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Enhancing Fourth-Grade Students' Learning Outcomes Using Rabdology Board Media in Elementary Mathematics Education

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ABSTRACT

Improving students' learning outcomes in mathematics, particularly multiplication, remains a challenge in elementary education. This study investigates the effectiveness of the rabdology board as a visual and interactive learning tool to enhance the multiplication skills of fourth-grade students at SD Negeri 16 Panjak, West Kalimantan. A combination of quantitative and qualitative approaches was used. The intervention included introducing the rabdology board, demonstrating its use, providing directed practice, facilitating group discussions, and evaluating student learning outcomes. Data were collected through learning outcome tests and classroom observations. Findings indicate a significant improvement in students' multiplication learning outcomes, increasing from 58% to 80% after using the Rabdology Board. Additionally, students demonstrated higher motivation and active engagement in learning. The study highlights the effectiveness of interactive and visual teaching aids in enhancing students' comprehension and engagement in mathematics. The rabdology board provided a structured approach that facilitated faster multiplication calculations and improved conceptual understanding. The rabdology board is an effective tool for improving multiplication learning outcomes in elementary students. Its integration into mathematics education can serve as an alternative strategy to enhance student performance and engagement. Further research could explore its application in other mathematical concepts and educational settings.

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1. INTRODUCTION

Education serves as a fundamental pillar in equipping individuals with the knowledge, understanding, and skills necessary to adapt to an ever-evolving world. In Indonesia, the principles of Pancasila and the 1945 Constitution form the foundation of national education, with the primary aim of

shaping individuals into morally upright and competent citizens. The overarching goal is not only to cultivate intellectual capabilities but also to instill strong character, ethics, and a sense of national identity. A successful education system is reflected in the development of a generation that is intelligent, ethical, and capable of contributing to societal progress, in alignment with the educational objectives outlined in the Constitution.

Achieving these national education goals, however, is a complex process fraught with challenges (Rukiyati, 2020). Continuous advancements in educational practices are essential to overcoming these obstacles, particularly in terms of pedagogy, teaching methodologies, and the integration of innovative learning media (Pan, Shankararaman, Koh, & Gan, 2021). The learning process itself is an interactive experience, requiring active engagement between educators and students. It involves individuals with diverse backgrounds coming together in a dynamic exchange of knowledge and experiences. Teachers, as key facilitators of this process, play a critical role in ensuring that learning is both effective and engaging. Their ability to select appropriate teaching strategies and media is vital in fostering student comprehension and participation.

In the school setting, student-centered learning is increasingly recognized as a crucial approach, with teachers assuming the role of facilitators and guides in the learning process (Rahmawati & Suryadi, 2019). This approach allows students to explore and develop their potential, enhancing skills such as critical thinking, problem-solving, and effective communication. Active learning has been shown to produce better educational outcomes compared to passive learning methods, as students who actively engage in discussions, group work, and hands-on activities are more likely to retain and apply the knowledge they acquire (Wibowo, 2016). Various studies highlight the effectiveness of active learning strategies in improving students' cognitive abilities and engagement (Jesionkowska, Wild, & Deval, 2020; Owens, Sadler, Barlow, & Smith-Walters, 2020). By fostering active participation, educators can create an interactive learning environment where students do not merely absorb information but also analyze, synthesize, and apply their knowledge in meaningful ways (Marwan, Firdaus, & Handayani, 2024).

One effective learning tool that aligns with the principles of active learning in mathematics education is the Rabdology Board. This tool, rooted in the historical mathematical principles of John Napier, is designed to simplify multiplication and division operations. The Rabdology Board consists of small slats or tiles arranged in a grid-like structure, with numerical values displayed systematically. Made from materials such as wood, plastic, or thick paper, the board provides a tangible and visual representation of arithmetic operations. Teachers introduce the tool by explaining its function and guiding students through interactive exercises, where they manipulate the slats to perform calculations. By allowing students to physically engage with numerical operations, the Rabdology Board transforms abstract mathematical concepts into a concrete and comprehensible learning experience. This hands-on approach not only enhances students' understanding but also fosters a deeper appreciation for mathematical problem-solving, making it a valuable addition to elementary mathematics education.

Through the use of the rabdology board, students are invited to be more involved in the learning process of mathematics, as this tool helps them understand abstract concepts such as multiplication and division in a visual and manipulative way. This learning experience involves repetitive practice, where students use the slats on the board to solve various problems, making it easier for them to understand the relationship between numbers and improving their understanding of mathematical operations.

