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The Impact of DMR Implementation on Students' Mathematical Problem-Solving Ability and Self-Efficacy

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Abstract

Background of study: Mathematical problem-solving skills and self-efficacy are crucial components in mathematics learning. Low levels of these two skills can cause students to struggle with non-routine problems.
Aims and scope of paper: To determine the impact of implementing the Multi-Representation Discourse (DMR) model on students' mathematical problem-solving abilities and self-efficacy.
Methods: This quasi-experimental study employed a posttest-only control group design. The population included all eighth-grade junior high school students in Bandar Lampung City in the 2024/2025 academic year. The sampling technique used was cluster random sampling, with 50 students as respondents. The hypothesis test used was MANOVA.
Result: The DMR model significantly influenced students' mathematical problem-solving abilities and self-efficacy. Students in the experimental class showed higher scores than those in the control class.
Conclusion: The DMR learning model effectively improves students' mathematical problem-solving abilities and self-efficacy.

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INTRODUCTION

Mathematics can be used as a tool to shape thought patterns (Mahfiroh et al., 2021). Cornelius stated the importance of learning mathematics, including as a means of logical thinking, getting used to solving everyday problems, developing creativity, recognizing the relationship patterns of concepts, and increasing awareness of cultural developments (Marasabessy, 2020). According to Susanto, problem solving is the process of applying previously acquired knowledge to new situations ((Eppe et al., 2022; Kou et al., 2022)

Problem solving is a basic activity in mathematics learning (Hidayat & Sariningsih, 2018). In line with this statement, Russefendi stated that the main skill in learning mathematics is problem-solving ability (Mahfiroh et al., 2021). Dahar also believes that the main goal of education is the ability of students to face or solve problems given (Mariam et al., 2019). Maimunah, Purwanto, Sa'dijah and Sisworo define problem solving as a thinking activity in an effort to find a solution to a problem by including knowledge and experience (Eppe et al., 2022). Meanwhile, Ulya defines problem solving as the ability to utilize existing knowledge to solve problems (Nengsih et al., 2019). The ability to solve problems is important to have as a provision for living life so that it can later be applied to various problem situations that are being faced (Siwi & Haerudin, 2019).

However, in reality, successfully mastering these skills is still considered difficult to achieve. This is evidenced by a survey conducted by researchers at a junior high school in Bandar Lampung, which showed that students' problem-solving skills were still below the Minimum Competency (KKM). This finding is also supported by research by Sumarmo and Fakhrudin (Somawati, 2018). The results of the PISA international survey also reinforce the assertion that students' mathematical problem-solving abilities are still suboptimal. Indonesia ranked 73rd out of 79 countries that participated in the 2018 PISA test (Sari et al., 2022). This clearly shows that students' mathematical problem-solving abilities are still far from expectations.

The students' mathematical problem-solving abilities are not yet optimal because during the learning process, students are not used to working on HOTS questions (Marasabessy, 2020; Putra et al., 2018). One of the internal factors of students that contributes to the success of learning mathematics is self-efficacy (Kholivah et al., 2020). Self-efficacy (SE) is a psychological aspect that influences students' success in completing assignments and problem-solving questions well (Jatisunda, 2017). According to Bandura, self-efficacy is a person's belief in their ability and capability to carry out a series of problem-solving activities or certain tasks (Somawati, 2018). SE plays an important role in achieving a learning process, has a strong influence on learning activities, motivation, and also performance in completing assignments (Haq, 2011). A student must have high self-confidence in his/her abilities and skills in carrying out his/her tasks in order to achieve maximum learning achievement (Somawati, 2018).

