



The Science, Technology, Engineering, Mathematics (STEM)-based Problem-Based Learning (PBL) Learning Model on the Numeracy Skills

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ARTICLE INFO

Article history:

Received March 27, 2023

Accepted July 10, 2023

Available online July 25, 2023

Kata Kunci:

Problem Based Learning, STEM, Kemampuan Numerasi

Keywords:

Problem Based Learning, STEM, Numeracy skill



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ABSTRAK

Rendahnya kemampuan numerasi siswa disebabkan karena proses pembelajaran yang dilakukan oleh guru masih berpusat pada penggunaan metode ceramah, sehingga dalam proses pembelajarannya siswa cenderung cepat bosan dan sulit untuk memahami materi yang disajikan oleh guru. Adapun tujuan dari penelitian ini adalah untuk mengidentifikasi dampak signifikan dari penggunaan PBL berbasis STEM terhadap kemampuan numerasi siswa di Kelas V SD. Penelitian ini tergolong kedalam jenis penelitian kuantitatif dengan menggunakan desain *quasi eksperimental* dengan jenis *nonequivalent control group design*. Populasi dalam penelitian ini yakni seluruh siswa kelas V yang berjumlah 201 anak. Penarikan sampel dalam penelitian dilakukan dengan menggunakan teknik *purposive sampling*, dengan jumlah sampel dalam penelitian ini yakni 25 siswa sebagai kelompok kontrol dan 25 siswa sebagai kelompok eksperimen. Pengumpulan data dalam penelitian dilakukan menggunakan metode tes, dengan instrument penelitian berupa tes essay. Data yang diperoleh dalam penelitian kemudian dianalisis melalui uji prasyarat, yang terdiri dari uji normalitas, uji homogenitas, uji hipotesis yang digunakan adalah uji T, dan uji effect size (pengaruh). Hasil analisis data menunjukkan penerapan STEM dalam PBL berpengaruh tinggi terhadap peningkatan kecakapan numerasi siswa. Berdasarkan hasil tersebut maka dapat disimpulkan bahwa penerapan model PBL berbasis STEM memiliki pengaruh yang signifikan terhadap kemampuan numerasi siswa kelas V di Sekolah Dasar.

ABSTRACT

The low numeracy ability of students is because the learning process carried out by the teacher is still centred on the use of the lecture method, so in the learning process, students tend to get bored quickly and find it difficult to understand the material presented by the teacher. This study aimed to identify the significant impact of the use of STEM-based PBL on students' numeracy skills in Grade V SD. This research belongs to the type of quantitative research using a quasi-experimental design with a nonequivalent control group design. The population in this study were all fifth-grade students, totalling 201 children. Sampling in the study was carried out using a purposive sampling technique, with the number of samples in this study, namely 25 students as the control group and 25 as the experimental group. Data collection in the study was carried out using the test method, with the research instrument being an essay test. The data obtained in the study were then analyzed through a prerequisite test, which consisted of the normality test, homogeneity test, hypothesis test using was T-test, and the effect size test. The results of the data analysis show that the application of STEM in PBL has a high effect on improving students' numeracy skills. Based on these results, applying the STEM-based PBL model significantly affects the numeracy abilities of fifth-grade students in elementary schools.

1. INTRODUCTION

Mathematics is one of the subjects that must be taught to students, starting from the basic education level to the university level. Mathematics education is carried out to develop students' problem-solving abilities and the ability to think logically, analytically, systematically, critically, creatively and collaboratively (Phasa, 2020; Vikiantika et al., 2022). Mathematics subjects also put more emphasis on

students' reasoning abilities. One of the important abilities to develop in the mathematics learning process is numeracy skills. Numeracy skills are developed by constructing, understanding and applying mathematical concepts (Ambarwati & Kurniasih, 2021; Nabilah et al., 2023; Wahyuni, 2022). Numeracy skills imply that utilizing mathematics in everyday life is as important as following the correct steps to solve math problems (Anderha & Maskar, 2021; Nasrah et al., 2021). Numeracy is a student's ability to think, analyze and communicate ideas in various aspects of mathematical problems (Rohim, 2021; Ulfa et al., 2022). In addition, numeracy ability is also interpreted as numeracy ability, namely the ability of students to understand, formulate, and solve mathematical problems in books and everyday life (Adinda et al., 2022; Shabrina, 2022). Students with good numeracy skills will have good skills and responsiveness to build self-confidence and become better individuals (Ekowati et al., 2019; Maghfiroh et al., 2021).

