The Effectiveness of Project Based Learning in Trigonometry

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Abstract. This research aimed to explore the effectiveness of Project-Based Learning (PjBL) with scientific approach viewed from interpersonal intelligence toward students’ achievement learning in mathematics. This research employed quasi experimental research. The subjects of this research were grade X MIPA students in Sleman Yogyakarta. The result of the research showed that project-based learning model is more effective to generate students’ mathematics learning achievement that classical model with scientific approach. This is because in PjBL model students are more able to think actively and creatively. Students are faced with a pleasant atmosphere to solve a problem in everyday life. The use of project-based learning model is expected to be the choice of teachers to improve mathematics education.

1. Introduction

Education is a very important aspect of life. Education has a function to shape one’s and to raise his or her dignity. In addition, education can ensure a better life. As time goes by, it challenges a person to have a good education. However, a good education is only seen in its results beside the learning process. The learning process is very important to support the success of students in learning. Nowadays, Indonesia has complex educational problems. One of them is the students’ difficulty of learning and understanding math materials. This is demonstrated by the 2015 international comparison of PISA (Program for International Student Assessment) on mathematics that Indonesia is ranked 63 out of 70 countries with an average score of 386 [1]. The low learning achievement of mathematics is also demonstrated by the mastery of mathematical material. As seen in the percentage of the value of the National Examination, especially SMA N 1 Godean or 1 Senior High School Godean in 2016. The average of the National Examination of mathematics in SMA N 1 Godean is 68.88, which is below the average of National level that is 69.25. Based on the results of interviews with students, students feel that mathematics especially on trigonometric material is a difficult material. This is in accordance with Hulya’s opinion that states that mathematics, particularly trigonometry is one of the school subjects that very few students like and succeed at, and which most students hate and struggle with. Trigonometry is an area of mathematics that students believe to be particularly difficult and abstract compared with the other subjects of mathematics [2]. Trigonometry is an unseparable part of mathematics in high school. It takes some subjects of arithmetics and geometry as any source. In other words, it is a product of algebraic techniques, geometrical realities and trigonometric relationships [3]. Research reports generally indicate that students’ difficulties are associated with the lack of procedural knowledge/strategies, skills of solving problem and the reasoning skills that go along with them. This is because most mathematics teachers still teach using the conventional method [4]. Mike reported that if the teacher is too old and too much talking then the students will be a passive receiver [5]. In this case, the students will not be able to get reasons and find solutions to the problems given. Therefore, a
A proper learning model is needed to teach trigonometry. For example, project-based learning (PjBL) model. Project-based learning is a comprehensive approach to classroom teaching and learning that is designed to engage students in investigation of authentic problems [6]. Project-based learning is centered on the learner and affords learners the opportunity for in-depth investigations of worthy topics. The learners are more autonomous as they construct personally-meaningful artifacts that are representations of their learning [7]. In project-based learning, students work in groups to solve challenging problems that are authentic, curriculum-based, and often interdisciplinary. Learners decide how to approach a problem and what activities to pursue. They gather information from a variety of sources and synthesize, analyze, and derive knowledge from it. Their learning is inherently valuable because it’s connected to something real and involves adult skills such as collaboration and reflection. At the end, students demonstrate their newly acquired knowledge and are judged by how much they’ve learned and how well they communicate it. Throughout this process, the teacher’s role is to guide and advise, rather than to direct and manage, student work [8]. Based on the characteristics, the PjBL model is in line with trigonometric learning that applies real life aspects. However, it is necessary to examine the extent to which the effectiveness of the PjBL model in trigonometric material is compared to the classical model often used by teachers. In this study, researchers modify the project based learning model with a scientific approach in accordance with the current curriculum in Indonesia. The step of core activity on the pjBL model with the scientific approach can be seen in Figure 1.

![Figure 1. The step of core activity on the pjBL model with the scientific approach](image)

The definition and the study of PjBL model have been written by Thomas. However, according to Thomas some studies lack information about the effectiveness of PjBL as compared to other methods[9]. Therefore, it is necessary to research how the effectiveness of PjBL model with scientific approach compared with classical model?

The aim of this research is to know the effectiveness of PjBL model compared with classical model. In this study, students are asked to work on projects related to trigonometric material. While other class students who are subjected to a classical model given the teaching as usual teachers do. Subsequently given a test of trigonometric material knowledge. The results show that the PjBL model is more effective than the classical model. This is because in the PjBL model children learn from their processes. They reflect on how well they worked in a collaborative group and how well they contributed, negotiated, listened, and welcomed other group members’ ideas. Students also self-evaluate their own projects, efforts, motivations, interests, and productivity levels. Students become critical friends by giving constructive feedback to each other, which helps them become aware of their
own strengths and improve on their interactions with each other [10]. Therefore, project-based learning model can be an alternative for teachers to teach trigonometric material.

