**The effect of problem-based learning model toward students' mathematics achievement based on gender**

**Yohannes, N Diana and Y Sukma**

Mathematics Education Study Program, Graduate School, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia

E-mail: yohannesyohannes@upi.edu

**Abstract**. This study aims to determine (1) whether the mathematics achievement of students taught with the PBL model is higher than the conventional model; (2) whether there is a difference in mathematics achievement between male and female students; (3) whether there is an interaction between learning models and gender on mathematics achievement. This study uses a quasi-experimental method. The population in this study were all students of grade XI of SMA Negeri 2 Balige. Sampling was done by cluster random sampling technique so that one class was obtained as an experimental class and another as a control class. Data collection was done through mathematics achievement tests. Data analysis and hypothesis testing using two-way ANOVA with the help of SPSS software. The findings show that: (1) the mathematical achievement of students taught with the PBL model is higher than the conventional model; (2) there is no difference in mathematics achievement between male and female students; (3) there is no interaction between learning models and gender on students' mathematics achievement. The findings in this study provide information about PBL model as a learning model that can improve students' mathematics achievement and can support the equality of learning achievement between male and female students.

1. **Introduction**

Education is a sector that has a significant role in supporting the development and progress of a nation. High-quality education will be able to improve the quality of human resources [1]. Education and its successful implementation are closely related to learning achievement. Learning achievement is considered as the knowledge and competence obtained by students after experiencing and receiving learning experiences and can be measured by the teacher [2]. Achievements can be in the form of skills and habits, knowledge and understanding, and attitudes and ideals [3].

In the mathematics aspect, mathematics achievement is defined as the abilities of students after they have received the mathematics learning experience. Mathematics achievement is also a benchmark that is used to determine the success rate of students in knowing and understanding the subject matter of mathematics after experiencing a learning experience that can be measured through tests [4]. Mathematical ability is related to educational achievement, higher grades, more excellent achievement qualifications, and higher socioeconomic status [5]. This mathematical achievement can predict a person's career, reputation, and personal income [6].

Based on preliminary observations, it was found that students' mathematical achievement was still relatively low and unsatisfactory. The low mathematical achievement of students is also shown by the results of PISA 2018, which put Indonesia ranked 73 out of 79 countries [7]. Low mathematical achievement is caused by the use of learning models that do not actively involve students. Teachers tend to dominate learning activities, so students become passive. As a result, the learning process becomes less meaningful and causes student mathematics achievement to be low. To overcome this weakness, we need an alternative learning model that can require students to think, discuss, and arrange solutions to the problems given so that students will experience the learning process. Thus, learning will be meaningful and encourage improvement in students' mathematical achievement. The learning model that can be implemented to achieve these objectives is the Problem-Based Learning (PBL) model.

PBL is a learning model that encourages students to learn through structured exploration activities of a problem [8]. Problems in PBL are used as a stimulus for students to begin the learning process. PBL provides an active learning activity that allows students to realize and determine their ability to solve problems, build adequate knowledge, and do group work in dealing with problems of daily life [9]. The PBL model also encourages students to take responsibility for their learning [10]. The existence of small groups in PBL provides benefits from the social aspect because the process of discussion, problem-solving, and learning is carried out with peers [11]. Several previous studies have shown that PBL has a positive effect on increasing students' mathematical achievement [12]–[16]. Thus, PBL provides great potential to improve students' mathematical achievement.

Apart from the learning model, other factors can affect mathematics achievement. One such factor is gender. Gender has a considerable influence on learning outcomes because there are differences in student learning styles between men and women, resulting in differences in achievement between genders [17], [18]. Male students are considered to be closer to mathematics [19]. Class interactions, student attitudes, student interests, and self-esteem, teacher attitudes, curriculum content, beliefs, social and cultural norms are all factors associated with the gender gap [10]. Based on previous research, it is obtained that there were different results regarding the effect of gender on mathematical achievement. There are significant differences in mathematics learning outcomes in terms of gender. Some studies state that male students tend to perform better in mathematics than females [20]–[23], while some other studies report that female students have better performance in mathematics [6], [24]. In contrast, there are also previous studies that indicate there is no difference in mathematics achievement in terms of gender [10], [25]–[31]. The variety of mathematics learning achievements in terms of gender shows there are still inconsistencies in results, so gender issues are still an interesting problem to discuss.

