Journal of Mathematics and Science Education
Available online at www.radenfatah.ac.id
Vol. 1 No. 1, May 2024, pages: 14-24
E-ISSN: 3063-6175
https://doi.org/10.19109/MathSciEdu.v1i1.18406

Research Article

Puzzle-assisted REACT Learning Strategy on Mathematical Literacy and Adaptive Reasoning Ability: A Study of Indonesian Junior High School Students

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Received: February 10, 2024	Revised: April 18, 2024	Accepted: May 15, 2024	Online: May 28, 2024

Abstract

The students' mathematical literacy and adaptive reasoning abilities are critical in teaching mathematics. This research aims to see how the puzzle-assisted REACT learning strategy affects students' mathematical literacy and adaptive reasoning abilities. The research employed a quantitative approach with the One-Way MANOVA to analyze the data. This research was conducted at SMP Muhammadiyah 2 Kalirejo, Central Lampung, with a sample size of 26 students for the experimental group and 25 for the control group. A test of students' mathematical literacy and a questionnaire on adaptive reasoning abilities were used as research instruments. The findings revealed that (1) the puzzle-assisted REACT learning strategy had an impact on the seventh-grade of junior high school students' mathematical literacy and adaptive reasoning abilities; (2) the puzzle-assisted REACT learning strategy had an impact on the seventh-grade of junior high school students' mathematical literacy ability; (3) the puzzle-assisted REACT learning strategy had an impact on the seventh-grade of junior high school students and adaptive reasoning ability.

Keywords:
REACT Learning Strategy, Puzzles, Mathematical Literacy Mathematics, Adaptive Reasoning.

INTRODUCTION

Mathematics significantly impacts youth's future potential [1]–[3]. It includes subjects that are vital for training students to participate in beneficial work in general and strengthening their ability to adapt to continually changing times [4]. are at least five essential components of mathematics: mathematical problem-solving [5], [6], mathematical communication [7], [8], mathematical reasoning [9], [10], mathematical connection [11], [12], and mathematical representation [13]–[15]. These components significantly impact student's life because they can help students solve problems efficiently using their abilities, allowing them to compete in the outside world.

Previous research indicates that enhancing students' mathematical literacy abilities can help them improve their higher-order thinking skills [16]. Höfer & Beckmann [17] claim that the ability to apply mathematical knowledge to various context-related problems in a functional, flexible, and practical manner is at the heart of mathematical literacy. Students require adaptive reasoning skills in addition to mathematical literacy skills when learning [18] and dealing with changing times [19], [20].

Studying students' literacy and adaptive reasoning abilities in mathematics has become a prominent topic in recent years

[21]–[30]. There are numerous variations in research findings in this field. Rizki, L. M., & Priatna, N. [29] defined mathematical literacy as the ability to comprehend mathematics in various situations, including mathematical reasoning and mathematical concepts, procedures, facts, and tools in explaining a phenomenon. Another point of view is represented by [30], who defines mathematical literacy as students' capacity to identify and comprehend the function of mathematics in everyday life. Awofala, A. O. [27] demonstrated that adaptive reasoning allows a person to evaluate various techniques to follow the mathematical logic of the provided evidence, noting logical flaws or contradictions and justifying findings. According to Syukriani, A., Juniati, D., & Siswono, T. Y. E. [28], adaptive reasoning ability is described as thinking logically about the relationship between concepts and situations.

People must have a set of abilities or a combination of abilities to solve everyday challenges. As a result, it is vital to develop learning methodologies that can promote student activity through group work and allow students to integrate material into real-life circumstances. Gupta, D. [31] proposed that this problem can be overcome by selecting the appropriate learning approach. The REACT Learning Strategy (Relating, Experiencing, Applying, Cooperating, Transferring) is a fast-expanding research study [32]–[35]. The REACT approach begins with the Relating, Experiencing, Applying, Cooperating, and Transferring phases. REACT has been shown to improve mathematical problem-solving skills [36], [37], mathematical communication ability [38]–[40], and critical thinking ability [41]–[43]. Furthermore, the key finding is that REACT is useful during learning.