To maximize students' problem-solving abilities and self-efficacy, it is necessary to use an appropriate learning model (Pratiwi, 2016). The learning environment for students must be set up in such a way that students are actively involved in every learning activity (Silviyani & Lestari, 2020). According to Ulvah, student participation in each learning activity will have an impact on students' problem-solving abilities (Putra et al., 2018). As students' problem-solving skills develop, their confidence in solving problems or assignments will increase. An alternative learning model that can be used is the Discourse Multi-Representation (DMR) learning model. DMR is a student-centered cooperative learning model in which students are required to express ideas, describe them in writing, and exchange opinions with others (Herdiana et al., 2021). The DMR learning model teaches how to solve problems and develops problem-solving skills. It emphasizes group learning, mutual assistance and collaboration in finding solutions, exchanging ideas, and integrating existing knowledge to achieve maximum learning outcomes. Sahyudin stated that several learning stages in the DMR learning model are preparation, introduction, development, implementation, and closing (Rukiyah et al., 2020).

The advantages of the DMR learning model include providing opportunities for students to interact, discuss and collaborate with group members to solve problems, fostering student activeness in learning, making it easier to understand the subject matter, making the learning process more enjoyable and not boring, and fostering good communication between students and between teachers and students. The disadvantages of the DMR learning model are that it takes quite a long time because of the discussion and information gathering process and also teachers must be able to plan learning well and prepare supporting media needed in learning (Rukiyah et al., 2020).

Previous research that supports this includes the DMR learning model having an effect on the ability to understand mathematical concepts (Agustina et al., 2019), student learning outcomes (Ahmad et al., 2020), problem solving skills (Azizah & Handayani, 2020), and mathematical representation capabilities (Rukiyah et al., 2020). Then problem-solving skills can be improved using the SAVI learning model (Murti & Negara, 2019), Open Ended method (Mariam et al., 2019), Multi-Representation Discourse Model (Azizah & Handayani, 2020), and the Teams Games Tournament method (Silviyani & Lestari, 2020). Previous researchers who have conducted research on self-efficacy have found that self-efficacy has an influence on mathematical representation ability (Nadia & Isnarto, 2017), problem solving skills (Kholivah et al., 2020), and the ability to understand mathematical concepts (Amani et al., 2023; Rahmi, 2020).

Referring to the previous research described above, including research on the use of the DMR learning model, mathematical problem-solving ability, and st udent self-efficacy, no researchers have examined the effect of the DMR learning model on student problem-solving ability and self-efficacy.

Based on this, this article was written to discuss in more depth the influence of the DMR model on student problem-solving ability and self-efficacy.

METHOD

Research Design

This study is a quasi-experimental study with a posttest-only control group design. This design was chosen because it allows researchers to compare learning outcomes between two groups, namely the experimental class that uses the DMR learning model and the control class that is taught using the direct teaching method. A pretest was not used to avoid the influence of the initial test (testing effect) on the posttest results, so that the research results better reflect the effect of the learning treatment.

Participant

The research participants consisted of 50 grade VIII students, divided into an experimental class and a control class of 25 students each.

Population and Sampling

The study population was all eighth-grade junior high school students in Bandar Lampung City in the 2024/2025 academic year. The sampling technique used was cluster random sampling.

Instrument

Data on mathematical problem solving abilities were collected using test instruments in the form of:

1. The essay questions consist of six items. All six items have passed the validation stage, including validity, difficulty level, discriminatory power, and reliability. All items also meet all mathematical problem-solving indicators. The problem-solving indicators refer to Polya: understanding a problem, making a plan, carrying out the plan, and rechecking each step and the results of the problem-solving process (Mahfiroh et al., 2021; Quintanilla et al., 2023).
2. A validated self-efficacy questionnaire with 27 statements. The validated questionnaire also meets all self-efficacy indicators. The self-efficacy indicators used include (1) confidence in one's own abilities, (2) confidence in one's ability to adapt and face difficult tasks, (3) confidence in one's ability to face given challenges, (4) confidence in one's ability to complete certain tasks, and (5) confidence in completing different tasks.

Procedures and time frame

The research was conducted in 4 meetings, with 3 sessions of learning and one meeting to carry out a mathematical problem-solving ability test and administer a self-efficacy questionnaire.