However, based on the 2019 PISA survey, Indonesia's numeracy skills are relatively low, placing Indonesia's mathematics skills at 73 out of 80 countries. The learning activities cause students' low numeracy ability in schools that tend to be passive, where teachers tend to apply more lecture methods in the learning process (Devya et al., 2022; Perdana & Suswandari, 2021). Excessive application of the lecture method certainly makes students quickly get bored in receiving concepts and information from the teacher. It aligns with the initial observations at PB Soedirman Islamic Elementary School during PLP 2. The observations show that interest and willingness to learn mathematics are still low, and students' motivation to participate in learning is minimal, so learning outcomes tend to decrease. This is influenced by learning, which is less active, less interesting, and less challenging for children, meaningful experiences for students. In the mathematics learning process, teachers have been unable to train students' critical thinking skills, so students have difficulty applying theory in real-life contexts and solving various problems. If this is allowed to continue, this will have an impact on the decline in students' numeracy skills and not achieving mathematics learning goals.

The application of problem-based learning can be an effort that can be used to improve students' numeracy skills. It is because PBL is learning that focuses on students' activities in facing and solving various real-life problems through an interesting learning process (Diana & Saputri, 2021; Lintang et al., 2022). The PBL learning model allows students to take part in solving a problem by using concrete situations that occur in everyday life (Hasanah et al., 2021; Mawarsari & Wardani, 2022). In its implementation, teachers can provide or propose problems to students, students can pose problems to the teacher, or students can identify problems themselves (Eprilia et al., 2023; Nasoha et al., 2022). This problem is then used as the focus of learning, which involves discussion and exploration for students. The PBL learning model can be applied using a STEM (Science, Technology, Engineering, and Mathematics) approach. STEM is a learning approach that integrates aspects of science, technology, engineering, and mathematics with the aim that students can increase their ability to think responsively in dealing with problems, communicate ideas and observe symptoms through concrete learning activities (Azhari et al., 2022; Musyafak & Agoestanto, 2022; Sari et al., 2021). Learning with a STEM approach focuses on teaching active exploration and involving students in solving problems related to concrete conditions (Furi et al., 2018; Yusuf et al., 2022). The STEM approach to learning aims to develop students' numeracy and technological literacy skills through the ability to read, observe, and apply mathematics and science concepts, as well as improve these skills in finding solutions to problems that are relevant to real life in the STEM science component (Abdi et al., 2021; Wicaksono, 2020).

Previous studies have revealed that applying STEM into the PBL model compared to not involving STEM shows significant differences in creativity scores and student learning outcomes (Furi et al., 2018). Other research results reveal that the STEM-based problem-based learning model increases students' critical thinking abilities (Mustofa et al., 2021). Further research revealed that STEM-based PBL model learning tools effectively trained blind students' creative thinking skills (Sarnita et al., 2019). Based on some of the results of these studies, it can be said that the STEM-based PBL model can significantly positively influence students' thinking skills. In previous research, no studies have specifically discussed the influence of the problem-based learning (PBL) learning model based on science, technology, engineering, and mathematics (STEM) on the numeracy abilities of fifth-grade elementary school students. So, this research focuses on this study to determine the influence of STEM-based PBL on the numeracy abilities of fifth-grade elementary school students.

2. METHOD

This research is classified as quantitative using a Nonequivalent Control Group Design. This research method uses two different samples. The experimental group consisted of students who received mathematics learning on volume material (cubes and blocks) using STEM-based PBL. Meanwhile, the control group included students who received Mathematics learning in the same material but used PBL,

which was not STEM-based. The population of this study included all 201 fifth-grade students. The sample in this study was taken using a purposive sampling technique because sampling was carried out by sample members from the population based on concrete objectives or certain conditions, not random or strata. Then, the sample chosen was class V-C students consisting of 25 students, the experimental group applying STEM-based PBL. Meanwhile, the control group consists of 25 students from class V-H who will apply PBL without STEM-based (conventional).