Rabdology boards play an important role in supporting multisensory learning approaches, which integrate multiple senses to help students better understand the material. In a visual context, rabdology boards help students see numbers and the results of math operations such as multiplication and division directly. The numbers arranged on the slats of the board make it easy for students to visualize the calculation process concretely. This visualization is especially beneficial for students who have difficulty understanding abstract concepts through numbers on paper alone, as they can see the relationship between the numbers they manipulate.

In addition, the rabdology board supports kinesthetic learning, where students actively use their hands to manipulate the blades on the board. This physical activity helps students who are more inclined

to learn by movement and touch, allowing them to physically experience numbers and the calculation process. It can also be combined with verbal instruction or group discussion, providing auditory support for students who understand more through hearing. By combining different sensory modalities, rabdology board makes math learning more inclusive and effective, allowing students with different learning styles to participate to the fullest and more easily understand the concepts being taught.

Maths learning is often faced with challenges such as low student engagement, limited concept understanding, and inadequate learning outcomes (Cárdenas-Sainz, Barrón-Estrada, Zatarain-Cabada, & Chavez-Echeagaray, 2023). Traditional teacher-centred teaching methods often make students passive and less engaged in the learning process (Boom-Cárcamo, Buelvas-Gutiérrez, Acosta-Oñate, & Boom-Cárcamo, 2024). This condition results in students tending to forget the material that has been taught and having difficulty in applying mathematical concepts in real situations (Handayani, Cintami, & Lestari, 2024). As education evolves, there is an urgent need to adopt a more interactive and participatory approach. Active learning emerges as a potential solution to address this issue. Active learning positions students as the centre of the learning process, with teachers acting as facilitators and guides. Through this approach, students are given the opportunity to collaborate, discuss and engage in hands-on problem solving.

Mathematics is taught at all levels of education, starting from primary school, with the intention of providing students with skills in logical, analytical, systematic, critical, and creative thinking, as well as the ability to work together (Rachmantika & Wardono, 2019). Mathematics has an important role in guiding each individual to develop an understanding of mathematics which can be started from school learning (Anwar, 2018). The use of a rabdology board in learning mathematics can be strengthened by the basis of educational theory, especially active learning theory and cognitive theory which underlies the importance of direct student involvement in the learning process and the development of a deeper cognitive understanding.

Active Learning Theory emphasizes that students achieve better learning outcomes when they actively engage in the learning process through discussion, hands-on problem-solving, and interaction with learning tools. John Dewey, a prominent philosopher and educator, argued that education should be rooted in students' experiences, allowing them to construct knowledge through direct involvement. The Rabdology Board aligns with this theory by providing a hands-on approach that encourages students to manipulate learning materials rather than passively receiving information. By actively using the Rabdology Board to perform multiplication, division, and other mathematical operations, students enhance both their cognitive and motor skills, leading to increased engagement and motivation—two key components of successful learning.

Moreover, the use of the Rabdology Board is strongly supported by cognitive development theories proposed by Jean Piaget and Lev Vygotsky. Piaget's theory suggests that children in the concrete operational stage (ages 7–11) learn best through tangible, visual representations before grasping abstract concepts. The Rabdology Board facilitates this process by providing a structured way for students to visualize numerical relationships and arithmetic operations, making complex mathematical ideas more accessible. Similarly, Vygotsky's concept of the Zone of Proximal Development (ZPD) highlights the importance of guided learning, where students perform tasks with assistance before mastering them independently. The Rabdology Board serves as an effective scaffolding tool, allowing teachers and peers to support students in understanding multiplication and division until they can solve problems independently. This interactive approach fosters deeper comprehension and ensures that students gradually develop their mathematical reasoning skills.

Despite the importance of active learning in mathematics education, observations conducted at **SD** Negeri 16 Panjak in a fourth-grade classroom indicate that student learning outcomes remain below the expected standard. In particular, students' cognitive achievements in multiplication and division have been found to be insufficient. Data from the 2023/2024 school year show that fewer than 60% of students met the Criteria for Achieving Learning Objectives (KKTP), as evidenced by their Daily Assessment (PH) scores. Out of 23 students, 12 scored below the KKTP benchmark, with an average class score of 66. This

means that the overall learning target has only reached 43.48%, while 56.52% of students have not yet achieved mastery. These findings suggest that the class has not reached the level of success needed for collective competency. One of the key contributing factors to this issue is the lack of student participation and engagement in the learning process. This underscores the urgent need for active learning strategies to strengthen students' conceptual understanding of mathematics. Implementing interactive media such as the Rabdology Board could serve as an effective solution to address these learning gaps, providing students with concrete, engaging methods to improve their mathematical comprehension and overall academic performance.

