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IMPLEMENTATION OF PROJECT-BASED LEARNING TO IMPROVE MATHEMATICAL LITERACY AND REDUCE MATHEMATICAL ANXIETY OF HIGH SCHOOL STUDENTS FROM A GENDER PERSPECTIVE

Abstract

One of the problems in mathematics learning is the low mathematical literacy of students. One of the causes of low mathematical literacy is mathematical anxiety. This study aims to apply Project-Based Learning to improve mathematical literacy and mathematical anxiety of students in terms of gender. The research method used is a mixed method embedded type with a quantitative quasi-experimental design and a qualitative design used is triangulation data collection. The population of this study was grade XI students at a high school in Cianjur, with samples of grades XI-1 and XI-2. The research instruments used were mathematical literacy tests, mathematical anxiety questionnaires, interviews and observations. Data analysis used was two-way ANOVA and linear regression. The results of the study showed that: (1) The increase in mathematical literacy of female students who received Project-Based Learning was better than the other groups, (2) The decrease in mathematical anxiety of female students who received Project-Based Learning was better than the other groups, (3) There was a negative correlation between mathematical literacy and mathematical anxiety of students who received Project-Based Learning.

Keywords: project-based learning, conventional learning, mathematical literacy, mathematical anxiety, correlation

INTRODUCTION

Curricula in a country frequently undergo changes. These changes are intended to improve overall educational standards (Anggini et al., 2022; Santika et al., 2022; Syauki et al., 2022). The curriculum currently used in Indonesia is the Independent Curriculum, which requires students to be more active in learning activities. This curriculum encourages students to independently explore ideas and steps in mathematics.

An individual's success in this era isn't solely determined by their intelligence. A person must be able to gain deeper insights to become more intelligent and analytical in processing information. This aspect is crucial for improving students' comprehension skills, which are becoming increasingly complex over time.

Mathematical literacy is a key skill that students need to master within the Merdeka Curriculum framework. Mathematical literacy can be defined as an individual's ability to design, apply, and utilize mathematics in various situations, including using mathematical reasoning to describe ideas, procedures, and data to illustrate, analyze, or predict events (PISA, 2018).

Students' mathematical literacy remains low, according to the 2022 PISA survey, with Indonesia ranked 68th out of 81 participating countries (PISA, 2022). Furthermore, various

other studies have also shown low levels of mathematical literacy among Indonesian students (Masfufah et al., 2021; Ridzkiyah et al., 2021; Yudiawati et al., 2021; Yuniati et al., 2020). Although Indonesia's ranking improved in 2022, its overall score actually declined compared to the previous year. In Indonesia, only 18% of students achieved a minimum proficiency level of 2 in mathematics, significantly lower than the OECD average (OECD average: 69%). At this basic level, students are only able to interpret and identify simple situations without having to directly apply mathematical models (PISA, 2022). According to the OECD report, Indonesian students' mathematical achievement remains unsatisfactory. Around 75% of Indonesian students are below level 2, which means they have difficulty applying basic mathematical concepts to real-world situations (OECD, 2019).

Many factors contribute to low student mathematical literacy. These factors include students' inability to model story problems in mathematical language (Hapsari, 2019), the use of inappropriate learning models/approaches, and affective factors experienced by students.

Mathematical anxiety is also a significant factor influencing student achievement. Mathematical anxiety is a feeling of discomfort experienced by students when facing mathematics learning (Juliyanti et al., 2020). Mathematical anxiety lowers students' cognitive abilities, and conversely, low cognitive abilities increase anxiety (Wardani, 2022; Nopela et al., 2020; Putri et al., 2021).

Learning using learning models related to everyday life can improve students' literacy and reduce mathematical anxiety (Das, 2020). One such model is Project-Based Learning. This learning model encourages students to be active, creative, and collaborative. The focus is on student ideas (Fisher et al., 2020). Learning that involves hands-on practice is more meaningful.

Project-Based Learning is able to improve several mathematical abilities and improve affective aspects in mathematics learning such as critical thinking skills (Sari, 2023), creative thinking (Widana, et al., 2021), problem solving (Priatna, et al., 2022), learning motivation (Mahendra, et al., 2023), etc. Project-Based Learning can also be used at various school levels, from elementary school, junior high school, high school, to college (Nurhadiyati, et al., 2020; Herawati, et al., 2021; Nasikin, et al., 2023; Nasution, et al., 2022).