According to Kristianti, N. K. H., Sudhita, I. W. R. S., & Riastini, P. N. [44], the REACT technique has a limitation in its execution, precisely the condition of students who frequently forget earlier mathematics subject matter. As a result, the teacher must repeat some of the topics students forgot. So, in this study, puzzle learning media was employed so that students could understand the subject more quickly and for a longer period since they were directly participating in the construction of their knowledge. This research, which investigates a decline in mathematical achievement, also highlights the significant impact of REACT on literacy and adaptive reasoning abilities. There has never been a study that attempts to determine the impact of the REACT strategy on students' literacy and adaptive reasoning abilities; thus, this study will yield novel results. This study aims to improve students' literacy and adaptive reasoning abilities through the intentional use of the REACT approach in the experimental class. Despite numerous studies, the REACT approach has never been applied to students' adaptive literacy and reasoning abilities.

Theoretical Background

Literacy Ability

Mathematical literacy is defined as the ability to perceive mathematics in a variety of circumstances. This ability comprises mathematical reasoning and mathematical concepts, methods, facts, and tools to describe a phenomenon [45]–[47]. Mathematical abilities include mathematical processes, mathematical content, and situations and contexts complementary to learning because students can give meaning to every process. For instance, students can recognize and understand which mathematical concepts are relevant when faced with mathematical problems [48]. The indicators of mathematical literacy abilities are formulating problems mathematically and employing mathematical concepts, facts, procedures, and reasoning. The last indicators are interpreting, applying, and assessing mathematical outcomes [49].

Adaptive Reasoning Ability

The ability to think logically about the relationship between concepts and situations is an adaptive reasoning ability. Adaptive reasoning allows one to evaluate various techniques to follow the mathematical logic of the provided evidence, identifying logical flaws or contradictions and justifying conclusions [50]. Students with adaptive reasoning can justify the solution and steps employed in logically addressing problems so they recognize when the solution steps are incorrect or correct. According to Klipatrick and Findell [51], students can demonstrate adaptive reasoning ability when three conditions are met: they know enough basic knowledge, the tasks can be understood or understood and inspire students, and the setting offered is familiar and attractive to many students. Therefore, adaptive reasoning abilities are required for students to prepare for the future [52]. The indicators of adaptive reasoning are making conjectures, presenting reasons or evidence for the veracity of a statement, deriving conclusions from a statement, testing the validity of an argument, and detecting patterns in mathematical phenomena.

METHODS

Type of Research

This research employed the true experimental design in which all external variables that impact the course of the experiment are controlled. Furthermore, this research employed the Control-only design with two groups: the experimental group (treated with puzzle-assisted REACT strategy) and the control group (treated with conventional or direct learning treatment). The puzzle-assisted REACT strategy is the independent variable, and mathematical literacy and adaptive reasoning is the dependent variable

Participants

The population in this study were the seventh-grade students of SMP Muhammadiyah 2 Kalirejo Central Lampung in the 2022/2023 academic year consisting of four classes. The research samples were class VIII A as the experimental class and class VIII B as the control class. The researchers employed the cluster random sampling technique.

REACT Learning Strategy

The steps of the puzzle-assisted REACT learning strategy are displayed in Table 1.

Table 1. The Steps of the Puzzle-Assisted REACT Learning Strategy [53], [54]

Stage	Activity
Relating	Students can relate everyday life situations to new information or problems being solved.
Experiencing	Conduct learning in the context of exploration and discovery to find new contexts.
Applying	Students do activities that are in line with the material that has been learned.
Cooperating	The teacher will divide the students into several groups. Each group looks for examples of the subject matter.
Transferring	After students understand the concepts, they apply or utilize the knowledge they have gained in a new context.

Instrument

The research data was gathered through a post-test. The instruments contained questions about mathematical literacy and adaptive reasoning ability. The test instruments were constructed based on mathematical literacy and adaptive reasoning abilities indicators, as indicated in Table 2 and Table 3.

Table 2. The Indicators of Mathematical Literacy Abilities [55]

Mathematical Literacy Indicators	Operational Forms
Formulating situations mathematically	Students' ability to present a situation mathematically, using appropriate variables, symbols, diagrams, and standard models.
Employing mathematical concepts, facts, procedures, and reasoning	Students' ability to employ mathematical tools, design, and strategies to find mathematical solutions.
Interpreting, applying, and evaluating mathematical outcomes	Students' ability to reinterpret mathematical outcomes into real-world contexts and evaluate the reasonableness of mathematical solutions in the context of real-world problems.