Based on the background description, it is necessary to research the consistency of gender influence on mathematics achievement. Therefore, this study was conducted to find out: (1) whether the mathematics achievement of students taught with the PBL model is higher than the conventional model; (2) whether there are differences in mathematics achievement between male and female students; (3) whether there is an interaction between learning models and gender on mathematics achievement. The findings in this study contribute to providing information about the effect of the PBL model and the effect of gender on students' mathematical achievement.

1. **Methods**

This study is quantitative research with a quasi-experimental type. The design of this study uses a 2 × 2 factorial design. The first factor is gender, which consists of two variables, male and female. At the same time, the second factor is the learning model, which includes two variables, namely the PBL model and the conventional learning model. The population in this study is all students of class XI in SMA Negeri 2 Balige, Toba Regency, North Sumatra. Then, the sample in this study is two classes that were chosen randomly using the cluster random sampling method. Class XI Science 6 became an experimental class taught using the PBL model, while Class XI Science 7 became a control class that was taught using conventional learning models. Before the treatment was given, the two classes were given a preliminary test to know whether the two classes have equal initial ability. After the treatment was given, then at the last meeting, a mathematics achievement evaluation test is carried out to collect further data to be analyzed.

The data collection instruments in this study used a test technique, which was a preliminary test and an evaluation of mathematics achievement tests on statistical topics. The form of the questions used is a multiple-choice test of 20 questions and has been through the validity and reliability test by experts, so it is feasible to be used to collect the required data. This mathematics achievement data is tabulated based on gender as many as 15 male students and 15 female students both in the experimental class and the control class. The quantitative data obtained were analyzed using SPSS 24.0. Preliminary test result data were analyzed through a normality test, homogeneity test, and t-test to find out whether the two classes had equivalent initial abilities. Next, the results of the evaluation tests were analyzed using two-way ANOVA statistics. However, before this test is carried out, it is necessary first to test normality and homogeneity. Then, the results of the two-way ANOVA are analyzed to test the hypothesis for further interpretation of decision making and conclusions.

1. **Results and Discussion**

Preliminary data of students in both classes were obtained through the provision of an initial test before treatment was given. After quantitative data is collected, the data is then processed and analyzed using SPSS 24.0 software. A summary of the initial test results, normality test, homogeneity test, and t-test data are given in the following table.

**Table 1.** Summary of Normality, Heterogeneity, and t-test for Initial Test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group | N | Mean | StdDev | Normality Test | Heterogeneity Test | t-test for Equality of Means |
| **Statistic** | **Sig.** | **Levene's Statistic** | **Sig.** | **t** | **Sig.** |
| Experiment (PBL) | 30 | 12.200 | 1.689 | 0.153 | 0.071 | 0.120 | 0.731 | 1.844 | 0.070 |
| Control (CL) | 30 | 11.367 | 1.810 | 0.130 | 0.200 |

Referring to the normality test against the initial test, it was found that the Sig. value for both classes more than 0.05 (α = 5%). This result means, at a significance level of 5%, all samples come from populations that are normally distributed. Furthermore, in the homogeneity test, the Sig. from Levene's statistics, that is 0.731 > 0.05, so it can be concluded that the data has a homogeneous variance. Because the initial test data is normally distributed and homogeneous, it is continued with t-test. From table 1, the Sig. value from the t-test that is 0.070 > 0.05, which means that there are no differences in the initial abilities of students. In other words, the initial abilities of students in the experimental class and the control class are in a balanced state, so for subsequent analysis using data from the mathematics achievement evaluation test.

Based on the preliminary analysis, information was obtained that the initial abilities of the two classes were the same, so that further analyzes were carried out using achievement data collected from the mathematics achievement evaluation tests. This test is given after the two groups are given treatment according to each learning model. The mathematical achievement data obtained were further analyzed by two-way ANOVA. But before this test is carried out, the prerequisite test is normality and homogeneity. A summary of the prerequisite test results is presented in table 2 below.

**Table 2.** Summary of Normality and Heterogeneity Test of Mathematics Achievement Test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Students' Mathematics Achievement | Group | N | Mean | Std | Normality Test | Heterogeneity Test |
| **L** | **Sig.** | **Levene's Statistic** | **Sig.** |
| Experiment | 30 | 16.800 | 1.750 | 0.145 | 0.105 | 0.002 | 0.961 |
| Control | 30 | 14.867 | 1.737 | 0.136 | 0.164 |
| Male | 30 | 15.733 | 1.981 | 0.144 | 0.112 | 0.002 | 0.964 |
| Female | 30 | 15.933 | 2.016 | 0.135 | 0.172 |

Based on table 2, at the significance level α = 5%, it was obtained that the students' mathematical achievement evaluation test data for each study group was normally distributed and had a homogeneous variance. This condition can be seen from the Sig. value in the normality test for each study group valued at more than 0.05. Also, Sig. value in the heterogeneity test for the study group of learning model factors and gender factors is also worth more than 0.05. Therefore, a further two-way ANOVA test can be carried out because both prerequisite tests have been fulfilled. A summary of the ANOVA calculation results is given in table 3 below.