2. Experimental Method

The method that is used in this research is quantitative method. This research employed quasi experimental research. Variables that will be observed are learning model as independent variable and students’ mathematics learning achievement as dependent variable.

Population of this research is grade X students in SMA N 1 Godean in semester 2 academic year 2016/2017. The used sampling technique is stratified cluster random sampling that is done by choosing 2 class randomly, one experimental class applying PjBL model with scientific approach with 32 students, and one control class applying classical learning model with scientific approach with 31 students. The data gathering conducted on February-April 2017. The research instruments used were tests and observation sheet. To collect mathematics learning achievement data, the author uses multiple choice instrument as many as 25 questions taken from trigonometry material that have been tried out before. Observation sheets are used to see the suitability of research with the plans that have been made.

Technique used to analyze data is by examining prerequisite analysis, which are normality test applying Liliefors test and homogeneity test applying Bartlet test on initial ability of students in both experimental and control classes. Afterwards, an equivalence test on students’ initial ability is conducted in order to obtain exact result influenced by given treatment. Equivalence test is done by applying one-way analysis of variance with a different cell. Preference tests including normality and homogeneity tests precede one-way analysis of variance with a different cell. Subsequently, the author conducts a further test using Scheffe method.

3. Result and Discussion

In the PjBL model with scientific approach, students form groups with 5 – 6 students. Then, students select the project topic on trigonometric material, the formulation of the problem, the preparation of tools and materials, and the project planning is done by the students in the group independently. The main tools used by students are clinometer and meter (distance meter). Problems can be taken by students such as choosing the height of objects that can not be measured directly, so that requires trigonometric calculations. The results of research activities can be seen in Figure 2. Student project report can be seen in Figure 3.

![Figure 2. Students practice the project plan](image1)

![Figure 3. Students project report](image2)
In the project result, students have been able to calculate the height of the object according to the topic. For example group 6 is presented in Figure 3. In calculating WiFi tower height, students use tangent formula. That means students have been able to identify what is known and what is being asked. In this case, what is known is the length of the sides in front of the angle and the elevation angle. While the question is the length of the front side. Once calculated it appears that the front side length is 24 m. The next step taken by the students is to find the total length of the tower by summing the student's height using the clinometer with the length of the front side being searched. In this activity, the teacher really does not direct the students how to find answers to the formulation of the problems they make. They learn from the results of their previous knowledge and learn independently from the source of the book they prepared. However, in reality there are two groups that have not been able to find answers to the problems that have been selected by the group. This is because students are not familiar with the given learning model. Thus, in the PjBL model the teacher has an important role as a facilitator to assist students in learning. However, 4 groups from 6 groups have given good project report results. After performing the practice directly and completing the project report, the students do the presentation. Teachers have a duty to evaluate and reward groups that successfully deliver the best reports. After completing the project assignment, students are given a test of knowledge on trigonometric material.

Learning in the control class is carried out the learning activities that the teacher does. In these activities the teacher provides learning with classical discussion and do the exercise questions independently. Based on the observation, students do look passive, not much activity, even just sitting still without doing the given problem. So the teacher is very active to assist students in doing trigonometric problems. After 8 meetings, at the 9th meeting students were given a test of trigonometrical material knowledge. The test results of students’ in PjBL model and classical model with scientific approach can be seen in Table 1.

**Table 1.** The test results of students’ in PjBL model and classical model

| Learning model                      | N  | Mean | Max Value | Min Value | Standard Deviation |
|-------------------------------------|----|------|-----------|-----------|--------------------|
| PjBL with scientific approach      | 32 | 84.50| 100.00    | 72.00     | 84.50              |
| Classical with scientific approach | 31 | 76.26| 92.00     | 56.00     | 11.07              |

Before conducting hypothesis test, it is necessary to carry out equivalence test on students’ initial ability. The data of students’ initial ability is taken from final examination result in first semester. Normality test using Liliefors method precede equivalence test. The result of normality test can be seen in Table 2.

**Table 2.** Summary of normalities data test results initial ability of students

| Class     | n   | $L_{0bs}$ | $L_{0.05\;32}$ | Decision | Conclusion |
|-----------|-----|-----------|-----------------|----------|------------|
| PjBL      | 32  | 0.1201    | 0.1566          | $H_0$ is accepted | Normal    |
| Classical | 32  | 0.0981    | 0.1566          | $H_0$ is accepted | Normal    |

After normality test is completed, homogenity test toward students’ initial ability data is conducted. By using Bartlet test, it is obtained that $\chi^2_{obs} = 0.0147$. $DK = \{\chi^2|\chi^2 > 3.841\}$ thus $\chi^2_{obs} = 0.01471 \notin DK$ therefore $H_0$ is rejected. To conclude, the variances of those two populations are homogenous. Result of the samples shows that they are from normal distributed population and variances of those two populations are homogenous. Subsequently, equivalence test is conducted using one-way analysis of variance provided in Table 3.

