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Enhancing Mathematical Representation Ability: Innovative DMR Learning Model with Question Box Media Integration

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Abstract: This study aimed to scrutinize the effectiveness of the DMR (Diskursus Multy Reprecentacy) model with Question Box media in bolstering the mathematical representation abilities of eighth-grade students. A quasi-experimental design was employed, engaging 96 students selected via Cluster Random Sampling technique. The effectiveness was evaluated by comparing the DMR model against the conventional expository teaching method using a t-test with a 5% significance level. In this research, data testing uses the SPSS application. Findings revealed that the DMR teaching model assisted by the Question Box media was significantly more effective in enhancing students' mathematical representation skills than the traditional expository model. These findings suggest that the integration of the DMR teaching model with Question Box media could serve as an alternative pedagogical strategy in mathematics education to facilitate a deeper understanding of mathematical concepts among students.

Keywords: DMR (Discursus Multy Reprecentacy) learning model; Mathematical Representation; Question Box

Meningkatkan Kemampuan Representasi Matematis: Model Pembelajaran DMR Inovatif dengan Integrasi Media Kotak Pertanyaan

Abstrak: Penelitian ini bertujuan untuk menganalisis efektivitas model DMR (Diskursus Multy Reprecentacy) dengan media *Question Box* dalam meningkatkan representasi matematis siswa. Menggunakan pendekatan quasi eksperimen, penelitian ini melibatkan 96 siswa yang dipilih sebagai sampel melalui teknik *Cluster Random Sampling*. Untuk menilai efektivitas, penelitian membandingkan hasil antara model DMR dan model ekspositori konvensional menggunakan uji-t dengan tingkat signifikansi 5%. Dalam penelitian ini, pengujian data menggunakan aplikasi SPSS. Hasil menunjukkan bahwa model pembelajaran DMR yang berbantuan media Question Box secara signifikan lebih efektif dalam meningkatkan kemampuan representasi matematis dibandingkan dengan pembelajaran model ekspositori. Temuan ini memberikan implikasi bahwa integrasi model pembelajaran DMR dengan media *Question Box* dapat dijadikan sebagai strategi alternatif dalam pembelajaran matematika untuk memfasilitasi pemahaman konsep matematis yang lebih baik di kalangan siswa.

Kata Kunci: model DMR (Discursus Multy Reprecentacy); Media Question Box; Representasi matematis.

INTRODUCTION

Mathematical representation stands as a fundamental cornerstone in the realm of mathematics education (Flores et al., 2020; Santia & Sutawidjadja, 2019). The ability to depict mathematical concepts through various representational forms such as visual, symbolic, and verbal articulations enables a profound comprehension and versatile application of

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mathematics in problem-solving and critical reasoning (NCTM, 2000). This skill set is crucial for students not only to interpret and express mathematical information but also to forge connections between mathematical ideas and real-world scenarios. Duval (2006, 2017) posits that mathematical representation transcends the mere transformation of symbols; it is about how students extract and manipulate the mathematical meaning from diverse representational forms. In the current educational landscape, the emphasis on mathematical representation has been magnified as a foundational element for students to achieve a comprehensive mathematical literacy. Representations can assist students in visualizing and conceptualizing complex mathematical problems, thereby enhancing the effectiveness of the learning process (Kenedi et al., 2019; Tekin, 2023; Zorzos & Avgerinos, 2023). By incorporating a variety of mathematical representation methods, students are equipped with a diverse set of strategies to interpret and resolve mathematical challenges, thereby establishing a foundation for advanced conceptual understanding and the practical application of these concepts in daily life. To assess the effectiveness of mathematical representation, specific indicators must be established, such as the ability to identify and utilize mathematical symbols, problem visualization, and the translation of concepts across different representational forms. Furthermore, distinctions between students with strong and weak representation skills can be observed through their ability to apply these concepts in real-world problem-solving, the speed and accuracy of their responses, and the depth and breadth of their explanations when resolving mathematical problems.

