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Effectiveness of Project Based Learning in Statistics for Lower Secondary Schools

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ABSTRACT

Purpose: This study aimed at investigating the effectiveness of implementing Project Based Learning (PBL) on the topic of statistics at a lower secondary school in Surabaya city, Indonesia, indicated by examining student learning outcomes, student responses, and student activity. **Research Methods**: A quasi experimental method was conducted over two months involving two classes of seventh grade students, consisting an experiment class (PBL) and a control class (conventional learning). Data were collected through student activity observation sheets, student responses, and pretest-posttests. Data were analyzed by employing covariance analysis (ANCOVA). **Findings**: Based on ANCOVA, student learning outcomes in PBL are higher than those in conventional learning. In addition, based on the results of a descriptive analysis, results of the student learning outcomes in PBL obtained more than the minimum standard score (MSC), the students' responses in learning were positive, and the students were active in the class activities. Thus, PBL is effective in statistical learning. **Implications for Research and Practice**: Based on the results of the research, it can be concluded that PBL was effective in statistical learning. These findings suggest that the students were enthusiastic in working the given project and actively discussed with other students in the class. We suggest teachers apply PBL on other mathematics topics so students can be enthusiastic in mathematics learning in the class. Alternatively, teachers can use PBL with technology-assisted learning to make learning more interesting for students.

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Introduction

One mathematics topic considered difficult by junior high school students is statistics (Garfield & Ahlgren, 1988). In relation to data presentation, some research found that many examples of incorrect choices of the graph in statistical projects were experienced by secondary students (Li & Shen, 1992). For example, some used a line graph with qualitative variables or a bar graph to represent the evolution of an index number through a sequence of years. Consequently, student statistical ability and interest decreased. Also, they were found to quickly get bored and lazy in learning (Basbay & Ales, 2009). Therefore, an interesting learning process in statistics in the presence of research is needed to solve this problem.

The teaching and learning process should place the teacher at the center to engage students in an active learning process. One interesting learning approach is Project Based Learning (PBL). PBL, which is recommended in the Indonesian curriculum, is touted as superior to teaching methods in improving problem solving and thinking skills (Siswono et al., 2017a) and engaging students in their learning (Berends, Boersma & Weggemann, 2003). PBL is expected to achieve the standard of learning. Thus, teachers are required to create an active student learning atmosphere by constructing, locating, and developing their knowledge (Erdem & Demirel, 2002; Siswono et al., 2017b). In this context, project-based learning (PBL) is one of the recommended lessons for enhancing active students' engagement and material understanding (Krajcik & Blumenfeld, 2006), even bringing new skills to teachers and students and improving their existing skills (Basbay, 2010).

PBL allows students to learn by doing, implementing their ideas while performing activities in the real world through investigating questions, proposing hypotheses and explanations, discussing their ideas, and eventually developing solutions or outcomes (Diffily, 2002; Krajcik & Blumenfeld, 2006). It therefore helps them in developing problem solving strategies, making authentic products such as models, stories, or presentations (Özdemir&Ubuz, 2006; Kaldi, et al., 2011; Korkmaz, 2002; Saracaloğlu et al., 2006; Robinson, 2009), working in groups, and learning social skills, interaction, cooperation, responsibility, social and democratic behavior, critical thinking, and decision making (Blumenfeld et al., 1991; Dede & Yaman, 2003; Demirhan, 2002; Ozden et al., 2009; Saracaloğlu et al., 2006; Thomas, 2000).

According to Demirhan (2002), PBL is defined and described as an approach that (1) requires interdisciplinary study, (2) encourages students to be responsible for groups or individuals and collaborative studies in real-life issues based on pre specified topics and their personal interests and skills, (3) provides teacher roles to facilitate the learning process as well as guide the students, (4) yields to students' authentic products or presentations outcome, and (5) integrates different approaches within themselves. Leviatan (2008) also explains in his research that project-based learning is an innovative learning that emphasizes complex activities with the goal of solving the problems based on inquiry activities. In addition, according to a study from Miswanto (2011), when the project-based learning model is applied, student learning outcomes on the topic of linear programming increases.