Gender issues are a frequently discussed topic in educational research. Several studies have shown that gender influences both cognitive and affective aspects of students (Yerizon et al., 2021; Trimayati et al., 2023; Harianandа et al., 2022). Gender differences not only impact variations in mathematical ability but also influence how students acquire and construct mathematical knowledge (Gurun et al., 2018). Considering this, the implementation of Project-Based Learning is seen as having the potential to improve mathematical literacy while reducing students' mathematical anxiety levels, both gender-specific.

METHOD

This study uses a mixed method model with an embedded type. The insertion is carried out in parts that require reinforcement or confirmation so that the resulting conclusions have a better level of understanding confidence when compared to using only one approach (Indrawan,

et al. 2017). Viewed from the objectives of this study, the research data uses statistical calculations, meaning the sole method is quantitative, but to emphasize the research conclusions, it is strengthened with qualitative. The following is the Embedded Design method (Indrawan, et al. 2017).

This research was conducted at SMAN 1 Karang Tengah, Cianjur, in the 2024/2025 academic year, with a population of eleventh-grade students. Two classes were selected purposively based on teacher recommendations and similar academic profiles. Class XI-1 served as the experimental group receiving project-based learning, while class XI-2 served as the control group receiving conventional learning. Each class consisted of 30 students, 15 boys and 15 girls. The total sample size was 60 participants. This number was considered sufficient to represent the population and allow for statistical comparisons between groups.

The data collection technique in this study used test and non-test instruments. The test instrument was a mathematical literacy test, while the non-test instruments were a mathematical anxiety questionnaire, observation, and interviews. The data analysis technique used for quantitative data was the analysis of students' mathematical literacy ability test data by measuring the normalized gain (N-Gain), normality test, homogeneity test, two-way ANOVA test, and Post Hoc. For qualitative data analysis, data triangulation was used.

RESULTS AND DISCUSSION

The research results were analyzed to determine the pretest and posttest data, and the improvement of students' mathematical literacy. First, the pretest data of students' mathematical literacy were analyzed. The data used to analyze students' initial mathematical literacy abilities were the results of the pretests obtained from the experimental and control classes. The pretest was given to students before the learning process began, which aimed to determine the initial abilities of students in the experimental and control classes. Then, normality and homogeneity tests of the pretest data were conducted to determine the statistics that would be used later in testing the differences in means.

In this study, the normality test used Shapiro Wilk and the homogeneity test used Levene. Based on the results of the pretest data normality test, it was found that the experimental class and the control class were normally and homogeneously distributed. Next, the data were tested using a two-way ANOVA to determine whether the initial abilities of the two groups were equal or not. After conducting the trial, the significance value for the class factor was $0.067 > 0.05$, meaning that there was no difference in mathematical literacy pretest scores between students who received Project-Based Learning and classes that received conventional learning. For the gender factor, the significance value was $0.000 < 0.05$, meaning that there was a difference in mathematical literacy pretest scores between male and female students.

Next, a normality and homogeneity test was conducted for the mathematical literacy post-test scores between students who received Project-Based Learning and the class that received conventional learning. The normality and homogeneity test of the mathematical literacy post-test scores showed that both classes were normally distributed and homogeneous. The next step

was to test the mean difference using a two-way ANOVA. The test results showed that the significance value of the class factor was 0.001 <0.05, meaning that there was a difference in the mathematical literacy post-test scores between the experimental and control classes. On the gender factor, the significance value was 0.000 <0.05, meaning that there was a difference in the results between male and female students. Meanwhile, the interaction between the class and gender factors showed a significance value of 0.040 <0.05, it can be concluded that there was an interaction between the two on students' mathematical literacy post-test scores.

After the pretest and posttest were tested for normality, homogeneity, and mean, the next test was conducted on the N-Gain score of mathematical literacy using the same steps. The results of the normality and homogeneity tests for the N-Gain score showed a value greater than 0.05, indicating that the N-Gain scores of both classes were normally and homogeneously distributed. The mean was then tested using a two-way ANOVA test. The results are presented in the table below:

Tabel 1. Results of the Average N-Gain Test of Students' Mathematical Literacy

	Sig.
Class	,001
Gender	,001
Class * Gender	,030

Referring to Table 1, the class factor has a Sig. value of 0.001 < 0.05, so H_0 is rejected. Thus, there is a difference in the N-Gain score of mathematical literacy between students in the experimental and control classes. The gender factor also obtained a Sig. value of 0.001 < 0.05, which resulted in H_0 being rejected, indicating a difference in the N-Gain score between male and female students. Furthermore, the interaction factor of class and gender shows a Sig. value of 0.030 < 0.05 so that H_0 is rejected, which means there is an interaction between the two on the N-Gain score of mathematical literacy.