This research collected data using the test method, with the research instrument as a description test. Numeracy ability assessment is carried out using several indicators, namely applying numbers and symbols related to basic mathematics to be able to help with various aspects of problems experienced in carrying out daily activities, describing the information received in the statistical form in the form of graphs, tables, charts and diagrams, and the results of the translation of the information received are then interpreted to project and make decisions. In this research, primary data has been collected on students' numeracy abilities in Mathematics learning. The completed instrument for students' numeracy skills in Mathematics subjects was designed and then tested using a validity test, calculating the validity test using the product moment formula, using the Microsoft Office Excel 2016 for Windows computer application. Second, a reliability test was carried out using Cronbach's alpha formula. Meanwhile, the prerequisite tests that must be carried out are the normality test, the homogeneity test, the hypothesis test using the T-test, and the effect size test (influence).

3. RESULT AND DISCUSSION

Result

The research began by treating the control group by implementing a non-STEM-based PBL model, while the experimental group received action in the form of a STEM-based PBL model. The post-test value data for the experimental and control groups can be seen in [Table 1](#).

Table 1. Description of Numeracy Ability Data Results

Descriptive statistics	Experiment group	Control group
Mean	78.24	64.52
Median	78.00	64.00
Modus	77.00	60.00
Standard Deviation	4.27	7.77
Minimum	70.00	50.00
Maximum	86.00	77.00

The data in [Table 1](#) shows that members of the experimental group who used STEM-based PBL had better numeracy skills than members of the control group who used the PBL model without STEM. This finding is evident from the average score (M), which shows that the experimental group was 78.24 while the control group was 64.52. After obtaining the post-test score data, the research continued with hypothesis testing, which was carried out to ensure the significance of the impact of the STEM-based PBL model, which required passing the Analysis Requirements Test first. Two data that must be determined in the analysis requirements test are the Normality Test and the Homogeneity Test. Using the Liliefors Test technique and a significance level of 5%, the Normality Test was carried out to determine whether the data was distributed normally or not. The results of the data normality test analysis can be seen in [Table 2](#).

Table 2. Normality Test Results

No.	Group	Sig.	Conclusion
1	Experimental Class Post-Test	0.093	Normal
2	Control Class Post-Test	0.123	Normal

The data in [Table 2](#) relates to the calculations using the Liliefors formula, which shows that the rcount from the post-test results of the experimental group is 0.093, while the rtable at the 5% significance level is 0.173. In this context, if the rcount value from the experimental group's post-test results is smaller than the specified rtable value (rcount < rtable), then the experimental group's numeracy ability data results have a normal distribution. Furthermore, Table 2 shows that the post-test results for the control group were calculated using the Liliefors Test, and the results were 0.123, while the rtable at a significant level of 5% was 0.173. In other words, the number of post-test results for the control group is lower than rtable (rcount < rtable). It shows that the numeracy ability of the control group also follows a normal distribution. The

homogeneity test is carried out after the normality test, determining whether the sample variants resemble each other. It is necessary to carry out Fisher's Test, which is applied to the Microsoft Excel computer program by comparing F_{count} with F_{table} to test the homogeneity of the two samples. F_{count} is obtained by comparing the numerator DK_{n-1} as the maximum variance with the denominator DK_{n-1} as the minimum variance. The data will have a homogeneous distribution if F_{count} is smaller than F_{table} with a significance level of 5% ($F_{count} < F_{table}$). The results of the Homogeneity Test data can be seen in [Table 3](#).

Table 3. Homogeneity Test Results

Sample	Variance	F_{count}	F_{table}
Experiment Group	23.9067	1.319	1.983
Control Group	18.1233		

Data in [Table 3](#) regarding the homogeneity test of the STEM-based PBL group (experimental group) and non-STEM-based PBL (control group) obtained a F_{count} with a score of 1.319. F_{table} , with a significance level of 5%, has a score of 1.983. Because F_{count} is smaller than F_{table} ($F_{count} < F_{table}$), then H_0 is accepted. So, the numeracy abilities of students in the experimental and control groups have a normal and homogeneous distribution. After that, a research hypothesis can be carried out to show that there is a significant influence when implementing STEM-based PBL on the numeracy abilities of fifth-grade students because the two previous tests stated that the data was normally distributed and homogeneous. Then, a t-test was carried out using the independent sample T-test. The test criterion is that if the statistical value of t_{count} is greater than t_{table} ($t_{count} > t_{table}$), then the null hypothesis (H_0) is rejected. Meanwhile, if the statistical value of t_{count} is less than t_{table} ($t_{count} < t_{table}$), then the null hypothesis (H_0) is accepted.