This research was conducted to explore the effectiveness of PBL as an alternative learning strategy that can be introduced to students both in teaching and learning mathematics. Students are taught in the school environment, especially when conventional learning strategies are preoccupied with theories, examples, and exercises (Soedjadi, 2001), but their application is limited in unusual situations such as solving real-life problems. This contrasts with PBL strategies, wherein students who are taught PBL strategies will be given the opportunity to develop their skills and adjust and change methods as they are in new situations. Furthermore, students who follow PBL teaching have a greater chance to engage in real-world activities through questioning, hypothesizing and explaining, discussing their ideas, and eventually developing solutions or outcomes (Diffily, 2002; Krajcik & Blumenfeld, 2006).

According to Markham et al. (2003), there are six aspects needed in PBL: 1) authentic, real-world challenges, 2) rigorous academics; 3) applying learning by using high-performances skills; 4) active exploration; 5) interacting and making adult connections, and 6) formal and informal assessment practices. Besides that, PBL also allows students to investigate questions, propose hypotheses and explanations, discuss their ideas, challenge the ideas of others, and try out new ideas (Krajcik and Blumenfeld, 2006).

In recent years there have been many studies relating to the effects and effectiveness of project-based learning in science education (Ladewski, Krajcik, and Harvey, 1994; Krajcik, et al., 1998; Dede & Yaman, 2003; Ozden et al., 2009). However, there have only been a few studies in Indonesia that examined the effectiveness of PBL on mathematical topics. Miswanto (2011), for instance, shows student improvements regarding learning outcomes on linear programming topics for secondary school students. However, these results show the effectiveness of PBL only on the basis of learning outcomes. In fact, Slavin (1997) states that the effectiveness of learning is not only determined by the quality of instruction (learning outcomes), but also the appropriate level of instruction, incentive, and time. Eggen and Kauchak (1998) also suggested that learning effectiveness is characterized by the students' active engagement. If the students are more active in the learning process, then this learning is more effective. In addition, Mudhofir (1987) shows that the effectiveness can be measured by observing student interest. This interest affects the learning process. If students are not interested in learning then they cannot be expected to succeed in this learning.

Based on the description above, the objectives of this study are to examine the effectiveness of PBL on statistical learning for secondary schools from three aspects: learning outcomes, students' responses, and students' activities.

Method

Research Design

This study is an experimental quasi-research using a factorial of non-equivalent pretest-posttest control group design. The experimental class was taught by applying project-based learning, while the control class was taught with conventional learning. The experimental class was divided into small groups, wherein each group has heterogeneous (consisting of low, medium, and high mathematical ability students). In addition to teacher information, the grouping was also based on the test score before project-based learning was carried out. The students carried out the project for two months.

Research Sample

The participants of the study were from two classes, selected using cluster random sampling from 10 classes in the same grade from a junior high school in Surabaya, Indonesia. The participants were divided into two groups: experimental and control (Cohen et al., 2005). The control group consisted of 38 students and the experimental group consisted of 37 students. All students were in grade seven and aged between 12 - 13 years.

Research Instruments and Procedures

The research instruments developed were a student activity observation sheet, student response questionnaire, and pretest posttests. The observation sheet and response questionnaire were adapted from previous research. Meanwhile, the pretest and posttest were developed by the researchers. The pretest and posttest have the same questions, each of which consist of nine essay items. All the items were then tested to examine validity and reliability to a class that was different from the control and experiment classes. Eight of the nine essay items were rated using a score of 0-10. The scores were as follows: understanding: 0-3; implementing strategy: 4-6; conclusion: 7-10. The scoring of the remaining item was: understanding: 0-5; implementing strategy: 6-15; conclusion: 16-20. Of the nine items, three tested about line graphs, three about bar charts, and three about pie charts. Therefore, the total score pretest and posttest obtained by each subject ranged from 0-100.