2. METHODS

This study aims to enhance the learning outcomes of fourth-grade students at SD Negeri 16 Panjak, West Kalimantan, by utilizing rabdology board media. In the initial phase, students' needs were identified by assessing their baseline understanding of multiplication and division concepts. Following this, an introductory session was held to familiarize students with the rabdology board as an interactive mathematics learning tool. Materials were designed using the rabdology board to make multiplication and division concepts more concrete. The research employed both quantitative and qualitative methods, with data collected through learning outcome tests and observations during the learning process.

Quantitative data analysis displays the percentage of student test results. In addition, this analysis also involved normality and homogeneity tests aimed at evaluating the uniformity of the data when student tests were conducted. The population in this study consisted of grade four students, with the focus of the research directed specifically at students in that grade. The number of respondents involved was 56 students.

Table 1. Percentage Criteria

Range	Category
81-100 %	Very good
61-80 %	Good
41-60 %	Fair
21-40 %	Less
0-20 %	Very Poor

Arikunto (2010)

To get the average value of student learning outcomes, (Arikunto, 2012: 264) provides a formula that can be applied as follows:

$$\bar{x} = \frac{\sum xi}{n}$$

$\bar{X}$ = Class Average *(mean)*
Σxi = Total Score

The sampling technique used in this study was random, and two different methods were applied: control class and experimental class. The control class is a group that does not use learning media, while the experimental class uses rabdology media. The purpose of using these two methods was to calculate paired sample T-test and independent sample T-test values. It was determined that the minimum sample size required was 35 students, but in this study, the sample size used was 56 students.

Learning outcome data was also analysed to determine the percentage of students who achieved or exceeded the Criteria for Achievement of Learning Objectives (KKTP), so that it can be seen how many students succeeded in the learning outcome test. The percentage score is obtained by dividing

the number of scores obtained by students by the maximum score that can be achieved, then the result is multiplied by 100%.

3. FINDINGS AND DISCUSSION

Learning is an individual effort to change their behaviour through interaction with the environment, as expressed by (Lestari, 2020). This suggests that in the learning process, individuals actively seek, process and adapt information from their environment into their behaviour. This learning process can take place consciously or unconsciously, and can be influenced by internal and external factors of the individual (Samsudin, 2020). Through this learning process, people can acquire new knowledge, skills and attitudes that help them adapt to environmental changes (Liu et al., 2024).

Rabdology boards, although originally designed to facilitate multiplication calculations, have significant potential to be used beyond multiplication, such as division and other concepts in basic math. In the context of division, the rabdology board can be modified to help students visualize division in a similar way to multiplication. By utilizing the bars on the board to track the numbers that divide other numbers, students can more easily understand the basic concept of division as the process of finding the number of times a number can be divided into another number. This helps students understand that division is the opposite of multiplication, which is often difficult to grasp if only explained theoretically.

Besides multiplication and division, rabdology boards can also be used to introduce other concepts in basic mathematics, such as factorization, prime numbers, or number patterns. For example, for factorization, the bars on the rabdology board can be arranged to help students find the factors of a number by checking which bar corresponds to the correct calculation result. Similarly, for prime numbers, the rabdology board can be used to visualize the pattern of numbers that have no factors other than themselves and one. With a creative approach, the rabdology board can be adapted for many different types of math concepts, making it a flexible and useful tool in teaching elementary math.

According to Pongoliu & Tohopi (2023), Learning outcomes are changes in behaviour that arise after individuals engage in the learning process with educational objectives. Evaluation is used to assess the extent to which the learning outcomes achieve the predetermined goals. Next, according to Seminar, Hdpgsdi, & Iv (2017), learning outcomes refer to the achievements obtained by students after following the learning process. These learning outcomes involve behavioural changes in the cognitive, affective, and psychomotor aspects (Nafiati, 2021).

