, learners answer questions on worksheet and product duties so that participants do not only receive information but also construct their knowledge. This is in accordance with the constructivist learning theory of the Master that the knowledge constructed by the child as the subject will be a meaningful knowledge, while the knowledge acquired only through the notification process will not be a meaningful knowledge. In addition, through performance assessment, the participants are used to perform their performance in all respects, either to solve the problem, to express opinions, to discuss, and to give reasons from the answers given; (3) the quality of PBL's learning with authentics assessment, the performance of the teacher, and the activities of the experiment class learners of the good and best criteria of the other classes, thus affecting the success of the learning process. The modeling learning can help teachers and learners to improve students' activity, self-confidence in learners so that they are motivated to achieve success.

4. Conclusion

According to the results of research, it can be concluded that PBL with authentic assessment affects to the students' mathematical problem solving ability at 11th grade of Tran Nhan Tong High School in Ho Chi Minh City, Vietnam in the academic year of 2017/2018 that shown by: (1) the result of mathematical problem solving test at the experiment class 1 which reaches classical completeness more than or equal to 75% of the students in the class and (2) students' mathematical problem solving ability at the experiment class 1 is better than students' mathematical problem solving ability at the experiment class 2, while students' mathematical problem solving ability at the experiment class 2 is better than students' mathematical problem solving ability at the control class.

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