In agreement with the multiple coding procedures of the scoring test, we calculated the interrater reliability for each essay item, which resulted in Cohen's Kappa of 0.71-0.85, which indicates that the coding of scores varies from substantial to perfect agreement (Landis & Koch, 1977). To confirm the validity and reliability of the pretest and posttest we applied a product moment correlation and alpha coefficient test (Cronbach's, 1951), each shown in Table 1.

Table 1
The Reliability and Validity of Instrumental Test

Test	Item								
Validity	1	2	3	4	5	6	7	8	9
(r_{xy})	0.48	0.50	0.56	0.44	0.49	0.71	0.45	0.51	0.43
Reliable					0.6				

Based on the test analysis conducted on 37 students, all the items tested are significantly valid, with the coefficient validity of each of the items is interpreted as at least medium ($r_{xy} > 0.40$), and the reliability coefficient (0.60) as medium as well. Data were collected through student activity observation sheets, student response questionnaires, and pre and posttests in learning. Observational data of student activity were observed during the learning process. In our study, the student activity categories observed include: 1) listening or paying attention to the teacher or friend's explanations; 2) observing, listening to, or viewing problems, events, or explanations in the student worksheet; 3) discussing or solving the student worksheet or finding ways and answers in the student worksheet; 4) presenting the results of the discussion and providing feedback in groups; 5) asking about the results of the discussion or observations from friends or teachers; and 6) making conclusions or summarizing the learning materials in groups or with teachers.

In this research, the steps of PBL in statistics, as follows:

Table 2

Steps of PBL in Statistics

No	PBL steps	Learning Activity
1	*Start with the essential question*	a. Teachers initiate learning by providing PBL problems that are demonstrated through video. b. This video contains statistics problems in daily life: "The headmaster of a school plan to build a new building in the school. Then, he asks a mathematics teacher to collect and present some types of data: (1) students visiting the school medical room or library from the years 2009-2014, (2) student hobbies/sports in the 7th graders, and (3) how the 7th graders go to school. The data are used for consideration of the construction of new buildings that will soon be made. c. Then, students start with the essential question about this video; for example, how to help the mathematics teacher in collecting and presenting the data.
2	*Design a plan for the project*	a. The students in the class are divided into three groups and each group must choose one type of data b. Teachers and students collaboratively create a plan for solving the problem.
3	*Create a schedule*	a. Teachers and students arrange the schedule of the project activity based on the plan they created. The schedule includes: 1) the students create a timeline (time allocation) to solve the project; 2) the students also create a project deadline; 3) the teacher guides the students when they use a method unrelated to the project; and 4) the teacher asks the students to explain an alternative method
4	*Monitor the students and the progress of the project*	a. Teacher is responsible for monitoring student activities during solving the project. b. Teacher becomes a mentor for student activities. c. Students implement and document projects that have been designed.
5	*Assess the outcome*	Students present the results of the project in front of the class to discuss with other groups.
6	*Evaluate the experience*	a. At the end of the lesson, teachers and students reflect on the activities of PBL and the outcomes of PBL that have been implemented. b. The reflection process is done both individually and in groups.

The results of the data tests were collected by giving the pretest before learning and the posttest given after learning in the experimental and control classes. Meanwhile, students' responses were collected by using a questionnaire in the experimental and control classes, with the aim to determine the student response to the learning. This was done after the learning process was completed.

Data Analysis

This study applies two data analysis techniques: inferential statistical analysis and descriptive statistical analysis.

*Inferential statistical analysis.*The purpose of this analysis is to see the differences in student learning outcomes following project-based learning or conventional learning on statistical materials. Pretest-posttest data were analyzed by the inferential statistics of ANCOVA. To perform ANCOVA, it was necessary to satisfy assumptions regarding normality, the equation of the variance, and the equation of the regression lines. Based on analyses performed to satisfy the assumptions, this was determined with the Shapiro-Wilk Test because the sample was less than 50 students, showing a significance value of 0.173 for the experimental group and of 0.329 for the control group. This finding suggested that the distribution of the data among the experimental group and the control group was normal. The homogeneity test of variance showed a significance value of 0.465, which indicated that the data had the same (homogeneous) variance. Descriptive statistical analysis was used to compare the average score of the pretest and posttest for the experimental and control groups.

