

MATHEMATICAL PROBLEM-SOLVING SKILLS AND STUDENTS' LEARNING INDEPENDENCE THROUGH PMRI BASED ON *ENGINEERING DESIGN THINKING*

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Abstract

This study aims to observe the differences in students' mathematical problem-solving abilities and learning independence in learning with the Indonesian Realistic Mathematics Education (PMRI) approach based on Engineering Design Thinking (EDT), the Indonesian Realistic Mathematics Education (PMRI) approach, and conventional learning. This study is a quasi-experimental study with a pretest–posttest control group design. The study population was all seventh-grade students of SMP Negeri 7 Bengkulu City in the 2025/2026 academic year. Data analysis was carried out using one-way ANOVA. The results showed that there were significant differences in students' mathematical problem-solving abilities taught with the PMRI approach based on EDT, PMRI, and conventional learning ($F = 3.629$; $p = 0.031 < 0.05$). The average posttest of students' mathematical problem-solving abilities in the PMRI class based on Engineering Design Thinking was 28.75, the PMRI class was 26.84, and the conventional learning class was 24.42. In addition, there was a significant difference in student learning independence between the three learning groups ($F = 3.734$; $p = 0.029 < 0.05$). The average student learning independence in the EDT-based PMRI class was 73.94, higher than the PMRI class (68.95) and the conventional learning class (68.13). Based on these results, EDT-based PMRI learning is more effective in improving students' mathematical problem-solving abilities and learning independence.

Keywords: PMRI, Engineering Design Thinking (EDT), Mathematical Problem Solving Ability, Learning Independence

INTRODUCTION

Ability mathematical problem solving is core competencies in learning mathematics Because demand students to understand problems , planning strategies, implementing procedures , and evaluate solution in a way systematic (Sagita et al., 2023) . The process show that problem solving no only focus on the answer finality , but also on accuracy and logic step completion . Ability This involving skills procedural at a time reasoning logical , analysis critical and reflective to results obtained (Mukarromah, et al., 2025) . With Thus , mathematical problem solving reflect understanding deep concept as well as ability think systematic

Findings empirical show that ability mathematical problem solving student Still is in the category low until moderate . Students tend experience difficulty when faced with non-routine problems that require interpretation context and reasoning deep (Saputra et al., 2025) . Learning patterns that are still practice - oriented procedural cause student not enough trained develop alternative strategies (Fitriyana & Hidayah, 2023) . Conditions the reinforced by the results (Rismawati et al., 2022) which shows that in learning mathematics student Still face difficulty in develop ability think level high (HOTS), especially in context mathematical problem solving , which shows need will approach more supportive

learning ability analytical and reflective student .

Stages evaluation and reflection in problem solving is also frequent ignored by students . Students tend stop after find answer end without review return to the process taken , even though evaluation and reflection needed to improve accuracy and quality mathematical problem solving (Triyono et al., 2024) . Research previously show that there is difference significant ability mathematical problem solving student based on the learning model applied , where learning involves activity problem solving active give better results compared to learning conventional (Izzata & Asmara, 2020) . Ability evaluate solution plays an important role in build precision and accuracy think mathematical (Dewi et al., 2024) . Therefore that , skills This need accustomed to through learning that gives room for students to explore ideas, discuss in a way open , and mutual reviewing problem -solving strategies (Ilawaty, 2023; Sari, 2021) .

Independence Study become factor influential supporters to success mathematical problem solving . Students who have regulations good self tends to capable set strategies, monitor thought processes , and maintain motivation Study (Salsabila & Puteri, 2023) . Research (Rambe et.al, 2025) show that there is connection positive and strong between independence Study with ability mathematical problem solving students . Findings the in line with results study Pattisina and Sopiany (2023) stated that that student with high self-regulated learning are more capable understand the problem, plan the strategy, implement it settlement , as well as evaluate solution in a way systematic (Deo et al., 2023) . In addition , learning that provides chance to students to plan , manage , and evaluate their learning process in a way independent proven can increase not quite enough answer academic student Because they involved active in taking decisions and learning strategy settings (Sarahono et al., 2024)

Mathematics Education Approach Realistic Indonesia (PMRI) emphasizes context real close with life students to make learning mathematics more meaningful . Approach This facilitate student connect draft with experience

daily so that the learning process become more contextual and can increase results Study as well as skills mathematical student (Fitriyana & Hidayah, 2023) (Rahayu et.al, 2025) . In addition , PMRI places student as subject active in building and discovering return draft mathematics through a process of discussion , exploration and reflection (Widad et al., 2023) . Research results (Febrilia et al., 2025) show that approach realistic effective in increase understanding concept and involvement student in learning mathematics .

