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Abstract

Numeracy skills are integral to the National Assessment, serving as a benchmark for gauging learning success. In addition to cognitive aspects, the affective aspect crucial in learning is self-efficacy. However, according to PISA 2018 data, the average score for numeracy skills of Indonesian students ranks in the bottom 6. The existing condition of students does not reflect optimal self-efficacy. This reality stems from the lack of meaningful application of the learning model. Consequently, there is a need for a student-centered learning approach, such as the project-based learning (PjBL) model. This study aimed to assess the enhancement of students' numeracy skills and mathematical self-efficacy when taught using the PjBL model. Employing an experimental design with a pretest-posttest control group, the research sample comprises two groups: experimental (PjBL) and control (conventional), each consisting of 50 students. Data collection involved tests and questionnaires, with the numeracy test and self-efficacy questionnaire serving as research instruments. The ANOVA test was applied for data analysis. The results indicate that 1) students' numeracy skills, when exposed to the PjBL model, surpass those of students undergoing conventional learning; 2) students' self-efficacy, influenced by the PjBL model, is superior to that of students engaged in conventional learning.

Introduction

The predominant concern in Indonesian education revolves around numeracy skills, as highlighted by the 2018 Program for International Student Assessment (PISA) results, which revealed a significant need for improvement. Indonesia ranked 73rd out of 79 participating countries, with an average numeracy score of 379, considerably below the global average of 487 (OECD, 2019). This deficiency is further emphasized by educational report cards and initial ability test results, indicating students' subpar level of numeracy skills. In addition, the breakdown of numeracy indicators from the educational report card indicates that 64.44% of students possess basic numeracy skills, 31.11% exhibit proficient numeracy skills and none demonstrate advanced numeracy skills. This distribution underscores the necessity for targeted interventions, as evidenced by a score of 1.63 within the nationally provided score range of 1-3 (Kemendikbud, 2021).

Observations during the initial ability test reveal students' struggles in accurately responding to questions, particularly when applying mathematical concepts to real-life problems. The issue's root lies in their difficulty comprehensively analyzing information within problem scenarios, resulting in inaccuracies in applying mathematical concepts to address presented problems. Similar challenges regarding numeracy skills have been observed in Asian countries, with studies in Vietnam and the Philippines identifying factors such as students' efforts, language skills, family size, and study habits influencing numeracy levels. Meanwhile, in Australia, research suggests that class size can impact numeracy performance and academic achievement (Cao Thi et al., 2023; Tanghal & Tanghal, 2022; Watson et al., 2016).

Addressing these challenges requires attention to students' affective aspects, particularly their self-efficacy. Interviews with teachers indicate low self-efficacy among students, manifested in task avoidance, self-doubt, and reluctance to tackle challenging assignments. This aligns with the findings of Atsila and Setyawan (2022), who identified a significant lack of confidence impacting students' learning outcomes. Implementing effective learning models is crucial to address these challenges. The Project-Based Learning (PjBL) model emerges as a promising strategy. Research by Rohman and Guntur (2022) suggested that the inadequate application of learning models contributes to persistently low numeracy skills, and the PjBL model, in particular, is recommended by the government for improving numeracy skills.

The PjBL model offers advantages such as fostering numeracy skills through real-world problem-solving and tangible product generation. It also enhances students' self-efficacy by emphasizing direct learning experiences. Numerous studies support the positive impact of the PjBL model on numeracy skills, problem-solving abilities, and students' confidence in presenting project outcomes (Ladyawati & Rahayu, 2022; Larmer et al., 2015; Mahasneh & Alwan, 2018).

While existing research has explored numeracy skills and self-efficacy using the PjBL model, there is a need for more focused investigations on junior high school students. Previous studies predominantly concentrate on elementary and high school students, making this current research essential for assessing numeracy skills and self-efficacy in junior high school students using the PjBL model.

Method

The methodology employed in this study is a quantitative approach utilizing a pretest-posttest control group design. This design was selected due to including a single sample group, specifically the experimental group. The research included 50 students in both the experimental and control classes. The experimental class received instruction using the PjBL model, while the control class underwent conventional teaching methods. Prior to the commencement of the learning sessions, students were administered a numeracy pretest and a self-efficacy questionnaire. Subsequently, following the learning sessions, a numeracy posttest and a self-efficacy questionnaire were administered to assess students' numeracy comprehension skills and self-efficacy in each class.