The ANCOVA test was conducted to reveal the effect of PBL in the statistical learning for students. The determined significance level was $\alpha = 0.05$.

Descriptive statistical analysis. This analysis was used to analyze the effectiveness of project-based learning on the topic of statistics. The data were collected from student activity data, student responses data, and student learning outcomes data. Student activities are said to be effective if the percentage of every aspect observed at each meeting is in the ideal time range of student activity. Student responses are said to be positive if the answers of students who choose the positive category for each aspect is more than 80%. Data analysis of learning outcomes and student learning outcomes descriptively aims to describe the student learning outcomes based on the tests implemented. A student has mastery of learning individually if their score is at least 70 with a maximum score of 100.

Results

This study found the results of inferential statistical data analysis and descriptive data analysis obtained during the research process. All data were analyzed using Statistics Package for Social Science (SPSS 22) and the results are presented as follows:

Inferential Statistical Data Analysis

Prior to statistical tests, normality tests were performed first to determine whether the sample data taken followed normal distribution. Normality is important for inferential statistics that aims to generalize the results of the analysis of sample data. The data reveals:

Table 3

Test the Normality of the Experimental Class Data and the Control Class by using the Shapiro Wilk test

	Tests of Normality		
	Shapiro-Wilk		
	Statistic	df	Sig.
x	.958	37	.173

a. Lilliefors Significance Correction

	Tests of Normality		
	Shapiro-Wilk		
	Statistic	df	Sig.
x	.967	37	.329

*. This is the lower bound of the true significance
a. Lilliefors Significance Correction

Table 4

Levine Test Results for Homogeneity of Variance

Levine Statistic	df1	df2	Sig.
.540	1	72	.465

As shown in Table 3, the Shapiro-Wilk Test reveals the following findings: the critical values for the variables x and y (coefficient x and y ratio) are 0.173 and 0.329 > significant (α) = 0.05. Hence, it can be concluded that Ho is accepted, meaning that the experiment class data (x) and data of control class (y) ratio come from a normally distributed population. The Levine test also showed a significance value of 0.465 (in Table 4), which indicated that the data had homogeneity of variance. Since the data is normally distributed and has homogeneity of variance, the independence test can be conducted to influence students' initial ability (x) to students’ learning outcomes for each experimental group and control group; the linearity test determines whether the linear model obtained can be applied to show the effect on students’ learning result. Based on the data obtained the results are as follows:

Table 5

Independence Test of Experimental Class and Control Class Data

Dependent variable: y

Source	Type I Sum of Squares	df	Mean Square	F	Sig.
z	740.670	1	740.670	11.183	.001
x	6850.800	1	6850.800	103.439	.000
Corrected Model	7591.471[a]	2	3795.735	57.311	.000

a R Squared = .618 (Adjusted R Squared = .607)

From the table above the variable x significance is 0.000. Because the value of significance is far below 0.05, it can be concluded that student initial ability influences student learning outcomes. Furthermore, for the corrected model, the significant value is 0.000 < significant level (α) = 0.05, thus, it can be concluded that the learning model in the experimental and control classes also influences student learning outcomes.

Furthermore, the ANCOVA test was administered to see whether the student learning outcomes in the experimental and control classes were different after being given conventional and PBL lessons. The results of the data analysis are as follows:

Table 6

ANCOVA Test of Experiment and Control Class Data

Test of Between-Subjects Effects

Dependent Variable: y

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected	7591.471[a]	2	3795.735	57.311	.000
Model	29972.490	1	29972.490	452.548	.000
Intercept	2463.687	1	2463.687	37.199	.000
z	6850.800	1	6850.800	103.439	.000
Error	4702.367	71	66.231		
Total	446432.000	74			
Corrected	12293.838	73			
Total					

a. R Squared = .618 (Adjusted R Squared = .607)

Based on the Tests of Between-Subjects Effects table above, it can be seen that F test results for x show the value of 103.439 with Sig. of 0,000. Since Sig value < significant (α) = 0.05, it can be concluded that there are differences in learning outcomes between students taught by PBL learning strategies and students taught with conventional learning strategies. Thus, using a regression test shows which of the two learning models is better. The analysis of data is shown as follows:

Table 7.1

Test of Experiment Class Data Regression

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
	B	Std. Error	Beta			Zero-order	Partial	Part
1 (Constant)	71.784	3.448		20.821	.000			
X	.423	.103	.568	4.084	.000	.568	.568	.568

a. Dependent Variable: y

Table 7.2.