Table 3. The Indicators of Adaptive Reasoning Abilities [56], [57]

Adaptive Reasoning Ability Indicators	Operational Forms
Constructing a presumption	Student's ability to formulate various possible solutions according to their knowledge.
Providing reasons or evidence for the truth of a statement	Students' ability to express reasons for the truth of a statement.
Concluding a statement	Students' ability to conclude from statements and thinking processes empowers their knowledge in such a way as to produce a thought.
Checking the validity of an argument	Students' ability to check and investigate the truth of an existing statement.
Finding patterns in mathematical phenomena	Students' ability to find patterns or ways from an existing statement so that they can develop into mathematical sentences.

Based on Cronbach's Alpha analysis, the reliability test for mathematical literacy and adaptive reasoning questions obtained 0.82 and 0.83, respectively. This finding shows that the test is suitable for measuring creative and critical thinking abilities.

Procedure and Data Analysis

The research's data analysis technique was the multivariate analysis of variance (MANOVA) utilizing SPSS 25.0. MANOVA analysis was used to compare the influence of the independent variable (Puzzle-assisted REACT learning strategy) on students' mathematical literacy and adaptive reasoning abilities in both univariate and multivariate analyses.

RESULTS AND DISCUSSIONS

Results

The results of testing students' mathematical literacy and adaptive reasoning skills in both the experimental class (the class that received the REACT strategy) and the control class (the class that did not get the REACT strategy) are shown in Table 4 and Table 5.

Table 4. The Data Analysis Results of Mathematical Literacy Abilities

Class	X_{Max}	X_{Min}	Central Tendency			Group Variance	
			$\bar{x}$	Me	Mo	R	Sd
Experimental Class	100	50	79,67	83	83,33	50	16,85
Control Class	100	33,33	66,67	66,67	83,33	66,67	17,64

Table 4 illustrates that the experimental class with the puzzle-assisted REACT strategy showed superior mathematical literacy skills compared to the control class. This finding is evidenced by the mean value ($\bar{x}$) of 79.67, mode value (Mo) of 83.33, and range of 50. The large range in the experimental class resulted in a statistically significant variance of 16.85. The data revealed that the experimental class showed a significant difference in the highest and lowest values when compared to the control class. The same result is also shown in the analysis of students' mathematical adaptive reasoning ability in Table 5.

Table 5. The Data Analysis Results of Adaptive Reasoning Abilities

Class	X_{Max}	X_{Min}	Central Tendency			Group Variance	
			$\bar{x}$	Me	Mo	R	Sd
Experimental Class	100	46	72,67	75	45,83	50	20,24
Control Class	95,83	37,50	64,74	66,67	79,16	58,33	18,72

Based on Table 5, the experimental class with REACT strategy showed superior mathematical adaptive reasoning compared to the control class. This data is evidenced by the mean value ($\bar{x}$) of 72.67, the mode value (Mo) of 45.83, and the range of 50. The large range in the experimental class resulted in a statistically significant variance of 20.24. The data revealed that the class with REACT strategy had a significant difference between the highest and lowest scores compared to the control class.

A multivariate analysis was also performed to see how the REACT technique influences students' mathematical literacy and mathematics adaptive reasoning abilities. Implementing the REACT technique affects students' mathematical literacy and mathematics adaptive reasoning skills. Table 6 displays the results of the multivariate analysis.

Table 6. Multivariate Analysis

Multivariant Test		
	Effect	Sig.
Intercept	Pillai's Trace	0.000
	Wilks' Lambda	0.000
	Hotelling's Trace	0.000
	Roy's Largest Root	0.000

The multivariate analysis results in Table 6 show that the comparison test is taken from the averages of the mathematical literacy and adaptive reasoning skills components of students in the experimental and control classes. There are statistical tests, namely Pillai's trace, Wilk's Lambda, Hottelling Trace, and Roy's Largest Root. Based on the overall statistical test results, a significant value of 0.000 (less than 0.05) was obtained. So, according to the criteria, H_0 is rejected so that the independent variable (puzzle-assisted REACT strategy) influenced the dependent variable (mathematical literacy and adaptive reasoning skills).