**Table 3.** Two-way ANOVA Analysis of Students' Mathematics Achievement Test

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
| Corrected Model | 56.733a | 3 | 18.911 | 6.031 | 0.001 |
| Intercept | 15041.667 | 1 | 15041.667 | 4796.887 | 0.000 |
| Gender | 0.600 | 1 | 0.600 | 0.191 | 0.663 |
| Model | 56.067 | 1 | 56.067 | 17.880 | 0.000 |
| Gender\*Model | 0.067 | 1 | 0.067 | 0.021 | 0.885 |
| Error | 175.600 | 56 | 3.136 |  |  |
| Total | 15274.000 | 60 |  |  |  |
| Corrected Total | 232.333 | 59 |  |  |  |

1. R Squared = 0.244 (Adjusted R Squared = 0.204)

In table 3, referring to the learning model factor, it can be seen that the Sig. value is 0.000 < 0.05. This result means different learning models provide different achievements. In other words, there are differences in mathematics achievement between students taught with the PBL model and students taught with the conventional model. This can be seen from the average achievement of students taught with the PBL model, which is 16.8 higher than students taught with the conventional model that is 14,867. This finding is in line with the results of previous studies, which found that the PBL model had a better influence on mathematical ability than the conventional model [10] - [14], [22]. The reason is that in the PBL model, students were placed as learning subjects and try to gain or find the knowledge by themselves through the problems given. The students have meaningful learning since the materials provided by the teacher are connected to the problem around daily life. Students also work actively as a team to solve the problem given. Thus, the PBL model can be an alternative learning model that can be used in mathematics learning to improve students' mathematical achievement.

Based on the two-way ANOVA calculation results in Table 3, the gender factor with a significance level of α = 5%, obtained that the Sig. value 0.663 > 0.05, which indicates that there are no differences in mathematical achievement between male and female students. This can also be seen from the average value that is not so different between groups of male students, which is 15.733, while the group of female students is 15.933. This finding is in line with the results of previous studies, which found that gender factors did not significantly influence mathematics achievement [10], [25]–[31]. Ajai & Imoko found that there was no significant difference between the average achievement of male and female students taught by the PBL model [10]. Also, this finding is consistent with the results of the Hyde & Mertz study, which states that in mathematics, female students can achieve a balanced ability with male students. This means that female students can do better assignments in solving complex problems, as presented in PBL [25]. However, this finding is different from the study by Asante, which found that there were significant gender differences in mathematics achievement [21].

The absence of differences in mathematics achievement between male and female students is because students realize that they are in the same position and are able to compete and collaborate in learning activities in class. This can be seen from the learning activities of male and female students both with the PBL model and the conventional model is not so different although there are found several conditions where female students are more active in discussing and submitting opinions. This condition is consistent with the concept of gender equality, which states that both male and female students experience the same learning experience and obtain the same learning achievement [1]. However, this fact contrasts with the opinion that gender differences in mathematics are based on differences in cognitive abilities and lateral brain conditions that differ between male and female students [32]. Various factors that might influence gender differences such as classroom and school culture, teacher attitudes, and parenting from parents can be considered for further research. One of the factors that influence the results in this study is the quality of schools, because the place of research is the school with the best school category in Toba Regency, North Sumatra, so that gender issues are not a problem in mathematics achievement [26]. However, from this study, it can be said that the application of PBL also shows that the orientation of understanding and thinking patterns in learning mathematics plays more role than gender.

Furthermore, based on the value of the interaction between gender and the learning model, it is found that the Sig. value is 0.885 > 0.05, which means there is no interaction between the learning model and male and female students on mathematics achievement. The absence of interaction between the two factors is due to the absence of differences in mathematical achievement between male and female students in each learning model. That is, the mathematical achievements of both male and female students taught with the PBL model are better than conventional models. This finding is consistent with the results of Awofala & Lawani and Ojaleye & Awofala's studies, which found that there were no significant interaction effects of treatment and gender on students' mathematical achievement [28], [33]. Furthermore, the average scores of male and female students in each treatment class are presented in Figure 1 below.