Previous research into mathematical representation reveal a significant challenge among students regarding the comprehension of problems and the identification of relevant formulas or concepts for their resolution. Faulkner et al. (2021) and Siagian et al. (2019) highlighted that students often struggle to understand the problems presented to them and determine the appropriate mathematical principles to apply. some also pointed out that students often face difficulties in translating problems into mathematical representations, such as diagrams, equations, and symbols (Jailani et al., 2020; Nurrahmawati et al., 2021). In SMP Negeri 14 Bandar Lampung, preliminary research has highlighted challenges faced by students in the area of mathematical representation to. Conversations with the math teachers reveal that students often struggle to convert problems into accurate mathematical representations, such as diagrams, equations, and symbols, a struggle primarily linked to a foundational understanding of mathematical concepts. Some research has indicated that the Discursus Multy Reprecentacy (DMR) model can significantly enhance the comprehension of mathematical notions by facilitating a learning design that evolves in response to the students' educational needs (Nurhidayati, 2023; Pratiwi & Selvianti, 2023; Sudianto & Riadin, 2021). This model encourages gradual understanding through the application of constructivist learning theories, emphasizing the learner's personal experience (Afandi et al., 2022). Additionally, DMR allows educators to methodically review and refine their teaching strategies, thereby potentially elevating the overall quality of math education.

To fully realize its potential, the Dynamic Mathematical Representation (DMR) model requires effective educational tools, one of which is the question box. DMR distinguishes itself

from other models by prioritizing the use of dynamic visual and symbolic representations to enhance students' understanding of mathematics, focusing on adaptability and flexibility in employing various mathematical symbols and representations as needed for problem-solving. This tool functions as a confidential communication channel that allows students to pose questions anonymously, thus avoiding the fear of classroom embarrassment and ensuring that the learning process becomes more inclusive with individual challenges addressed discreetly. Similar to the DMR (Direct Mathematical Response) method, this question box can be created physically or virtually. Previous research has primarily focused on the role of the question box in enhancing student participation; however, existing research gaps include its effectiveness in overcoming communication barriers in mathematics education and its impact on students' achievement of conceptual understanding. (Sari & Sayekti, 2023; Zulherman et al., 2021). The question box complements DMR by providing immediate student feedback, crucial for tailoring and fine-tuning teaching activities to meet student needs. Thus, integrating the DMR model with the question box medium can forge a supportive learning, empowering each student to excel in mathematical representation.

Prior investigations have scrutinised the Direct-Modeling-Reflective (DMR) learning approach initially introduced by Domu et al. (2020), revealing its effectiveness throughout classroom educational processes. This particular pedagogical model has been validated as an effective means of engaging students actively in understanding problems and devising solutions, with a pivotal role in these processes (Rostika & Junita, 2017; Rusmilah et al., 2022). Nevertheless, there is a scarcity of research focusing on the integration of question box media within the DMR framework. The current study aims to explore the impact of incorporating a question box tool into the DMR model on students' mathematical representational abilities.

METHOD

This study was conducted as a quasi-experimental investigation utilising a posttest-only control group design. The sample selection process was carried out through cluster random sampling, where a random assortment from the population was chosen to assign students to two experimental groups and one control group. The interventions spanned a period of four weeks. The first experimental group was exposed to the DMR learning model supplemented by the Question Box media tool, whereas the second experimental group engaged with the DMR model without auxiliary media. The control group was instructed using an expository teaching model.

The population of this research comprised Year 8 students from Bandar Lampung State Secondary School No. 14. The sample included 32 students from Class VIII A designated as experimental group I (DMR Learning Model with Question Box Media), another 32 students from Class VIII B as experimental group II (DMR Learning Model), and 32 students from Class VIII C serving as the control group (Conventional Learning Model). These samples were then subjected to normality and homogeneity tests using the SPSS 26 software, with a significance

threshold set at 5%. The outcomes affirmed that the samples were normally distributed and homogeneous.