Test of Control Class Data Regression

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations		
	B	Std. Error	Beta			Zero-order	Partial	Part
1	48.630	4.620		10.526	.000			
(Constant) x	.512	.114	.603	4.474	.000	.603	.603	.603

a. Dependent Variable: y

From the above regression test, the constants obtained from the test of the experiment class data regression are 71.784 and the constant of a test of the control class data regression is 48.630. Both regression models show that the constant regression line for the experimental class is greater than the constant regression line of the control class, while the two regression lines are parallel. This shows a significant difference. Geometrically, the regression line for the experimental class is the regression line for the control class. This means student learning outcomes when PBL learning is applied are higher than the student learning outcomes when conventional learning is employed on statistical topics. This shows that PBL is effective in statistical learning for students.

The Results of Descriptive Statistical Data Analysis

Analysis of data obtained on the implementation of PBL and conventional learning is as follows.

Table 8

Comparison of Student Learning Results in Experiment and Control Classes

Information	Experiment Class	Control Class
Average of student learning outcomes	84,9	68,3
Percentage of students who mastered learning	100%	48,6%

Regarding mastery of learning outcomes, the result of table 7 shows there are 37 students in the experimental class who pass in learning (who obtained more than the minimum standard score (MSC), with MSC = 70). Thus, the percentage of student learning mastery is 100%. This is compared to the control class, which had 19 students who failed in the learning process; we can thus conclude their students are not passing in learning.

Observation of student activity during three meetings at the PBL class shows that during every five minute observation, the student could do at least one category of student activity. Most of the students were in the activity of category 3 (discussing or solving the student worksheet or finding ways and answers in the student worksheet). Since the students did PBL activities every 5 minutes instead of irrelevant activities, the students in each meeting can be considered active; thus, it can be concluded that the student activity category is effective. However, in the conventional class some students did irrelevant activities instead of PBL activities, for as long as 75 minutes, such as sleeping and playing. Therefore, the control class did not meet the effective category.

The result of a questionnaire for student responses to the learning shows that the number of students who selected response items in the positive category is 78.02%. Thus, the student responses are positive. Meanwhile, in conventional learning the student responses are positive but much lower, with only 55% selecting positive responses.

Discussion and Conclusion

Based on analysis of inferential statistical data, the results of the analysis showed ANCOVA test $F = 103.4339$ against $p = 0.000$. Because $p < 0.05$, there is a significant difference between project-based learning in the experimental class and conventional learning in the control class.

In addition, from the regression test results, it is seen that the constant of the regression line for the experimental class is higher than the constant of the regression line for the control group. This shows that student learning outcomes in PBL learning are higher than the student learning outcomes in conventional learning. This might be because the learning strategies in the experimental and control classes affected the student learning outcomes. According to Miswanto's findings (2011), after students are engaged in project-based learning, student learning outcomes increase compared to the previous test (pretest). Similarly, Dede & Yaman's (2003) study explains that learning projects are effective in science and mathematics. Moreover, Özdemir (2006) also confirms project learning is effective in grade seven geometry. In line with these results, Ay (2013) notes that PBL is highly considered as a process in which learners' heterogeneity is beneficial in their learning and development.

Meanwhile, in the descriptive analysis, student learning outcomes that followed project based learning got an average score of 84.9% and mastery learning students achieved a score of 100%. Therefore, it can be concluded that this learning is effective.

This is line with the finding of Morrison, et al. (2010), in which measurement of effectiveness can be ascertained from test scores.