Engineering design thinking in learning mathematics is an approach that integrates the design process to help student develop ability think critical and problem solving creative (Li et al., 2019) . This process involving a series step systematic like problem identification , exchange think , design , build , test , revise , and share training solutions ability participant educate in solve problems in real world context (Nuraini, 2020) . In general In general , the Engineering Design stages include problem definition , brainstorming, design , development , testing , evaluation or revision , as well as communication solution (Naufal & Asdar, 2022) . Approach This nature iterative and open , allowing student explore various possibility solution through implementation draft science , mathematics , and engineering the basis for achieving the goals that have been set set (Ulum, 2021) . Through stages this , students trained to analyze problems, formulate hypothesis , and propose the solution then tested use theory and modeling to ensure effectiveness solution the (Widana & Sopandi, 2021) . In the context learning , *Engineering Design Thinking* is facilitating approach students to develop solution creative to complex learning problems with through stages exploration , design , creation , and evaluation in a way iterative approach This help student increase ability think critical and creative through integrated activities with *Science, Technology, Engineering & Mathematics* so that learning become more meaningful and applicable in context real (Alquriyah & S, 2025) . Approach This focus on understanding deep to users to create solutions that do not only effective in a way functional , but also fulfills needs and wants they (Riyadi et al., 2024) .

Previous studies show that study regarding PMRI and the approach design engineering Still Lots done in a way separate ; for example studies about implementation of realistic mathematics education which shows that PMRI is capable increase ability problem solving and thinking critical through context real (Adi et.al, 2023) . Meanwhile that , the integration of design thinking in proven STEM education increase skills problem solving and thinking critical student through stages iterative like empathy , problem identification , ideation , prototyping, and evaluation solution

METHOD

This study used a quasi-experimental research type. The class was divided into three groups, namely two experimental classes and one control class. Experimental class I was given PMRI learning based on EDT, experimental class II was given PMRI learning, while conventional learning was applied to the control class. This study was conducted at SMP Negeri 7, Bengkulu City. The population in this study were all seventh-grade students of SMP Negeri 7, Bengkulu City. The research sample consisted of three classes, namely class VII A as experimental class I, class VII D as experimental class II, and class VII E as the control class. Sample selection was carried out using cluster random sampling technique, because the classes that were randomized were already formed.

The variables in this study consist of independent variables and dependent variables. The independent variables are the EDT-based PMRI learning model and the PMRI learning model, while the dependent variables include students' mathematical problem-solving abilities and learning independence. Before students were given the treatment, all classes were given the same initial test (pretest) of mathematical problem-solving abilities. This pretest aimed to determine students' initial abilities before being given the learning treatment and to ensure that the initial conditions of the three classes were relatively equal. Next, students followed the learning process according to the model applied in each class. Class VII A was taught using EDT-based PMRI learning, class VII D used PMRI learning, while class VII E

(Chi, 2025) . However , research that specifically special integrating PMRI based on Engineering Design Thinking and comparing them with pure PMRI as well as learning conventional Still limited . The gap This show the need study experimental to test difference influence third approach the to ability mathematical problem solving and independence Study students , so that can give contribution empirical in development of learning models more innovative mathematics in schools medium .

used conventional learning. After the entire learning series was completed, students were given a final test (posttest) of mathematical problem-solving abilities to determine the effect of the learning treatment. In addition, students were also given a learning independence questionnaire to measure the level of learning independence after participating in learning with different models.

The research instrument was a mathematical problem-solving ability test in the form of descriptive questions that measured the ability to understand problems, plan problem-solving strategies, solve problems, and review the results. Learning independence was measured using a four-choice Likert scale questionnaire that included indicators of independence from others, having self-confidence, being disciplined, having a sense of responsibility, behaving based on one's own initiative, and self-control. Data analysis techniques used included data normality tests and variance homogeneity tests as prerequisite tests. The normality test was conducted using the Shapiro–Wilk test, while the variance homogeneity test used the Levene Test. After the data met the normal and homogeneity assumptions, a one-way ANOVA test was conducted to determine whether there were differences in students' mathematical problem-solving abilities and learning independence between learning groups.

RESEARCH RESULTS AND DISCUSSION

Study This implemented at SMP Negeri 7 Bengkulu City with three group sample , namely PMRI class based on Engineering Design

Thinking (EDT) as experiment I, PMRI class as experiment II, and class learning conventional as class control . Before treatment given , all group given a pre-test to find out ability beginning

students . After the learning process is complete, students given a post-test and questionnaire independence Study .