The research employed a numeracy test and a self-efficacy questionnaire as the instruments. In terms of instructional materials, a Lesson Plan, Student Worksheets, and project materials for constructing polyhedron materials were developed. The data for analysis were derived from pretest and posttest results, subjected to an ANOVA test. The hypotheses for this study are (1) Students' numeracy skills through PjBL are better than to students' numeracy skills using conventional methods, and (2) Students' self-efficacy through PjBL is better than students' self-efficacy using conventional methods.

Results

The data obtained from the study comprises quantitative data explicitly about numeracy ability and student self-efficacy. Before implementing the PjBL model in the experimental class and conventional learning in the control class, each class underwent a pretest to assess the initial similarity in numeracy ability and self-efficacy. Once this similarity was confirmed, the subsequent step involved conducting an ANOVA test to ascertain differences in numeracy ability and self-efficacy. Data analysis encompassed tests for normality, homogeneity, and ANOVA. The following section presents the outcomes of analyzing students' numeracy skills and self-efficacy.

Data Analysis of Students' Numeracy Skills

Pretest Data Analysis of Numeracy Ability

The results of the normality test for the pretest data are displayed in Table 1.

Table 1. Data for the Normality Test of the Mean Scores of the Numeracy Pretest and Post-test

Result	Class	*Kolmogorov-Smirnov*[a]		
		Statistic	df	Sig.
Pretest of Numeracy Skills	Control	0.124	50	0.052*
	Experiment	0.124	50	0.053*

Table 1 presents the results of the normality test of pretest scores for students' numeracy skills in both classes ($p> 0.05$). Subsequently, a homogeneity test was conducted. The results of the analysis of variance for homogeneity of pretest data on numeracy skills between the experimental and control classes are presented in Table 2.

Table 2. The Results of Variance Homogeneity Test for Pretest Data of Numeracy Ability

Skills Aspect	*Levene Statistic*	df1	df2	Sig.
Pretest of Numeracy Skills	0.137	1	98	0.712

Table 2 demonstrates H0 is accepted ($p=0.712$), indicating that the numeracy pretest data in both classes exhibit homogeneous variances. Given the normal distribution of pretest data on numeracy skills in both the experimental and control classes and the homogeneity of variances, the analysis proceeds with t-test. The pretest score mean of the difference test is conducted to ascertain whether there is a significant difference in pretest abilities between the experimental class and the control class regarding numeracy skills. The outcomes of the mean difference test for the numeracy pretest data are presented in Table 3.

Table 3. The Mean of the Difference Test Results of Pretest Data of Numeracy Skills

t-test for Equality of Means		
t	df	Sig. (2-tailed)
0.229	98	0.820

Table 3 indicates that H0 is accepted (p=0.820). It implies that there is no statistically significant difference between the pretest numeracy skills of the experimental class and the control class. Thus, it can be concluded that these two classes exhibit similar initial abilities.

Post-test Data Analysis of Numeracy Skills

After implementing the PjBL model in the experimental class and conventional teaching in the control class, each group underwent a posttest to evaluate students' numeracy skills. Prior to conducting the ANOVA test, a normality test for the post-test data in both the experimental and control classes was administered. The outcomes of the normality analysis using the Kolmogorov-Smirnov test for the post-test data in the experimental and control classes are presented in Table 4.

Table 4. The Normality Test Results of Post-test Data for Numeracy Skills

Result	Class	*Kolmogorov-Smirnov[a]*		
		Statistic	Df	Sig.
Post-test of Numeracy Skills	Control	0.122	50	0.059
	Experiment	0.123	50	0.058

Table 4 shows the posttest results of numeracy skills among students in both the experimental and control classes are not significantly different (p>0.05). Consequently, H0 is accepted, indicating that the post-test data on numeracy skills in the experimental and control classes are drawn from normally distributed populations. Subsequently, a homogeneity test is conducted, as outlined in Table 5.