For the measurement instrument, a descriptive test was specifically developed to assess the mathematical representation abilities of the students. Prior to its official administration, the test instrument underwent a pilot phase to determine its validity, reliability, difficulty level, and discriminatory power. This preliminary assessment indicated that the test was both valid and reliable.

In terms of data analysis, the study shifted focus to exclusively evaluate mathematical representation skills, thereby employing the t-test for hypothesis testing. This statistical test aimed to detect significant differences in the mathematical representation abilities between the first and second experimental groups and the control group post-intervention.

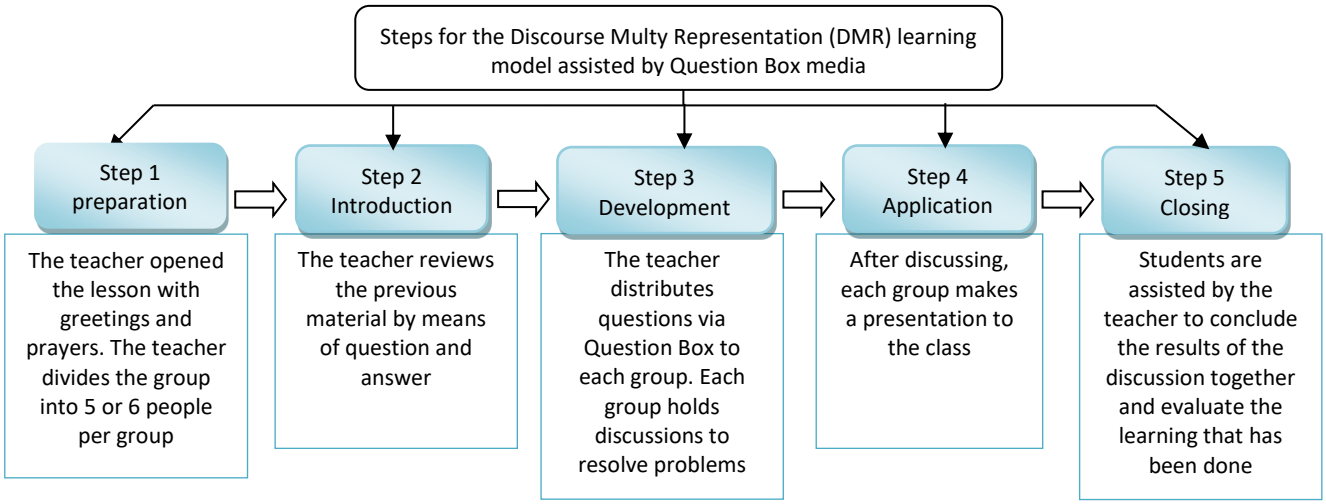


Figure 1. Steps in the learning model

RESULT AND DISCUSSION

The post-test data analysis for mathematical representation skills, as illustrated in Table 1, draws upon the mean scores from both experimental classes and the control group. The findings reveal that the first experimental class achieved an average representation score of 83, whilst the second experimental class attained a score of 75. In comparison, the control group's representation score averaged at 63.67.

Table 1. Mathematical Representation Ability

Data	Experiment Class 1	Experiment Class 2	Control Class
Average	83	75	63,12
Min Score	56,25	50	37,5
Max Score	100	93,75	81,25

In Table 1, it is evident that the average post-test scores for mathematical representation abilities in Experimental Group One surpassed those observed in both Experimental Group Two and the Control Group. It was observed that students in Experimental Group One achieved an average score of 83, whereas their counterparts in Experimental Group Two attained an average of 75, and the Control Group was noted to have secured an average score of 63.67. This disparity highlights the enhanced performance in mathematical representation capabilities of Experimental Group One, placing them above their peers in the other two groups.

The implementation of the DMR educational model, supplemented with the Question Box media aid, appears to be markedly beneficial when it leads to a tangible enhancement in students' abilities to represent mathematical concepts accurately. This innovative approach to teaching has shown promise in bolstering students' mathematical representation skills, an assertion supported by t-test results presented in Table 3. The data in Table 3 reveal a significant positive impact of the DMR model, integrated with Question Box media, on students' mathematical representation. This indicates that the model substantially aids students in comprehending material in a way that enables them to proficiently tackle mathematical problems. For a detailed examination of the effects, Table 3 provides extensive insights.