Analysis plan

The data that has been obtained then goes through the data analysis stage by conducting prerequisite tests which include normality tests using the Kolmogorov Smirnov test and homogeneity tests using the Box's M test. After it is known that the data distribution is normally distributed and the variance in the population is homogeneous (the same) at the preliminary test stage, hypothesis testing is carried out using Manova.

RESULTS AND DISCUSSION

Results

After the learning activities and data collection process (tests and questionnaires) were completed in both the class using the DMR learning model (experimental class) and the class using the direct learning model (control class), the results of the mathematical problem-solving ability test were obtained as described in Table 1.

Table 1. Description of Data from Students' Mathematical Problem Solving Ability Test Results

		Experimental Mathematical Problem Solving	Mathematical Problem Solving of Control
N	Valid	25	25
	Missing	0	0
Mean		68,3333	23,0667

Median	72,0000	19,0000
Mode	74,00	48,00
Standard Deviation	13,24135	14,58136
Variance	175,333	212,616
Skewness	-,465	,748
Standard Error of Skewness	,427	,427
Kurtosis	-,758	-,730
Standard Error of Kurtosis	,833	,833
Minimum	44,00	7,00
Maximum	89,00	48,00
Sum	2050,00	692,00

Table 1 shows that the highest, lowest, median, mode, and mean scores in the experimental class were higher than those in the control class. This indicates that the problem-solving abilities of students learning using the DMR model are better than those of students learning using the direct learning model.

The data from the results of administering the student self-efficacy questionnaire are contained descriptively in Table 2.

Table 2. Description of Student Self-Efficacy Questionnaire Data

		*Self-efficacy*Experiment	*Self-efficacy*Control
N	Valid	25	25
	Missing	0	0
Mean		78,2968	71,3344
Median		79,6300	72,2200
Mode		79,63a	63,89
Standard Deviation		5,43333	6,47784
Variance		29,521	41,962
Range		16,67	26,85
Minimum		68,52	55,56
Maximum		85,19	82,41
a. Multiple modes exist. The smallest value is shown			

The table shows that the average, middle, most frequently occurring, highest, and lowest scores of students in the experimental class were higher than those in the control class. This indicates that the self-efficacy questionnaire results for the experimental class were better than those for the control class.

Then, the first prerequisite test was continued, namely the normality test using the Kolmogorov-Smirnov test. The results of the normality test can be seen in Table 3 below:

Table 3. Results of the Normality Test of the Mathematical Problem Solving Ability Test

Tests of Normality				
		Kolmogorov-Smirnova		
	Class	Statistics	df	Sig.
Solution Problem	Experiment	,166	25	,053
	Control	,156	25	,059
*. This is a lower bound of the true significance. a. Lilliefors Significance Correction				

In Table 3, it is known that the sig value in the experimental class is 0,53 and the sig value in the control class is 0,059, because all sig values in the Kolmogorov Smirnov column are greater than the significance level of 0,05, it can be concluded that the data from the mathematical problem-solving ability test results in both the experimental and control classes have a normal distribution of data.

Table 4. Results of the Normality Test for the Student Self-Efficacy Questionnaire Results
Tests of Normality

		Kolmogorov-Smirnova		
	Class	Statistics	df	Sig.
Self-efficacy	Experiment	,157	25	,114
	Control	,098	25	,200

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on Table 4 in the Kolmogorov Smirnov column, it is known that the sig in the experimental class is 0,114 and in the control class is 0,200. Because sig is more than 0,05, the distribution of self-efficacy data for both the experimental and control classes is normally distributed.