Table 5. The Results of Variance Homogeneity Test Data of Numeracy Skills of Post-test

Skills Aspect	*Levene Statistic*	df1	df2	Sig.
Post-test of Numeracy Skills	0.087	1	98	0.768

Table 5 present the results of variance homogeneity test data of numeracy skills of post-test (p=0.788). Consequently, H0 is accepted, indicating that both classes' posttest data on numeracy skills exhibit homogeneous variances. The preceding tests established that the post-test data on numeracy skills in the experimental and control classes are typically distributed, and the variances in both classes were homogeneous. Therefore, the ANOVA test was subsequently conducted. The test for the average difference in posttest scores was carried out to determine whether the numeracy skills of students who received instruction with the PjBL model are superior to those who received conventional teaching. The hypothesis formulation is as follows.

H_0 : $\mu_1 = \mu_2$ The numeracy skills are similar between students who received the PjBL model and those who underwent conventional learning.

H_1 : $\mu_1 > \mu_2$ The numeracy skills are similar between students who received the PjBL model and those who underwent conventional learning.

The results of the mean difference test for post-test data on numeracy skills are presented in Table 6.

Table 6. The ANOVA Test Results of Post-test Data of Numeracy Skills

	Sum of Squares	df	*Mean Square*	F	Sig.
Between Groups	954.810	1	954.810	4.223	0.043
Within Groups	22155.780	98	226.079		
Total	23110.590	99			

Table 6 indicates H0 is rejected, and H1 is accepted (p=0.043). It signifies that the numeracy skills of students who underwent the PjBL model are superior to those of students who received conventional learning in terms of overall student performance. The results of data analysis, encompassing both descriptive analysis and statistical tests post-learning, reveal that the numeracy skills of students in the experimental class surpass those of students in the control class. The differential treatment in the form of the PjBL model is identified as one of the factors contributing to the enhanced numeracy skills of students in the experimental class. The PjBL model, a problem-based learning approach rooted in everyday life, culminates in creating tangible products after the learning process. Problem-solving within real-world contexts is an integral aspect of numeracy skills. The efficacy of the PjBL model in improving numeracy skills is attributed to its ability to heighten student engagement and activity in acquiring knowledge. According to Bruner (1991) when students actively formulate ideas to acquire knowledge, the resulting knowledge is high quality.

In the phase of designing project planning, the teacher ensured that each student was grouped and acquainted with the project-making procedures. Student cooperation was encouraged during discussions. Nurcahyono (2023) research yielded findings indicating that the PjBL model improves numeracy skills by incorporating real-life problems. This approach fosters a sense of satisfaction and motivation among students, inspiring them to engage in learning activities actively. Sumarno et al. (2022) research similarly concluded that students using the PjBL model exhibited enhanced numeracy skills compared to those utilizing direct learning. Students' attitudes toward applying the PjBL model also demonstrated a positive outlook. Serin (2019) revealed that engaging in the PBL strategy offers students numerous advantages, including influencing goal orientation, boosting curiosity, enhancing engagement, and promoting mastery of new knowledge.

Based on the research results, the PjBL model exhibits advantages in enhancing students' numeracy skills. Students grasp the material being studied and actively generate ideas during project planning. In this study, the teacher's efforts align with the stages of the PjBL model, commencing with formulating essential questions—the teacher endeavors to guide students in formulating ideas accurately, thereby achieving the intended learning objectives. Additionally, the teacher employs questioning techniques to prompt students to plan ideas effectively. Videos depicting real-life events related to the material are presented to the students by the teacher. Research conducted by Ralph (2016) suggested that there is a positive association between PjBL and content knowledge learning. Rehman et al. (2023) concluded that the initial step in the PjBL model, involving the formulation of questions related to the material, is effectively applied to facilitate learning. Yustinaningrum (2019) research similarly concluded that the PjBL model's initiation with essential questions empowers students to undertake the steps necessary for productive work activities.

The fourth step in the PjBL model involves monitoring project development, which encompasses teachers presenting challenges to prompt students to complete projects and assisting students encountering difficulties in numeracy skills. Research findings by Azizahwati et al. (2018) supported this approach, concluding that through the PjBL model, students can reconstruct previously learned concepts and apply them to solve mathematical problems. Similarly, research by Baharuddin et al. (2021) revealed that the PjBL model enables students to develop their numeracy skills further and apply them to complete projects successfully.