The results of the two-way ANOVA analysis showed a difference in the mean between groups. To identify which group had a higher increase in mathematical literacy, a post hoc test was conducted. The results showed that the significance value for the experimental class students was below 0.05 in all group comparisons. Thus, it can be concluded that the improvement in mathematical literacy skills of female students in the experimental class was superior to that of the other groups.

Next, an analysis was conducted for mathematical anxiety, starting with the initial score of mathematical anxiety. The score was tested for normality and homogeneity, resulting in data on the initial score of mathematical anxiety in students who received Project-Based Learning and students who received conventional learning with normal and homogeneous distribution. Next, the data were tested for the average using a two-way ANOVA test. The test showed that for the class factor, the Sig. value was 1.000 > 0.05 so that H_0 was accepted. This indicates that there was no difference in the initial score of mathematical anxiety between students in the experimental class and the control class. Meanwhile, for the gender factor, the Sig. value was

0.900 > 0.05 so that H_0 was accepted. Thus, there was no difference in the initial score of mathematical anxiety between male and female students.

The final score of mathematical anxiety was also tested with the same steps as the initial score of mathematical anxiety. The final score of mathematical anxiety was tested for normality and homogeneity, showing a significance result of more than 0.05. This means that the final score data of mathematical anxiety in the experimental and control class students were normally and homogeneously distributed. Furthermore, a mean test was carried out which showed that in the class factor the value of Sig. ,000 < 0.05, meaning that there was a difference in the final score of mathematical anxiety between the experimental and control class students. The gender factor produced Sig. ,000 < 0.05, meaning that there was a difference in the final score of mathematical anxiety between male and female students.

The N-Gain score of mathematical anxiety in the class that received Project-Based Learning and that received conventional learning was tested for normality and homogeneity. Both data produced a significance value of more than 0.05, meaning that the N-Gain data of both classes were normally distributed. Then a mean test was carried out using a two-way ANOVA, the results of the class factor were Sig. ,000 <0.05, meaning that there was a difference in the N-Gain score of mathematical anxiety between students in the experimental class and the control class. The gender factor produced Sig. ,000 <0.05, meaning that there was a difference in the N-Gain score of mathematical anxiety between male and female students. The interaction factor of class and gender showed a Sig. value of 0.006 <0.05, meaning that there was an interaction between class (experimental vs. control) and gender on the N-Gain score of students' mathematical anxiety.

To determine which group had the highest significance value, a post-hoc test was conducted. The results showed that female students in the experimental class had a Sig. value less than 0.05 compared to all other groups. This indicates that female students' mathematical anxiety reduction was better than that of the other groups.

To see whether mathematical literacy and mathematical anxiety are correlated, a Pearson correlation test was conducted, the results of which can be seen in the table below:

Tabel 2. Correlation Test between Mathematical Literacy and Students' Mathematical Anxiety

Group	Pearson Correlation	Sig. (2-tailed)	Interpretasi
Man	-,625	,000	Strong
Woman	-,908	,000	Very Strong

Based on Table 2, the significance value for the relationship between mathematical literacy and math anxiety in male and female students was recorded at 0.000, which is less than 0.05. Thus, the null hypothesis (H_0) is rejected. This indicates a significant correlation between mathematical literacy and students' math anxiety levels. The correlation is inversely proportional, as the resulting Pearson correlation value is negative.

Judging from the Pearson correlation value, for males it is -0.625 and for females it is -0.908. This indicates that the Pearson correlation is stronger for female students than for male students.

CONCLUSIONS

Based on the results of previous research and discussions regarding the improvement of students' mathematical literacy through mathematics learning with the Project-Based Learning approach and conventional learning, it can be concluded that there are differences in mathematical literacy between students who receive learning with Project-Based Learning and students who receive conventional learning models. The improvement in mathematical literacy of students who receive Project-Based Learning is better than students who receive conventional learning models. In addition, when analyzed by gender, the mathematical literacy of female students who participate in Project-Based Learning experiences the most significant improvement compared to other groups.

There was a difference in the level of mathematical anxiety between students who received Project-Based Learning and those who received conventional learning models. The reduction in mathematical anxiety in students who received Project-Based Learning was better than in students who received conventional learning models. When viewed by gender, the reduction in mathematical anxiety in female students who received Project-Based Learning experienced the most significant decrease compared to the other groups.

There is a correlation between mathematical literacy and mathematical anxiety in students who receive Project-Based Learning. The resulting correlation is negative, where the higher the literacy score, the lower the anxiety score. The correlation between mathematical literacy and mathematical anxiety in female students who receive Project-Based Learning is stronger than in male students who receive Project-Based Learning.

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