**Figure 1.** Students′ Mathematics Achievement

Based on figure 1, descriptively, it can be observed that mathematics achievement in the experimental class taught by the PBL model, both for male and female students is higher than the achievement in the control class taught by the conventional model. Besides, the mathematics achievement of female students in both the experimental class and the control class is higher than the achievement of male students even though the difference is quite small and statistically not different. This result is consistent with the findings in recent studies that the ability of female students in countries that have recognized gender equality has good mathematics learning achievement, and is even better than male students [34]. The results of the TIMSS in the last few years have also indicated that the differences between male and female students are minimal [35], and female students are also able to obtain the same or even better performance than male students [23]. So, it can be said that based on the results of this study, gender is not a factor that significantly influences mathematics achievement. These findings can be input into the practice of implementing education, which shows that the PBL model can be a choice of learning models that can improve the achievement of male and female students in a balanced manner.

1. **Conclusion**

Based on the findings in this study, it can be concluded as follows: (1) the mathematical achievement of students taught with the PBL model is better than the mathematics achievement taught by conventional models, (2) there is no difference in mathematical achievement between male and female students, (3) there is no interaction between learning models and gender on mathematics achievement. Mathematics learning should provide equal opportunities and challenges for male and female students to achieve mathematics learning achievement. The results of studies that show no difference in achievement in terms of gender indicate that male and female students have the same competence to achieve learning achievement. PBL models can also be an alternative learning model that can improve mathematics achievement. Also, PBL can encourage equality between men and women to compete, work together, collaborate, and obtain the same knowledge and skills in learning mathematics. Lastly, this study is still limited to the dependent variable, namely achievement, so that further research is possible to see the effectiveness of PBL on other dependent variables, especially mathematical abilities and also in terms of gender or other factors.

1. **References**

[1] UNESCO, 2003 *Gender and Education for All: The Leap to Equality* Paris: UNESCO.

[2] Kunhertanti K and Santosa R H, 2018 The Influence of Students’ Self Confidence on Mathematics Learning Achievement *J. Phys. Conf. Ser.* **1097**, 1.

[3] OECD, 2019 Attitudes and Values for 2030 in Brief *OECD Futur. Educ. Ski. 2030* p. 1–18.

[4] Linn R *et al.*, 2011 Student Learning, Student Achievement: How Do Teachers Measure Up? *Arlington, VA Natl. Board Prof. Teach. Stand.* p. 1–20.

[5] Ritchie S J and Bates T C, 2013 Enduring Links From Childhood Mathematics and Reading Achievement to Adult Socioeconomic Status *Psychol. Sci.* **24**, 7 p. 1301–1308.

[6] Lee C Y and Kung H Y, 2018 Math self-concept and mathematics achievement: Examining gender variation and reciprocal relations among junior high school students in Taiwan *Eurasia J. Math. Sci. Technol. Educ.* **14**, 4 p. 1239–1252.

[7] OECD, 2019 PISA 2018 insights and interpretations *OECD Publ.* p. 64.

[8] Delisle R, 1997 *How to Use Problem-Based Learning in The Classroom* USA: Association for Supervision and Curriculum Development.

[9] Akinoǧlu O and Tandoǧan R Ö, 2007 The effects of problem-based active learning in science education on students’ academic achievement, attitude and concept learning *Eurasia J. Math. Sci. Technol. Educ.* **3**, 1 p. 71–81.

[10] Ajai J T and Imoko B I, 2015 Gender differences in mathematics achievement and retention scores: A case of problem-based learning method *Int. J. Res. Educ. Sci.* **1**, 1 p. 45–50.

[11] Hmelo-Silver C E, 2004 Problem-Based Learning: What and How Do Students Learn? *Educ. Psychol. Rev.* **16**, 3 p. 235–266.

[12] Dochy F Segers M Van den Bossche P and Gijbels D, 2003 Effects of problem-based learning: A meta-analysis *Learn. Instr.* **13**, 5 p. 533–568.

[13] Strobel J and van Barneveld A, 2009 When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms *Interdiscip. J. Probl. Learn.* **3**, 1.

[14] Fatade A O Mogari D and Arigbabu A A, 2013 Effect of Problem-Based Learning on Senior Secondary School Students’ Achievements in Further Mathematics. *Acta Didact. Napocensia* **6**, 3 p. 27–44.