Table 4. T-Test Results

Class	Average	Number of samples	T_{count}
Experiment	78.24	25	8.73
Control	64.52	25	

The data in [Table 4](#) shows that the t_{count} is 8.730, and for t_{table} with a significance level of 5%, it is 2.010. Therefore, it can be stated that t_{count} is greater than t_{table} ($t_{count} > t_{table}$). So H_0 is rejected, and H_1 is accepted. With this statement, it is stated that STEM-based PBL significantly affects students' numeracy abilities. Then, using Cohen's effect size formula, an effect size test was carried out to determine the magnitude of STEM-based PBL's influence on fifth-grade students' numeracy abilities. The criteria for the Effect Size test are said to be high if $D > 0.8$. In [Table 5](#), the value of D (numeracy ability) is 2.188 and $D > 0.8$. Therefore, the application of STEM in PBL to improve students' numeracy skills is High.

Discussion

Based on the results of the data analysis that has been carried out, it can be said that the STEM-based PBL model is very suitable for improving students' numeracy skills. This is because STEM-based PBL can produce better skills than the application of non-STEM-based PBL models. Implementing learning by applying the STEM-based PBL model can make students more dynamic in learning and change the learning styles of students and teachers who are always fixated on textbooks and lecture methods only ([Furi et al., 2018](#); [Rasimin et al., 2021](#); [Yusuf et al., 2022](#)). The STEM-based PBL model is a learning model that integrates science, technology, engineering, and mathematics approaches that actively involve students in learning ([Abdi et al., 2021](#); [Wicaksono, 2020](#)). STEM-based PBL in teaching is carried out by presenting problems and questions, facilitating exploration, initiating conversations, increasing literacy skills and increasing students' creativity in sensitivity to their environment ([Azhari et al., 2022](#); [Musyafak & Agoestanto, 2022](#); [Sari et al., 2021](#)). At the learning stage, STEM-based PBL empowers student activity, coordinated efforts, and cooperative associations in the examination and problem-solving cycle. With PBL learning that combines science, technology, engineering and mathematics (STEM), students express positive responses, gain integrated conceptual and procedural knowledge, and demonstrate active student behavior ([Hasanah et al., 2021](#); [Mawarsari & Wardani, 2022](#)).

Applying PBL in the learning process can support students' high-order thinking processes to provide progress in students' critical thinking skills ([Kusnandar, 2019](#)). Applying learning that focuses on the STEM field requires a learning transformation from a teacher-centered approach to a student-centered, from individual to collaborative, as well as emphasizing creativity and problem-solving abilities in the application of student knowledge ([Diana & Saputri, 2021](#); [Lintang et al., 2022](#)). It is further explained that the learning process utilizing the PBL and STEM models can focus on active exploration teaching and

involving students in solving problems related to concrete conditions (Furi et al., 2018; Yusuf et al., 2022). The STEM approach to learning aims to develop students' numeracy and technological literacy skills through the ability to read, observe, and apply mathematics and science concepts, as well as improve these skills in finding solutions to problems that are relevant to real life in the STEM science component (Abdi et al., 2021; Wicaksono, 2020; Yusuf et al., 2022).

The results obtained in this study align with previous research results, which also revealed that implementing STEM into the PBL model compared to not involving STEM showed significant differences in the value of creativity and student learning outcomes (Furi et al., 2018). Other research results reveal that the STEM-based problem-based learning model increases students' critical thinking abilities (Mustofa et al., 2021). Further research revealed that STEM-based PBL model learning tools effectively trained blind students' creative thinking skills (Sarnita et al., 2019). Based on several research results, it can be said that the STEM-based PBL model can significantly positively influence students' thinking abilities.

4. CONCLUSION

Based on the research data analysis, it can be concluded that STEM-based PBL significantly affects the numeracy abilities of fifth-grade students in elementary schools. Therefore, improving students' numeracy skills can be done by implementing STEM-based PBL. The researcher provides advice to other researchers conducting similar research, namely by applying STEM-based PBL to other competencies and learning materials, so that the impact of the STEM-based PBL model can be seen with a different concept.

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