Rabdology board can be aligned with Merdeka Curriculum or other national education standards in several ways that support the core principles in a more flexible, creative and student-centred learning approach. The Merdeka Curriculum emphasizes project-based learning, in-depth understanding of concepts, and learning that suits the needs and potential of students. In this case, the rabdology board, as a manipulative and interactive tool, is very suitable for supporting this approach.

First, the rabdology board is in line with the Merdeka Curriculum as it encourages independent exploration and problem-solving. Students can use this tool to explore the concepts of multiplication, division and other basic math concepts in a concrete and fun way. They can work in groups or individually to understand patterns and relationships between numbers, which is in line with the project-based learning and problem-solving principles in the curriculum. This allows teachers to provide a more personalized learning experience that meets the needs of each student, increasing student motivation and interest in learning. Second, the rabdology board also supports differentiation of learning, which is one of the important aspects of the Merdeka Curriculum. This tool can be adapted for use by students with different abilities, from those who still need basic understanding to those who want to deepen math concepts. The use of rabdology board also enriches the learning process as it integrates a multisensory approach, which helps students with visual, kinesthetic and auditory learning styles to more easily understand math concepts. With its flexibility in teaching methods, the

rabdology board helps teachers meet the standards of the Pancasila learner profile in the Merdeka Curriculum, such as critical thinking skills, independence, and mutual cooperation in learning.

In this study, data were analysed using qualitative and quantitative methods with a percentage approach. Qualitative analysis was carried out by observers, who compiled research data based on teacher and student activity sheets during the mathematics learning process using Rabdology board media. Meanwhile, quantitative method is a research approach that collects and analyses data in the form of numbers and statistics. The aim is to measure variables objectively and produce generalisable conclusions. Here are the general steps in the quantitative method. Teacher performance and student behaviour during learning were evaluated using a Guttman scale, where the responses were only 'Yes' or 'No'.

The following mathematics test data, both with and without media, were first tested for homogeneity and normality. The results showed that the data were normal and homogeneous, as shown in the table below.

Table 2. The results of pretest and posttest data show normality in the control and experimental

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Nilai	Pretest BK Kontrol	.177	20	.100	.956	20	.462
	Posttest BK Kontrol	.161	20	.186	.943	20	.268
	Pretest PM Kontrol	.191	20	.053	.950	20	.360
	Posttest PM Kontrol	.158	20	.200*	.943	20	.273
	Pretest BK Eks	.133	36	.108	.958	36	.190
	Posttest BK Eks	.140	36	.070	.943	36	.062
	Pretest PM Eks	.145	36	.055	.938	36	.044
	Posttest PM Eks	.128	36	.145	.954	36	.139

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

From the table above, the significant values for the pre-test and post-test groups in the control class are 0.956 and 0.943. Similarly, the experimental class showed pre-test and post-test values of 0.108 and 0.55, respectively, which are also greater than 0.05. Thus, if the significant value is greater than 0.05 (Sig > 0.05), the hypothesis stating that the sample comes from a normally distributed population is accepted. Therefore, it can be concluded that the normality of the distribution is fulfilled, and the results of the Normality test show that the research data is Normal.

Table 3. The results of pretest and posttest data show homogeneity in control and experimental

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	1.519	7	216	.162
	Based on Median	1.146	7	216	.335
	Based on Median and with adjusted df	1.146	7	190.374	.336
	Based on trimmed mean	1.446	7	216	.188

From the table above, the significant values for the pre-test and post-test groups in the control class are 0.162 and 0.335. Similarly, the experimental class showed pre-test and post-test values of 0.336 and 0.188, respectively, which are also greater than 0.05. Thus, if the significant value is greater than 0.05 (Sig > 0.05), the hypothesis stating that the sample comes from a normally distributed population is accepted. Therefore, it can be concluded that the normality of the distribution is fulfilled, and the results of the Normality test show that the research data are Normal.

Table 4. T-test results Rabdology board media

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	PreteskontrolBK - PostesKontrolBK	-9.500	6.428	1.437	-12.508	-6.492	-6.610	19	<,001

The effectiveness test using paired sample t-test showed a significance value of 0.001 <0.05, indicating a significant difference in the average score in students with rabdology board media to improve student multiplication learning outcomes.

Discussion

Rabdology serves as an interactive educational medium that enhances students' learning experiences by integrating visual arts with interactive components. This innovative tool consists of colorful boards designed to display various educational content, including mathematical problems, language exercises, and scientific concepts. By offering a multisensory approach, Rabdology caters to diverse learning styles, engaging students through both tactile and visual stimulation (Sanfilippo et al., 2022).