Positive results were also obtained regarding the students activities in the experimental class; from the first meeting to the third meeting, it is indicated that the students' activity was in the effective category. At the beginning of the meeting, the students felt unfamiliar with this learning situation, but in the second and third meetings, the implementation of learning came better, wherein students already knew what was done in a learning activity. The students were enthusiastic about working the given project, and actively discussed and presented their group work to other groups. This is in accordance with Barab & Luehmann (2002) in which PBL principles are deduced from the constructivist perspective, emphasizing active learning and higher order thinking skills. Similarly, Green (1998) emphasized that participants in project-based learning learn better and are more actively acting in their learning. In relation to the student response to the implementation of project-based learning, the results of the analysis showed that 85.83% of the students agreed with all statements in the questionnaire, which means that the students responded positively to the implementation of the lesson.

Based on the research results it can be concluded that PBL in learning study is effective. The student learning outcomes in PBL obtained a greater score than of MSC, student activity was active, and student response to learning was positive. In addition, the experimental classes wherein the project based learning was applied were more effective than the control classes that used conventional learning. Thus, PBL demonstrated higher learning outcomes than conventional groups.

Further studies should be conducted to discover the importance of project-based learning and relevance in mathematics. This research study may be repeated with a different topic in mathematics. Furthermore, experimental studies may be carried on to discover the dynamics of project-based learning to compare individual work with group work. Alternatively, the use of certain technologies might be changed to determine ways in which it affects the process, if at all.

References

Ay, S. (2013). Öğretmen adaylarının proje tabanlı öğrenme ve geleneksel öğretime ilişkin görüşleri [Trainee teachers' views on project-based learning and traditional education]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 28(1), 53-67.

Barab, S. A., & Luehmann, A. L. (2002). Building sustainable science curriculum: Acknowledging and accommodating local adaptation. *Science Education*, 87, 454–467.

Berends, H., Boersma, K., & Weggeman, M. (2003). The structuration of organizational learning. *Human Relations*, 56(9), 1035-1056.

Basbay, M. Y. (2010). Proje tabanlı öğrenme [Project based learning]. In Ö. Demirel (Ed.), *Eğitimde yeni yönelimler* (4. baskı) (pp. 67-80). Ankara: Pegem A Yayıncılık.

Basbay, M., & Ales, A. (2009). The reflections of student teachers on project based learning and investigating self evaluation versus teacher evaluation. *Procedia social and Behavioural Sciences*, 1, 242-247.

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26 (3&4), 369-398.

Cohen, L., Manion, L., & Morrison, K. (2005). *Research methods in education (5th ed.).* UK: Taylor & Francis e-Library.

Cronbach, L., J. (1951). Coefficient alpha and the internal structure of tests. *Psyclzometrika*, 16, 297-334.

Dede, Y., & Yaman, S. (2003). Fen vema tematik eğitimin deprojeç alışma larını nyeri, önemi vede ğerlen diril mesi [The place, importance and assessment of project work in science and mathematics education]. *Gazi Eğitim Fakültesi Der*gisi, 23(1), 117-132.

Demirhan, C. (2002). *Program geliştir mede projet emelli öğren meyaklaşımı [Project basedlearning in program development*]. (Unpublished doctoral dissertation). Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü, Ankara.

Diffily, D. (2002). Project-based learning: Meeting social studies standards and the needs of gifted learners. *Gifted Child Today*, 25(3), 40-59.

Eggen, P.D., & Kauchak, D.P. (1998). *Strategies for the teacher: Teaching Content and Thinking Skill*. Allyn and Bacon: Boston

Erdem, E., & Demirel, Ö. (2002). Constructivism in curriculum development. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 23, 81-87.

Garfield, J., & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for research in Mathematics Education*, 44-63.

Green, A. M. (1998). *Project-based-learning: moving students toward meaningful learning*. ERIC Data base, ED422466

Kaldi, S., Filippatou, D., & Govaris, C. (2011). Project-based learning in primary schools: effects on pupils' learning and attitudes. *Education* 3–13, 39(1), 35–47.

Korkmaz, H. (2002). *Fen eğitiminde projet emelli öğrenmenin yaratıcı düşünme, problem çöz meve akademik risk alma düzeylerineetkisi [The effects of project based learning in science* *education on creative thinking, problem solution and academic risk taking levels]*. (Unpublished doctoral dissertation). Hacettepe Üniversitesi, Ankara.