Table 3. the Results of t-test

Data	Sig
Class	0,000

Table 4. DMR Learning with Question Box Media

DMR Learning with Question Box Media	Kemampuan Representasi Matematis
The teacher questions and answers the material by posing a problem 	**Visual Representation** Students will present answers which can be expressed in graphs, tables or pictures

The teacher distributes questions via Question Box to each group

Students make presentations in front of the class

Students are assisted by the teacher to conclude the results of the discussion together

Representation of Mathematical Expressions

Students create mathematical models to solve a problem by involving mathematical expressions

Verbal Representation

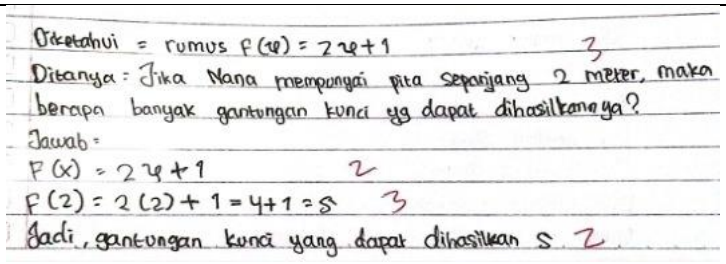
Students write situations based on data results that have been completed using mathematical models in words

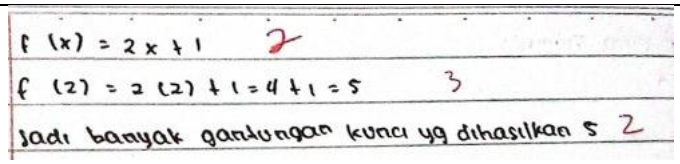
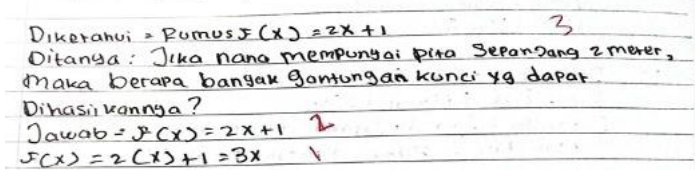
Mathematical representation skills are of paramount importance for students engaging with mathematics. These skills facilitate students' comprehension of complex concepts and empower them to articulate ideas using a variety of representations such as symbols, graphs, images, tables, written text, and mathematical expressions. Such multi-faceted fluency in representation is essential for a robust understanding of mathematical principles and for communicating intricate mathematical ideas effectively.

The impact of employing the Direct Instruction, Modeling, Reinforcement (DMR) approach, complemented by the interactive Question Box media, was evaluated through hypothesis testing using the t-test as depicted in Table 3 of our study. The findings indicate a significant enhancement in students' capabilities in mathematical representation due to the DMR model paired with Question Box media. This notable improvement can be attributed to the active engagement and dynamic involvement of students in the learning process. The DMR model, augmented by this media, introduces an element of competition among students to earn points, which fosters a vibrant and interactive classroom atmosphere, steering clear of monotonous and passive learning.

During the learning sessions, students were able to grasp the material comprehensively, which in turn equipped them to tackle various problems using the necessary representations. This learning approach has revealed that mathematics can be approached with ease when the right strategies are employed. As a result of implementing this model, students have shown increased confidence and less apprehension in addressing problems with diverse representations in front of their peers, indicating a positive shift in their perspective towards solving mathematical challenges.

Drawing on previous studies of the DMR (Direct Instruction, Modeling, Reinforcement) learning model and its impact on educational outcomes (Ahmad et al., 2020; Matin et al., 2022), communication skills (Asmara & Asnawati, 2020), mathematical cognition (Pecahan, 2023), and creative thinking (Putri & Fuadi, 2023), it has been observed that students engage actively during lessons employing this model, leading to enhanced learning experiences. Such engagement not only fosters a positive learning environment but also encourages students to tackle problems independently, without heavily relying on peers for solutions. Table 5 illustrates the post-test results of the three sample classes, which will reveal differences in the students' abilities to solve problems.