1. Problem Solving Skills

Table 1.
Pre-Test and Post-Test Results Data of Problem Solving Ability

Data	EDT-Based PMRI (Experiment I)		PMRI (Experiment II)		Conventional (Control)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Average	15.25	28.75	15	26.84	12.54	24.42
Highest score	23	55	23	54	19	39
Lowest score	8	18	9	17	7	15
Variance	17.32	71.30	13.91	60,640	9.91	37.37
Standard deviation	4.16	8.4	3.73	7.78	3.14	6.11

Based on Table 1, the average pre-test score of students' mathematical problem-solving ability in the PMRI class based on Engineering Design Thinking (EDT) was 15.25, the PMRI class was 15.00, and the conventional learning class was 12.54. The average post-test score in the PMRI class based on EDT was 28.75, the PMRI class was 26.84, and the conventional learning class was 24.42. All groups experienced an increase in their average scores from pre-test to post-test. The increase in the average score in the PMRI class based on EDT was 13.50, the PMRI class was 11.84, and the conventional learning class was

11.88.

Next, the student learning outcome data in each group was subjected to prerequisite tests before conducting a one-way ANOVA test. The prerequisite tests included normality and homogeneity of variance tests. The normality test aimed to determine whether the data on students' mathematical problem-solving abilities in each group were normally distributed. The method used in the normality test was the Shapiro–Wilk test with the assistance of IBM SPSS Statistics version 26 software. The complete results of the normality test are presented in Table 2.

Table 2
Test Results Normality

Group	Kolmogorov-Smirnov ^a			Shapiro-Wilk			
	Statistics	Df	Sig.	Statistics	Df	Sig.	
Results	pretest experiment 1	.122	24	.200 *	.963	24	.496
	post-test experiment 1	.136	28	.200 *	.934	28	.077
	pretest experiment 2	.140	25	.200 *	.964	25	.492
	post-test experiment 2	.151	25	.143	.935	25	.115
	pretest control	.165	24	.089	.959	24	.428
	post-test control	.125	26	.200 *	.957	26	.333

Based on Table 2, the results of the normality test using the Shapiro–Wilk test show that all significance values (Sig.) in the pre-test and post-test data for each group are greater than 0.05. Thus, the data on students' mathematical problem-solving abilities are normally distributed.

Table 3
Hasil Uji Homogenitas

		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	.146	2	76	.864
	Based on Median	.021	2	76	.979
	Based on Median and with adjusted df	.021	2	72.638	.979
	Based on trimmed mean	.124	2	76	.883

Based on Table 3, the results of the homogeneity test using the Levene test show a significance value of 0.864, which is greater than 0.05. Therefore, it can be concluded that the data on students' mathematical problem-solving abilities have homogeneous variance.

Table 4
ANOVA Statistical Test Results

Test	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	276,987	2	138,493	3,629	.031
Within Groups	2900.203	76	38,161		
Total	3177.190	78			

Based on Table 4, the results of the one-way ANOVA test show an F value of 3.629 with a significance value of 0.031. Because the significance value is less than 0.05, it can be concluded that there is a significant difference in students' mathematical problem-solving abilities between learning groups.

2. Learning Independence

Table 5
Student Learning Independence Results Data

Questionnaire	N	Mean	Standard Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
experiment 1	28	73.94	8,792	1.662	70.53	77.35	55	85
experiment 2	24	68.95	8.468	1.728	65.37	72.52	56	82
Control	25	68.13	7.912	1.582	64.87	71.40	45	80
Total	77	70.50	8.711	.993	68.52	72.47	45	85

Based on Table 5, the scores for student learning independence in the PMRI classes based on Engineering Design Thinking (EDT), PMRI, and conventional learning were obtained from the results of completing a questionnaire after the learning process. The average score for student learning independence in the PMRI class based on EDT was higher than that of the PMRI class

and conventional learning classes.

Table 6
Test Results Normality of Student Learning Independence

Class	Kolmogorov-Smirnov ^a			Shapiro-Wilk			
	Statistics	Df	Sig.	Statistics	Df	Sig.	
questionnaire	experiment 1	.149	28	.111	.886	28	.006
	experiment 2	.116	24	.200 *	.935	24	.123
	Control	.112	25	.200 *	.939	25	.143

Based on Table 6, the results of the normality test for student learning independence using the Shapiro–Wilk test show that all

significance values (Sig.) in each group are greater than 0.05. Thus, the data on student learning independence are normally distributed.