Krajcik, J.S., & Blumenfeld, P. (2006). Project-based learning. In Sawyer, R. K. (Ed.), *The Cambridge handbook of the learning sciences.* New York: Cambridge

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E.(1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *The Journal of the Learning Sciences*, 7, 313-350.

Ladewski, B. G., Krajcik, J. S., & Harvey, C. L. (1994). A middle grade science teacher's emerging understanding of project-based instruction. *The Elementary School Journal*, 94(5), 498-515.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159-174.

Leviatan, T. (2008). *Innovative Teaching and assessment Method: QBI and project based learning*. *Mathematics Education Research Journal,* 10(2), 105 – 116.

LI, K. Y., & Shen, S. M. (1992). Students' weaknesses in statistical projects. *Teaching Statistics,* 14(1), 2-8.

Markham, T. (2003). *Project based learning handbook: A guide to standards-focused project based learning for middle and high school teachers*. Novato, CA: Buck Institute for Education.

Miswanto. (2011). Penerapan model pembelajaran berbasis proyek pada materi program linier siswa kelas X SMK Negeri 1 Singosari [Application of project-based learning model on linear program topic of students of class X in SMK Negeri 1 Singosari]. *Jurnal Penelitian Dan Pemikiran pendidikan*, 1, 1-7.

Morrison, G. R., Ross, S. M., Kemp, J. E., & Kalman, H. (2010). *Designing effective instruction*. John Wiley & Sons.

Mudhofir. (1987). *Teknologi instruksional [Instructional technology]*. Bandung: Remaja Rosdakarya

Özdemir, E. (2006). *An ınvestıgatıon on the effects of project-based learnıng on students' achıevement ın and attıtude towards geometry*. (Unpublished dissertation). Mıddle East TechnıcalUnıversıty, Ankara.

Özdemir, E., & Ubuz, B. (2006). *Projet emelli öğren meninö ğrencil erin geometriye yönelik tutum larınaet kisi [Effects of project based learning on student attitudes towards geometry].* VII. Ulusal Fen Bilim lerive Matematik Eğitimi Kongresi, (7-9 Eylül). (pp.225), Gazi Üniversitesi, Ankara.

Özden, M., Aydın, M., Erdem, A., & Ekmekçi, S. (2009). Öğretmenlerin proje tabanlı fen öğretimi konusunda görüşlerinin değerlendirilmesi [Evaluation of teacher views about project based learning in science education]. *Elektronik Sosyal Bilimler Dergisi*, 8(30), 92-102.

Robinson, D. L. (2009). *Project-based hıgh school geometry*. (Unpublished Thesis). B.S. Louisiana State University.

Saracaloğlu, A. S., ÖzyılmazAkamca, G., & Yeşildere, S. (2006). İlköğretimde proje temelli öğrenmenin yeri [The place of project based learning in elementary education]. *Gazi Türk Eğitim Bilimleri Dergisi*, 4(3), 241-260.

Siswono, T. Y. E., Kohar, A. W., & Hartono, S. (2017a). Secondary teachers' mathematics-related beliefs and knowledge about mathematical problem-solving. *In Journal of Physics: Conference Series* (Vol. 812, No. 1, p. 012046). IOP Publishing.

Siswono, T. Y. E., Kohar, A. W., Rosyidi, A. H., & Hartono, S. (2017b). Primary school teachers' beliefs and knowledge about mathematical problem-solving and their performance on problem-solving task. *World Transactions on Engineering and Technology Education*, 15, 2.

Slavin, R. E. (1997). *Educational psychology theory and practice*. (Fifth Edition). Boston: Allyn and Baco.

Soedjadi. (2001). *Kiat Pendidikan Matematika Indonesia [Tips for Indonesian Mathematics Education].* Jakarta: Dirjen dikti depdikbud.

Thomas, J. W. (2000). *A review of research on project-based learning executive summary*. San Rafael, CA: The Autodesk Foundation.