Student engagement in PjBL is highly active, driven by the challenges presented in the Student Worksheets that students must collectively address during group learning. The discussion of Student Worksheets within student groups promotes interaction, fostering a collaborative environment where students jointly construct knowledge and deepen their understanding.

Data Analysis of Student’s Self Efficacy

Students' self-efficacy is assessed through questionnaires administered before and after the learning process—the questionnaire, comprising 28 closed-form questions, gauges students' self-efficacy. Before implementing the PjBL model in the experimental class and conventional learning in the control class, both took a pretest to evaluate the initial similarity of students' self-efficacy toward learning. The subsequent section analyzes the results obtained from the self-efficacy questionnaire.

Data Analysis of the Self Efficacy Pretest

The results of the normality analysis of students' pretest data with the Kolmogorov-Smirnov test are presented in Table 7.

Table 7. The Results of Data Normality Test of Self Efficacy Pretest

Results	Class	*Kolmogorov-Smirnov*[a]		
		Statistic	df	Sig.
Pretest of Self Efficacy questionnaire	Control	0.079	50	0.200
	Experiment	0.120	50	0.070

Table 7 shows the results of data normality test of self efficacy pretest ($p>0.05$). Consequently, H0 is accepted, indicating that the pretest data for self-efficacy in the experimental and control classes originate from a normally distributed population. Subsequently, a homogeneity test was conducted, yielding the results in Table 8.

Table 8. The Test of Homogeneity of Variance Data of Self Efficacy Pretest

Skills aspect	*Levene Statistic*	df1	df2	Sig.
Self Efficacy Pretest	1.143	1	98	0.288

Table 8 presents the results of the test of homogeneity of variance data of self efficacy pretest (p=0.288). Consequently, H0 is accepted, indicating that the pretest self-efficacy data in both classes exhibit homogeneous variance. The preceding test results demonstrate that the pretest self-efficacy data for the experimental and control classes are normally distributed, and the variance in both classes is also homogeneous. Therefore, the t-test is subsequently conducted to determine whether there is a significant difference or similarity between the experimental and control classes' pretest abilities in terms of self-efficacy. The results of the mean difference test of the self-efficacy pretest are presented in Table 9.

Table. 9. The Results of Mean Difference Test Data of Self Efficacy Pretest

t-test for Equality of Means		
t	Df	Sig. (2-tailed)
0.750	98	0.455

Table 9 indicates H0 is accepted (p=0.455). It implies that there is no statistically significant difference between the pretest self-efficacy of the experimental class and the control class. Therefore, it can be concluded that these two classes have similar initial abilities.

Data Analysis of Self Efficacy Post-test

Based on the self-efficacy posttest results obtained by students in the experimental and control classes, it can be generally inferred that self-efficacy in the experimental class is superior to that in the control class. However, further statistical testing is required to ascertain the difference in self-efficacy between the two classes. The results of the normality analysis, conducted using the Kolmogorov-Smirnov test for the post-test data of the experimental and control classes, are presented in Table 10.

Table 10. The Results of Data Normality Test of Self Efficacy Post-test

Results	Class	*Kolmogorov-Smirnov*[a]		
		Statistic	df	Sig.
Self efficacy Post-test	Control	0.091	50	0.200
	Experiment	0.109	50	0.196

Based on Table 10, it is evident that the results of the self-efficacy post-test for both experimental and control class students are not significant (p>0.05). Consequently, H0 is accepted, indicating that the posttest self-efficacy data in both the experimental and control classes originate from a normally distributed population. Additionally, the outcomes of the homogeneity analysis of variance for the self-efficacy post-test data in the experimental and control classes are presented in Table 11.

Table 11. The Test of Variance Homogeneity Data of Self efficacy Post-test

Skills Aspect	*Levene Statistic*	df1	df2	Sig.
Self efficacy Post-test	2.723	1	98	0.102

These results in Table 11 indicate that H0 is accepted (p=0.102), indicating that the self-efficacy post-test data in both classes exhibit homogeneous variance. The preceding test results demonstrate that the self-efficacy posttest data for the experimental and control classes are normally distributed, and the variance in both classes is also homogeneous. Therefore, the statistical test used to examine the average difference between the two samples is a parametric test, namely the ANOVA test. The mean difference test of post-test score is conducted to determine whether students' self-efficacy with the PjBL model is superior to that of students who receive conventional learning.