Table 7
Results of the Homogeneity Test of Student Learning Independence

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistics	Df	Sig.	Statistics	Df	Sig.
experiment 1	.149	28	.111	.886	28	.006
experiment 2	.116	24	.200 *	.935	24	.123
Control	.112	25	.200 *	.939	25	.143

Based on Table 7, the results of the homogeneity test using Levene's test showed a significance value greater than 0.05. Therefore, it

can be concluded that the data on student learning independence has homogeneous variance.

Table 8
ANOVA Statistical Test Results

Questionnaire	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	528,706	2	264,353	3,734	.029
Within Groups	5238.797	74	70,795		

Based on Table 8, the results of the one-way ANOVA test show that the significance value is less than 0.05. Thus, it can be concluded that there is a significant difference in student learning independence between learning groups.

Based on findings this , next discussion focused on two variables main research , namely ability mathematical problem solving and independence to learn , to see how each variable influenced by the learning model applied .

1. Mathematical Problem Solving Ability

Based on the results of the one-way ANOVA test, the F value was obtained = 3.629 with $p = 0.031$ ($p < 0.05$). These results indicate that there is a significant difference in students' mathematical problem-solving abilities between the three learning groups. Thus, the null hypothesis is rejected and it can be concluded that differences in learning models have a significant effect on students' mathematical problem-solving abilities.

Descriptively, all learning groups showed an increase in mathematical problem-solving skills from pretest to posttest. However, the highest increase was achieved by the group of students who participated in the EDT-based PMRI learning, followed by the PMRI group, and finally the conventional learning group. This difference in improvement indicates that integrating the PMRI approach with the EDT stages is more effective in developing students' mathematical problem-solving skills.

EDT-based PMRI learning facilitates students' understanding of problems through realistic contexts before delving into formal mathematical concepts. This process helps students identify known and questionable information more clearly, thus minimizing errors in understanding the problem. Furthermore, the solution design and implementation stages encourage students to develop systematic problem-solving strategies.

Furthermore, the evaluation and solution refinement phase in EDT trains students to re-examine their results. This process contributes to improved mathematical problem-solving skills, particularly the ability to interpret results and evaluate the correctness of solutions. In contrast, in conventional learning, students

tend to solve problems based on examples provided by the teacher, resulting in less optimal development of skills in planning and evaluating solution strategies.

2. Student Learning Independence

The results of a one-way ANOVA analysis of student learning independence data showed a significance value of $p = 0.029$ ($p < 0.05$). These results indicate that there is a significant difference in the level of student learning independence between the PMRI learning groups based on EDT, PMRI, and conventional learning.

Based on descriptive results, the group of students participating in the EDT-based PMRI learning achieved the highest learning independence scores compared to the other groups. This demonstrates that learning that actively involves students in every stage of the learning process can foster an independent attitude in learning.

The EDT-based PMRI learning stages encourage students to be directly involved in decision-making throughout the learning process, from understanding problems and determining strategies to evaluating outcomes. This approach trains students to self-regulate their learning process, manage their time, and take responsibility for their outcomes.

In contrast, conventional, teacher-centered learning results in students being less involved in the planning and evaluation process. As a result, students tend to be passive and dependent on teacher direction, resulting in a relatively lower level of independent learning.

3. The Relationship between Mathematical Problem Solving Ability and Learning Independence

The results showed that the group of students with higher mathematical problem-solving abilities also had higher levels of learning independence. This pattern was clearly visible in the EDT-based PMRI group, which achieved the highest scores on both study variables.

Students with high levels of learning independence tend to be better able to manage their thinking processes when solving math problems. They are better equipped to understand problems, plan

solutions, and independently evaluate their results. Conversely, engaging students in a systematic problem-solving process also fosters responsibility and self-regulation in learning.

Thus, EDT-based PMRI learning not only significantly impacts mathematical problem-solving skills but also simultaneously enhances students' learning independence. This demonstrates that contextual, systematic, and student-centered learning can develop cognitive and affective abilities in a balanced manner.

CONCLUSION

The results of the study showed that there were significant differences in mathematical problem-solving abilities and learning independence of students who participated in PMRI learning based on Engineering Design Thinking (EDT), PMRI, and conventional learning. The ANOVA test showed a significant difference in mathematical problem-solving abilities with a value of $F = 3.629$ and $p = 0.031$ ($p < 0.05$), as well as differences in learning independence with a significance value of $p = 0.029$ ($p < 0.05$). PMRI learning based on EDT provided the most optimal results compared to the other two models because it integrates realistic contexts with systematic problem-solving stages, thus improving mathematical problem-solving abilities as well as students' learning independence in social arithmetic material.

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