Next, the second prerequisite test was carried out, namely the homogeneity test using the Box's M test. The results of the homogeneity test are listed in the following table:

Table 5. Test Results*Box's Test of Equality of Covariance Matrices*

Box's M	1,667
F	,535
df1	
df2	605520,000
Sig.	,658

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + A

Based on Table 5, the Box's M value is 1,667 with a sig value of 0,658. Since the sig value exceeds the 0,05 significance level, it can be concluded that mathematical problem solving and self-efficacy have a homogeneous variance-covariance matrix. Meanwhile, the homogeneity test for each data group uses the Levene test. The results of the Levene test are presented in Table 6 below:

Table 6. Test Results*Levene's Test of Equality of Error Variances*

	F	df1	df2	Sig.
Mathematical Problem Solving	,318	1	48	,575
Self-efficacy	,240	1	48	,626

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Learning Model

In Table 6, the sig value in the mathematical problem-solving row is 0,575 and the sig value in the self-efficacy row is 0,626. Since all sig values are greater than 0,05, it can be concluded that the data variance in the mathematical problem-solving data population is distributed equally (homogeneously), and the data variance in the self-efficacy data population is also distributed homogeneously.

After the data is declared normally distributed and homogeneous, the hypothesis is tested using the MANOVA test. The MANOVA test is conducted using the SPSS application. The following SPSS output shows the results of the MANOVA test, presented in

Table 7. Multivariate Test Results

	Effect	Value	F	Hypothesis df	Error df	Sig.
Learning model	Pillai's Trace	,349	12,589b	2,000	47,000	,000

	Wilks' Lambda	,651	12,589b	2,000	47,000	,000
	Hotelling's Trace	,536	12,589b	2,000	47,000	,000
	Roy's Largest Root	,536	12,589b	2,000	47,000	,000

In Table 7, the Wilks Lambda row learning model section shows that the sig value is 0,000 and because the sig value is less than 0,05, there are different results in mathematical problem-solving abilities and self-efficacy between students who learn using the DMR model and students who learn using the direct learning model.

Next, a test was conducted to determine the influence between subjects/variables. The results of the intersubject influence test are described in Table 8.

Table 8. Results of the Inter-Subject Influence Test

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Learning model	Mathematical Problem Solving	829,222	1	829,222	7,524	,009
	Self-efficacy	605,938	1	605,938	16,953	,000

Based on Table 8, the mathematical problem solving row has a sig value of 0,000. Because the sig value is less than 0,05, it can be concluded that there is a difference in the problem-solving abilities of students between those who learn using the DMR learning model and those who learn using the direct learning model. Meanwhile, for the self-efficacy row, it can be seen that the sig value is 0,000 and because the sig value is smaller than the significance level of 0,05, it can be concluded that there is a difference in self-efficacy between students who learn with the DMR learning model and those who learn using the direct learning model.

Discussion

The use of the DMR learning model has a positive influence on students' problem-solving abilities. In the DMR learning model, the learning process is carried out through numerous discussions, collaborating with each other to exchange ideas, knowledge, and experiences among students to solve the given problems. Through this learning, students will find it easier to solve the given math problems because they seek solutions together rather than working independently. Students will exchange ideas to determine the most appropriate solution to solve the problem.

During the process of finding solutions to problems, knowledge transfer occurs between members of the discussion group so that the knowledge possessed by students will be better. The learning atmosphere in learning using the DMR model is not boring because each student is actively involved in various learning activities such as expressing ideas, communicating ideas in writing from what is thought, listening to the ideas and opinions of other students, and conducting discussions both among group members and between students and the teacher. Providing problems at each meeting and group discussion activities that are carried out continuously will provide many additional knowledge and experience for students in solving problems. This certainly has an impact on increasing students' mathematical problem-solving abilities.

Unlike classroom learning that uses a direct learning model, learning activities are carried out more by the teacher than by students. The teacher plays a more active role in the learning process, the teacher provides lesson material and provides several example problems related to the material being studied, students listen and take notes on what the teacher has conveyed, then the teacher will provide practice problems if there is still enough study time. So during learning, students are passive and students tend to be fixated on how to solve problems given by the teacher as examples. So if given problems outside the example questions given by the teacher, students will experience difficulties because so far the problem-solving process in learning students only follow the problem-solving method used by the teacher without students being given the opportunity to carry out the problem-solving process using their own methods. Such learning makes students have minimal problem-solving experience because so far students have only followed the problem-solving method used by the teacher. This is what causes the mathematical problem-solving ability of students who learn using the DMR learning model to be better than students who learn using the direct learning model.