The formulation of hypothesis 2 is as follows:

$H_0 : \mu_1 = \mu_2$ There is no difference in the self-efficacy of students who receive the PjBL model compared to students who undergo conventional learning.

$H_1 : \mu_1 > \mu_2$ The self-efficacy of students who received the PjBL model was superior to that of students who underwent conventional learning.

The results of the mean difference test of self efficacy post-test data are presented in Table 12.

Table 12. The Test of the Mean difference of Self Efficacy Posttest Data

	Sum of Squares	df	*Mean Square*	F	Sig.
Between Groups	806.560	1	806.560	37.018	0.000
Within Groups	2135.280	98	21.789		
Total	2941.840	99			

Table 12 indicates that H0 is rejected (p=0.00), and consequently, H1 is accepted. It implies that the self-efficacy of students who undergo learning with the PjBL model is superior to that of students who undergo conventional learning in terms of overall student performance.

Discussion and Conclusion

The study's findings indicate a notable enhancement in the self-efficacy of students who underwent Project-based Learning (PBL) compared to those subjected to conventional learning. The diminished self-efficacy observed in the control group can be attributed to the monotonous learning model, resulting in disinterest during the learning process. This aligns with Reid-Griffin et al. (2020) assertion that PBL positively influences students' self-efficacy. Notably, the initial phase of the PBL model, involving project planning and scheduling, necessitates adept teacher facilitation to engage students in generating project ideas relevant to the material.

Teachers play a pivotal role in fostering self-efficacy by providing students opportunities to articulate the material's significance and designing a project sequence that aligns with the curriculum. Sagala and Widyastuti (2021) research corroborate that the PBL model encourages students to establish connections between various learned concepts. However, challenges may arise for some students relating the project idea plan to the concepts they are expected to grasp, as Wan (2021) study highlights. Wan concluded that PBL, with its guided stages for student problem-solving activities, significantly enhances self-efficacy and facilitates the retention of collaboratively acquired concepts.

In the subsequent step, students showcased their problem-solving prowess using Student Worksheets. However, unlike the initial phase, some students resisted addressing pivotal questions. The resistance dissipated as the project work schedule was comprehended in the third step, marking the emergence of students' self-efficacy, as evidenced by decreased reliance on teachers and peers. The fourth step revealed a conducive learning environment, affirming the proficiency and self-efficacy of students. This collaborative spirit aligns with Helle et al. (2006) assertion that collaboration is a crucial characteristic of PBL, with students working collectively to complete tasks.

During the subsequent steps of the PBL model—analyzing and evaluating project results—the teacher was crucial in guiding students to interpret and conclude project outcomes using appropriate concepts and presentations. Some students encountered challenges in drawing precise conclusions from the acquired concepts, indicating deficiencies in the analysis process. This finding resonates with Wasimin (2022) research, which suggests that the final stages of PBL may not significantly enhance self-efficacy if students struggle to draw appropriate conclusions. Aprilia et al. (2023) research further supports this, emphasizing that the ability to draw accurate and thoughtful conclusions from learned concepts indicates solid self-efficacy after PBL learning.

Based on the data analysis and discussion, students' numeracy skills through the PjBL model are superior to students who undergo conventional learning. Additionally, students' self-efficacy through the PjBL model is better than students who experience conventional learning. Therefore, the implementation of the PjBL model is effective in enhancing both numeracy skills and student self-efficacy.

The PjBL model in teaching mathematics to junior high school students should be further developed to enhance numeracy and self-efficacy. The author suggests that mathematics teachers consider adopting the PjBL model as an alternative learning approach, given its effectiveness in improving numeracy skills. Moreover, it is noteworthy that the government recommends the PjBL model for implementation in the independent curriculum. For future research, it is encouraged to explore the application of the PjBL model in other subjects and assess its impact on various aspects of understanding mathematical concepts.

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