Class	Post-test
Experiment 1	 Diketahui = rumus f(x) = 2x+1 Ditanya = Jika Nana mempunyai pita sepanjang 2 meter, maka berapa banyak gantungan kunci yg dapat dihasilkannya? Jawab = F(x) = 2x + 1 F(2) = 2(2) + 1 = 4+1 = 5 Jadi, gantungan kunci yang dapat dihasilkan 5 Nana has embarked on a small business venture where she crafts keychains from ribbon. The relationship between the length of ribbon used and the number of keychains produced can be expressed by the function f(x) = 2x + 1. Should Nana have a ribbon length of 2 meters at her disposal, the query arises as to how many keychains she could potentially create. Given: The function f(x) = 2x + 1 Question: How many keychains is Nana able to produce with her 2 meters of ribbon? $f(x)$ = 2 x + 1 <=> $f(2)$ = 2 (2) + 1 = 4 +1 = 5 So, the number of key chains that can be produced is 5

Experiment 2	
Control	

In Table 5, it is apparent that there are distinctions in the response methods among students in Experimental Group 1, Experimental Group 2, and the Control Group. The implementation of the DMR teaching model assisted by the Question Box media yielded optimal results as it facilitated students' understanding of the material and promoted effective discussion. This tool also contributed to the efficiency of the learning time. In contrast, the learning process in Experimental Group 2 was less time-efficient, which impacted the effectiveness of the teaching outcomes negatively. Similarly, the learning environment in the Control Group was observed to be less conducive, with students exhibiting a passive approach to learning.

When the students tackled the post-test questions, clear differences emerged in the accuracy and precision of the responses among the samples. Students who were taught using the DMR model with the support of the Question Box media provided more accurate and comprehensive answers compared to their peers in Experimental Group 2 and the Control Group. These differences were identified by evaluating the students' problem-solving responses, their application of appropriate methods, and their ability to draw well-reasoned conclusions.

The integration of the DMR model with the support of the Question Box media can impart knowledge and experiences to students, enabling them to comprehend, assimilate, and apply what they have learned. It encourages them to independently or collaboratively articulate problems and to record their answers accurately and precisely. Observations made during the research phase suggest that this instructional approach enhances mathematical representation abilities. This is in line with findings from a study by Dewi Azizah et al., which demonstrated an improvement in mathematical problem-solving (Azizah & Handayani, 2020). During the preliminary stage, students engage actively in responding to the teacher's questions. In the development phase, they select questions from the Question Box and discuss with their peers to bolster their problem-solving capabilities. In the application stage, students present their discussion outcomes, with group representatives earning points for thorough explanations and correct answers, thereby motivating all students to put forth their best effort. In the concluding phase, teachers assist students in summarizing the material covered. The research findings are corroborated by hypothesis testing results, indicating that the DMR

learning model supplemented with the Question Box positively influences mathematical representation skills.

CONCLUSION AND RECOMMENDATION

The findings of this study lead to the conclusion that the integration of Question Box media with the Direct Instruction, Modeling, Reinforcement (DMR) learning model is effective in enhancing students' mathematical representation abilities. Evidence from t-test analysis indicates a significant improvement at a level of less than 5%, which underscores the high impact of the DMR model supplemented by Question Box on students' mathematical representation skills.

Furthermore, the implications of these results are multifaceted. Firstly, educators can consider incorporating multimedia aids like the Question Box into traditional teaching methodologies to bolster mathematical comprehension and application among students. Secondly, curriculum developers may explore the potential of media-assisted learning models in formal educational settings to foster deeper engagement with mathematical concepts. Lastly, this study underscores the necessity for educational stakeholders to continuously adapt and innovate teaching strategies to meet the evolving needs of learners in the subject of mathematics.

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