In addition to influencing mathematical problem-solving abilities, the use of the DMR learning model also influences students' self-efficacy. In DMR learning, students are required to carry out various activities, including expressing ideas or opinions, writing down their ideas, participating inquestion and answer discussions, and presenting the results of their discussions. To be able to carry out these various activities, students must have the confidence that with their knowledge and abilities, they are capable of solving the problems given. The activities of expressing and writing down ideas require students to have confidence in themselves that the ideas they express can help in the process of finding solutions to the problems they face. In discussion activities to solve problems, students must be confident that they and their group members are capable of solving the problems given. With high confidence in their ability to solve problems, they can achieve maximum learning outcomes.

Conversely, students who learn using the direct learning model are more dependent on teachers. This is because during the learning process, the teacher plays a more prominent role, while students are accustomed to receiving material from the teacher. Thus, when students are given math problems, they lack confidence in their ability to solve them because during the direct learning process, students are accustomed to following the problem-solving methods demonstrated by the teacher. This makes the self-efficacy of students who learn using the DMR model better than that of students who learn using the direct learning model.

The findings in this study are in line with the findings of Azizah and Handayani who obtained results that students' mathematical problem-solving abilities were better when learning using the DMR learning model (Azizah & Handayani, 2020). In addition, research conducted by Herdiana, Zakiah, and Sunaryo also provided the same results, namely that the use of the DMR learning model had an effect on students' mathematical problem-solving abilities (Herdiana et al., 2021).

Implications

The results of this study have implications for mathematics teaching practices, particularly in materials requiring representation and problem-solving skills. Teachers can utilize the DMR model as an alternative learning method that encourages students to actively discuss and represent their ideas. This model is also useful in increasing student motivation and confidence in completing mathematics assignments, so it can be applied to various other materials at the junior high school level.

Research contribution

This research contributes to the literature on representation- and discourse-based learning models. It examines not only cognitive problem-solving skills but also affective aspects, such as self-efficacy. Thus, this study broadens our understanding of how the DMR model impacts both aspects simultaneously through a MANOVA analysis.

Limitations

This study has several limitations. First, it was conducted in only one school with a limited sample size, so generalizations of the results should be approached with caution. Second, the study's relatively short duration meant it was not possible to assess the long-term development of DMR implementation. Third, the study used only a posttest design, so it did not directly measure changes in ability through the pretest.

Suggestions

Future research could consider using a pretest-posttest design to more comprehensively assess skill development. Furthermore, research could be conducted at other levels or materials to assess the effectiveness of the DMR model more broadly. Further research could also explore integrating DMR with digital technology or other interactive learning media to enrich the representation process in mathematics learning. An in-depth analysis of why DMR is effective, linked to representation theory, interaction, discussion, and previous research, is warranted.

CONCLUSION

Based on the research conducted, the problem-solving abilities of students who participated in DMR-based learning showed better results than those who participated in direct learning. This finding is also supported by the higher self-efficacy scores of students in classes that implemented the DMR model. Thus, the implementation of the DMR learning model has been proven to improve student learning outcomes.

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AUTHOR CONTRIBUTION STATEMENT

DS is responsible for conceptualizing the research idea, developing the quasi-experimental design, developing test instruments and questionnaires, implementing data collection, statistical analysis, and writing the initial draft of the manuscript as P1. Meanwhile, BSA as P2 provides supervision of the entire research process, validating the methodology, conducting critical reviews of the introduction, methods, and discussion sections, and providing substantial input in data analysis, drawing conclusions, and refining research recommendations.

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