Table 7. Test of Between Subjects Effects

Tests of Between-Subjects Effects

Source	Dependent Variable	F	Sig.
Intercept	Mathematical Literacy	916.30	.000
	Adaptive Reasoning	634.40	.000

Based on Table 7, the significant value of mathematical literacy ability is 0.000 (smaller than 0.05), which means H_0 is rejected. So, it can be concluded that the average mathematical literacy ability influences variable X (puzzle-assisted REACT strategy). In adaptive reasoning, the significant value obtained is 0.000 (smaller than 0.05), which means H_0 is rejected. So, it can be concluded that the average adaptive reasoning influences variable X (puzzle-assisted REACT strategy).

Discussion

The data analysis shows a relationship between students' mathematical literacy and adaptive reasoning abilities. Significant student scores on mathematical literacy and adaptive reasoning abilities support this finding. Following treatment in each sample class, the REACT strategy can stimulate the thinking process to enhance mathematical abilities and is beneficial for polishing students' ideas or thoughts in mathematical literacy and adaptive reasoning. The influence and interest of students demonstrate a positive attitude toward mathematics instruction [58], [59]. The learning can inspire students to reason about a specific topic, fostering active learning through experimentation.

This research was conducted in one of the junior high schools in Lampung by taking two classes as research samples, one as an experimental class using puzzle-assisted REACT strategy and one as a control class (not using puzzle-assisted REACT strategy). The second hypothesis is about the effect of the puzzle-assisted REACT strategy on mathematical literacy and adaptive reasoning skills. The between subject effect test results showed that the students' mathematical literacy ability is 0.000 (smaller than 0.05). Therefore, it can be concluded that H_0 is rejected. It can be concluded that the REACT strategy with puzzle media can affect mathematical literacy abilities.

The results of this study show that the puzzle-assisted REACT strategy outperforms the conventional strategy. The statement is based on the results of hypothesis testing with the multivariate test, which yielded a significance value of 0.000 (less than 0.05); thus, H_0 is rejected. Therefore, we might conclude that H_0 is rejected. Because mathematical literacy is the focal point of learning, students must solve problems in everyday life quantitatively and utilize adaptive reasoning in reaching conclusions and making decisions. According to the study's findings, adopting the puzzle-assisted REACT technique in the experimental class improves average mathematical literacy and adaptive reasoning skills over the control class. There is a considerable difference in the students' mathematical literacy skills taught using the puzzle-assisted REACT strategy and those taught using the conventional learning strategy.

The puzzle-assisted REACT strategy connects classroom learning materials with daily contexts [36], [60] by actively seeking and investigating to gain meaning from concepts learned [61]. Furthermore, presenting learning in Applying stage allows students to learn through cooperation (cooperating) and utilizing knowledge to solve

everyday problems (transferring). The puzzle-assisted REACT strategy serves as a link between new material learned and material already owned by students.

Sehat Matua Ritonga [62] found that the problem-solving ability in the control class did not increase significantly because no media treatment encouraged students to work together to solve a problem. Masi, L., Misu, L., & Pitasari, D. [37] claim that the REACT strategy can positively influence students' mathematical problem-solving skills when compared to the direct learning model. This finding demonstrates that, compared to conventional learning, the puzzle-assisted REACT strategy can influence and improve mathematical literacy and adaptive reasoning abilities. Furthermore, students' activities and understanding of learning reflect well on learning implementation, and students respond positively, indicating that the learning can increase students' motivation and ability to solve a mathematical problem. Previous research has found that the REACT Strategy is effective in improving concept understanding and assisting 12th-grade students in making connections between scientific concepts and everyday life [33], [38], [63], [64]. Researchers also recommend developing the puzzle-assisted REACT strategy because it can be used as an alternative learning strategy to improve mathematical literacy skills and develop adaptive reasoning by keeping in mind that the number of students in one group at the time of the experiment should not be too large. The time that must be considered is also important.

CONCLUSIONS

Based on the analysis and discussion, it can be concluded that puzzle-assisted REACT learning strategy affects the seventh-grade students' mathematical literacy and adaptive reasoning abilities in junior high school, puzzle-assisted REACT learning strategy affects the seventh-grade students' mathematical literacy skills in junior high school, and puzzle-assisted REACT learning strategy affects the seventh-grade students' adaptive reasoning in junior high school.

Future lesson models will explore students' mathematical literacy and adaptive reasoning abilities. It is envisaged, in particular, that objective criteria that indicate the amount of originality of the work will be discovered and validated. The sample size and number of participants will be increased to achieve more reliable results.

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Conflicts of Interest

The authors declare no conflict of interest.

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