Rabdology, a refined version of Rabdology, employs interactive elements such as buttons, handles, and sliders to promote active student engagement. These features encourage learners to interact directly with educational materials, fostering deeper comprehension. The incorporation of fine arts within Rabdology creates an engaging and enjoyable learning environment, making lessons more appealing. One of its key advantages is its adaptability to individual student needs (Shatri, 2020). By allowing students to select difficulty levels based on their capabilities, Rabdology facilitates self-paced learning. Additionally, its inclusive design supports students with special needs, such as those with visual or hearing impairments. Studies have demonstrated that Rabdology significantly enhances student learning outcomes, improving conceptual understanding, problem-solving skills, and overall motivation (Kwangmuang, Jarutkamolpong, Sangboonraung, & Daungtod, 2021; Parwata & Sudiatmika, 2020). By merging fine arts with interactivity, Rabdology creates a dynamic and meaningful educational experience (Daryanes et al., 2023; Gong, 2021).

Research suggests that visual aids play a crucial role in improving students' comprehension and retention of information. For fourth-grade students, who are still developing critical thinking and problem-solving skills, interactive tools such as Rabdology simplify complex concepts (Fajari & Chumdari, 2021). The use of vibrant colors and engaging visuals helps capture students' attention, making learning more effective (Fernandez Nieto, Kitto, Buckingham Shum, & Martinez-Maldonado, 2022; Winner, Hetland, Veenema, Sheridan, & Palmer, 2020). At SD Negeri 16 Panjak, teachers have successfully incorporated Rabdology boards into daily lessons. These boards structure classroom activities, enabling active student participation. For instance, in mathematics lessons, students engage with problems displayed on the Rabdology board, encouraging teamwork and discussion. This interactive approach fosters a supportive learning environment where students feel confident

expressing their ideas (Molina Roldán, Marauri, Aubert, & Flecha, 2021; Selfa-Sastre, Pifarré, Cujba, Cutillas, & Falguera, 2022).

A notable benefit of Rabdology is the significant increase in student engagement levels. Traditional teaching methods often lead to passive learning, where students struggle to maintain focus (Ang, Afzal, & Crawford, 2021). Conversely, the interactive nature of Rabdology promotes active participation, resulting in heightened interest and enthusiasm for learning. Teachers have reported improvements in students' grasp of complex concepts, facilitated by the combination of visual representation and hands-on activities (Doerner & Horst, 2022). For example, in science lessons, students can visualize processes such as the water cycle through illustrations on the board, enhancing information retention.

Furthermore, Rabdology encourages collaboration among students. Group activities centred on the board promote teamwork, communication, and social skills. Through these exercises, students learn to articulate their thoughts and engage in meaningful discussions with peers, skills essential for both academic and personal growth (Leng, 2020; Toshpulatova & Kinjemuratova, 2020). Despite its advantages, the integration of RABDOLIA into educational settings presents certain challenges. Teachers may require additional training to optimize its use within the curriculum. Moreover, resource availability can be a limiting factor in some schools. Ensuring equal access to this technology is vital to maximizing its educational benefits (O'Keefe, Rafferty, Gunder, & Vignare, 2020; Wilkens, Haage, Lüttmann, & Bühler, 2021).

Overall, Rabdology represents a promising educational tool that enhances learning by combining interactive elements with artistic expression. Its ability to engage students, accommodate diverse learning styles, and foster collaboration underscores its value in modern education. Addressing implementation challenges will be key to ensuring its widespread adoption and success in classrooms.

4. CONCLUSION

The results of the data analysis showed that the rabdology board media provided a significant improvement in Grade 4 students' multiplication learning outcomes, especially in tens multiplication. However, the effect of rabdology board media was greater in lessons that did not use media. Thus, the rabdology board proved to be an effective method for students to learn multiplication at the primary school level. This finding also has implications for the development of various other types of lessons, especially lessons that are difficult for students to understand. The teachers have implemented the rabdology board in this low-grade class as one of the recommendations that can be developed further.

This research is still limited to testing the effect of rabdology boards on learning multiplication for primary school students, so the effectiveness of this method for other multiplication activities has not been significantly known. Therefore, it is important to ensure their teaching activities are of high quality, meet the demands of the current era of globalisation, and can be adapted to the Merdeka curriculum that the Indonesian government has implemented in schools.

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