[15] Paloloang M F B, 2014 Penerapan Model Problem Based Learning (PBL) untuk Meningkatkan Hasil Belajar Siswa pada Materi Panjang Garis Singgung Persekutuan Dua Lingkaran di Kelas VIII SMP Negeri 19 Palu *J. Elektron. Pendidik. Mat. Tadulako* **2**, 1 p. 67–77.

[16] Olaoye O and Adu E O, 2015 Problem-based Learning Strategies and Gender as Determinant of Grade 9 Students’ Academic Achievement in Algebra *Int. J. Educ. Sci.* **8**, 3 p. 485–492.

[17] Weis M Heikamp T and Trommsdorff G, 2013 Gender differences in school achievement: The role of self-regulation *Front. Psychol.* **4**, JUL p. 1–10.

[18] Nizoloman O N, 2013 Relationship between Mathematical Ability and Achievement in Mathematics among Female Secondary School Students in Bayelsa State Nigeria *Procedia - Soc. Behav. Sci.* **106** p. 2230–2240.

[19] Brandell G Leder G and Nyström P, 2007 Gender and Mathematics: Recent development from a Swedish perspective *ZDM - Int. J. Math. Educ.* **39**, 3 p. 235–250.

[20] Bassey S W Joshua M T and Asim A E, 2015 Gender Differences and Mathematics Achievement of Rural Senior Secondary Students in Cross River State , Nigeria *Univ. Calabar, Calabar, Niger.* **2000**, May p. 56–60.

[21] Asante K, 2010 Sex Differences in Mathematics Performance among Senior High Students in Ghana *Gend. Behav.* **8**, 2.

[22] Butt I H and Dogar A H, 2015 Gender Disparity in Mathematics Achievement among the Rural and Urban High School Students in Pakistan Abstract : I . Introduction **34**, 1 p. 93–100.

[23] Ross J A Scott G and Bruce C D, 2012 The Gender Confidence Gap in Fractions Knowledge: Gender Differences in Student Belief-Achievement Relationships *Sch. Sci. Math.* **112**, 5 p. 278–288.

[24] Alkhateeb H M, 2001 Gender Differences in Mathematics Achievement Among High School Students in the United Arab Emirates, 1991-2000 *Sch. Sci. Math.* **101**, 1 p. 5–9.

[25] Hyde J S and Mertz J E, 2009 Gender, culture, and mathematics performance *Proc. Natl. Acad. Sci. U. S. A.* **106**, 37 p. 8801–8807.

[26] Andari I E and Sugiman, 2019 Is there any interaction effects of students’ gender and mathematical disposition towards learning achievement? *J. Phys. Conf. Ser.* **1320**, 1.

[27] Chongo S Osman K and Nayan N A, 2016 Level of Computational Thinking Skills among Secondary Science Student: Variation across Gender and Mathematics Achievement *Int. Counc. Assoc. Sci. Educ.* **31**, 2 p. 159–163.

[28] Awofala A O A and Lawani A O, 2020 Increasing Mathematics Achievement of Senior Secondary School Students through Differentiated Instruction *J. Educ. Sci.* **4**, 1 p. 1.

[29] Sarouphim K M and Chartouny M, 2017 Mathematics education in Lebanon: gender differences in attitudes and achievement *Educ. Stud. Math.* **94**, 1 p. 55–68.

[30] Pratiwi I M Rachman S P D and Ariawan V A N, 2019 Students’ mathematical understanding reviewed by gender through discourse learning assisted by mathematical bet line strategy *J. Phys. Conf. Ser.* **1157**, 4.

[31] Dewi N R Arini F Y Suhito S Mulyono M and Masrukan, 2019 Gender perspective in mathematical thinking ability *J. Phys. Conf. Ser.* **1321**, 2.

[32] Fennema E and Leder G C, 1990 *Mathematics and Gender* Wilson VT: Teachers College Press.

[33] Ojaleye O and Awofala A O A, 2018 Blended learning and problem-based learning instructional strategies as determinants of senior secondary school students’ achievement in Algebra *Int. J. Res. Educ. Sci.* **4**, 2 p. 486–501.

[34] MZ Z A, 2013 Perspektif Gender Dalam Pembelajaran Matematika *Marwah J. Perempuan, Agama dan Jender* **12**, 1 p. 15.

[35] Mullis I V Martin M O Foy P and Arora A, 2012 *TIMSS 2011 international result in mathematics* Chestnut Hill: MA: TIMSS & PIRLS International Study Center.

**Acknowledgments**

We express our gratitude to LPDP for providing financial support to this study. We also thank all students who participated in this study.