**Table 3.** Summary of test results initial ability data balance students

| Source | JK   | dK  | RK   | $F_{obs}$ | $F_{critical}$ | Decision |
|--------|------|-----|------|-----------|----------------|----------|
| Model  | 87.89| 1   | 87.89| 0.73      | 3.995          | $H_0$ is accepted |
| Galat  | 7473.05 | 62 | 120.53| 3.995      | 12.03          | $H_0$ is accepted |
| Total  | 7560.94 | 63 | |          |                |           |
Since $H_0$ is accepted, it can be understood that students from both classes have similar initial ability. Subsequently, prerequisite tests covering normality and homogeneity tests are performed. Normality test is served in Table 4.

| Class   | $n$ | $L_{obs}$ | $L_{0.05;n}$ | Decision | Conclusion |
|---------|-----|-----------|--------------|----------|------------|
| PjBL    | 32  | 0.1474    | 0.1566       | $H_0$ is accepted | Normal     |
| Classical | 31  | 0.1226    | 0.1590       | $H_0$ is accepted | Normal     |

After normality test is completed, homogeneity test toward students’ mathematics learning achievement data is conducted. By using Bartlet test, it is obtained that $\chi^2_{obs} = 2.131$. $DK = \{\chi^2 | \chi^2 > 3.841\}$ thus $\chi^2_{obs} = 2.131 \notin DK$ therefore $H_0$ is rejected. To conclude, the variances of those two populations are homogenous. Result of the samples shows that they are from normal distributed population and variances of those two populations are homogenous. Hence, prerequisite tests including normality and homogeneity tests are fulfilled.

The obtained data is then analyzed using one-way analysis of variance with different cell as can be seen in Table 5.

| Source        | $J$  | $K$  | $dK$ | $R$  | $F_{obs}$ | $F_{h}$ | Decision      |
|---------------|------|------|------|------|-----------|---------|---------------|
| Learning Model| 1069.62 | 1    | 1069.62 | 11.04 | 4.00      |         | $H_0$ is rejected |
| Galat         | 5909.94 | 61   | 96.88 | -    | -         | -       |               |
| Total         | 6979.56 | 63   | -    | -    | -         | -       |               |

According to the result of two-way analysis of variance with different cell, it can be concluded that Learning model gives influences toward mathematics learning achievement of students. The result of anova proves that $H_0$ are rejected, so that double comparison test must be conducted. Double comparison test can be seen in Table 6.

| $H_0$ | $F_{obs}$ | $(1)F_{0.05;1:63}$ |
|-------|-----------|--------------------|
| $i_1 = i_2$ | 11.04 | 4.00 |

Based on the result seen in Table 6, it is obtained that $H_0$ is rejected since $F_{obs} > F_{critical}$. it means that PjBL and classical learning models result in different mathematics learning achievement. From mean mathematics learning in PjBL and PBL model, it is obtained that $i_1 > i_2$. Thus, it can be concluded that PjBL model is proved more effective than classical model in terms of giving mathematics learning achievement for students.

The result of hypothesis test proves that learning models give different influences. Generally, applying PjBL model is more effective than classical model in order to obtain better mathematics learning achievement. This is consistent with Alacapina research that the average cognitive domain achievement of the group in which the project-based technique was used was found to be significantly higher that the average for the other group. Based on these findings, it can be asserted that the project technique is effective in reaching targets in the cognitive domain [11]. Michael & Richard’s reported that inductive methods such as project based learning are consistently found to be at least equal to, and generally more effective than traditional deductive methods to achieve various learning outcomes [12]. Students in PjBL applied class, according to the observation, are more active and creative and think more critically than students in classical learning applied class. By providing pleasant ambiance, students can get along during learning process. This is in accordance with Marian’s research that project-based learning is truly learning in action. It engages students so that they are no longer passive receptacles of information, but active pursuers of knowledge. Innovative classrooms break down the walls of boredom and apathy. They engage and motivate students to take an active part in their
learning. Students become collaborative members of the teaching, sharing, and learning process. They are constructors of knowledge. Children become collaborators building understanding. These new learning goals change the relationship between assessment and instruction [13]. In classical learning class, students tend to be passive and they are less encouraged to explore their potentials.

4. Conclusion
Research result and hypothesis test prove that project based learning model is more effective to generate students’ mathematics learning achievement that classical model with scientific approach. However, PjBL model in this research is done with a limited time so that the next research can be done with time according to the characteristics of the model and the material being taught. In the material trigonometry with PjBL model is more effective than classical model, so the PjBL model can be a good alternative for teachers to teach mathematics, especially in trigonometry.

Acknowledgments
The author thank Dr. Mardiyana, M. Si. and Dr. Ikrar Pramudya, M. Si. in Universitas Sebelas Maret for advice in writing of this journal. The author also thank Tri Hartiningsih, S. Pd. in SMA N 1 Godean which gives the author the opportunity to conduct research.

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