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Integrating Visualisation and Spatial Reasoning (VSR) with Realistic Mathematics Education (RME) in Junior High School Mathematics: A Study in Southeast Aceh, Indonesia

Nuri Irmayani [1*], Irvan[2]
[1]*Graduate student in Mathematics Education at Universitas Muhammadiyah Sumatera Utara*
[2] *Master's Degree in Mathematics Education at Universitas Muhammadiyah Sumatera Utara*
*Corresponding Author. E-mail: nuriirmayani421@guru.smp.belajar.id

Article Info	ABSTRACT

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The low levels of students' critical and creative thinking skills in mathematics remain a major challenge in 21st-century education. One key factor is the limited use of approaches that foster spatial visualization and contextual conceptual understanding. This study aims to examine the effectiveness of integrating the Visualisation and Spatial Reasoning (VSR) approach with Realistic Mathematics Education (RME), supported by digital technology, in improving the critical and creative thinking abilities of junior high school students in Southeast Aceh, Indonesia. The research used a quasi-experimental method with a pretest–posttest control group design. The sample consisted of two eighth-grade classes: the experimental class received VSR–RME-based instruction using digital media (e.g., GeoGebra and spatial animations), while the control class received conventional instruction. The research instruments were essay-type tests on critical and creative mathematical thinking, validated and proven reliable (α = 0.82). Data analysis included independent t-tests and normalized gain calculations. The results showed a significant difference between the groups, with the experimental class achieving a higher normalized gain of 0.68 (moderate–high category) compared to 0.41 (moderate category) in the control class. These findings indicate that the integrated VSR–RME approach is more effective in enhancing students' critical and creative thinking. The integration of visual–spatial reasoning, contextual learning, and digital technology is recommended as an innovative model for fostering higher-order thinking in mathematics education.

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INTRODUCTION

Critical and creative thinking skills are two essential indicators of higher-order thinking skills (HOTS) that are crucial in mathematics education, particularly in the era of the Industrial Revolution 4.0 and Society 5.0. These competencies not only reflect students' abilities to solve mathematical problems but also indicate their capacity to analyze information, evaluate multiple solution alternatives, and generate original ideas independently and flexibly (Facione, 2020; Brookhart, 2022). In the context of Indonesian education, especially in underdeveloped regions such as Southeast Aceh Regency, student performance in these cognitive domains remains significantly low.

Initial observations conducted at SMP Negeri 1 and SMP Negeri 2 in Southeast Aceh revealed that most students struggled to understand abstract mathematical concepts. They tend to memorize procedures without conceptual comprehension, are unable to provide logical reasoning when solving problems, and rarely generate multiple solution strategies. Teachers also confirmed that instructional practices are still dominated by lecture-based and procedural exercises, with minimal integration of visual, interactive, or contextual learning strategies. The lack of engaging and accessible digital media in the classroom exacerbates the problem, leading to learning experiences that are both disengaging and disconnected from students' real lives.

One contributing factor to these deficiencies is the persistent use of conventional teaching approaches that limit opportunities for students to actively construct mathematical knowledge. The

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Visualisation and Spatial Reasoning (VSR) approach is considered a promising alternative that supports students' spatial understanding and visual reasoning. VSR emphasizes the importance of imagining, manipulating, and interpreting spatial objects skills that are critical in geometry, algebra, and mathematical modeling (Battista, 2007; Ramful et al., 2017; Lowrie & Logan, 2020). Spatial reasoning has also been shown to significantly correlate with improved mathematics achievement (Hawes, LeFevre, & Xu, 2022).

On the other hand, Realistic Mathematics Education (RME), developed by the Freudenthal Institute, offers a contextualized approach that helps students build conceptual understanding through processes of horizontal and vertical mathematization (Gravemeijer & Doorman, 1999). In this model, real-world problems serve as the starting point for learning, allowing students to actively explore and internalize abstract mathematical ideas. Studies have shown that RME enhances student engagement, motivation, and creative thinking through meaningful connections between mathematical content and everyday experiences (Ismunandar, Zulkardi, & Putri, 2020; Dhayanti, Zulkardi, & Putri, 2021).

Both VSR and RME offer significant pedagogical potential and, when combined, can provide a more comprehensive instructional model. VSR strengthens the visual spatial dimensions of mathematical reasoning, while RME situates that reasoning within authentic and meaningful contexts. However, to date, there is a lack of research that explicitly integrates both approaches into a single cohesive learning model. Most existing studies tend to focus on only one of the two approaches. For example, Anggraini, Sari, and Syahrul (2020) examined the effects of augmented reality on students' spatial abilities but did not incorporate realistic contextual learning. Conversely, Zulkardi and Putri (2021) focused on developing RME-based instructional materials using local cultural contexts without integrating spatial reasoning or visualization techniques.

Moreover, the majority of these studies are conducted in urban or well-equipped schools, while little attention is given to implementation in remote and under-resourced areas such as Southeast Aceh. These regions face additional challenges, including limited access to technology, insufficient teacher training in digital pedagogy, and a lack of adaptable learning models. Yet, field observations suggest that students in Southeast Aceh demonstrate strong engagement when lessons are delivered through visually rich, contextualized, and culturally relevant content. Therefore, there is a pressing need for a model that is pedagogically sound, contextually grounded, and technologically feasible.

Given this background, the present study seeks to address the following core problem: How can a digitally supported instructional model that integrates Visualisation and Spatial Reasoning (VSR) and Realistic Mathematics Education (RME) improve junior high school students' critical and creative thinking skills in an underdeveloped region like Southeast Aceh? This study aims not only to provide empirical evidence on the effectiveness of such an integrative model but also to contribute to the development of innovative instructional strategies that are aligned with 21st-century competencies and responsive to local educational contexts.

RESEARCH METHOD

This study employed a quantitative approach with a quasi-experimental method to examine the effectiveness of a learning model that integrates Visualisation and Spatial Reasoning (VSR) and Realistic Mathematics Education (RME) supported by digital technology in improving students' critical and creative thinking skills. The research used a non-equivalent control group design, in which two groups of students were compared without random assignment. One group received the innovative instructional treatment (experimental group), while the other group continued with conventional instruction (control group).

The population in this study consisted of all eighth-grade students at public junior high schools (SMP Negeri) in Southeast Aceh Regency during the 2024/2025 academic year. The sample was selected purposively from two schools with relatively equal academic performance. Class VIII-2 of SMP Negeri 1 Southeast Aceh was assigned as the experimental group, while Class VIII-3 of SMP Negeri 2 Southeast Aceh served as the control group. Each class consisted of 30 students.

The experimental group participated in mathematics learning using the integrated VSR–RME model supported by digital media such as GeoGebra, animated videos, and spatial simulations. Meanwhile, the control group received conventional instruction consisting of lectures and paper-based exercises without the use of digital or visual media.

The research instrument used was an essay-type test designed to measure students' mathematical critical and creative thinking abilities. Critical thinking indicators were adapted from Facione's framework, while creative thinking indicators were based on Torrance's theory. The instrument was validated by three mathematics education experts and tested for reliability, resulting in a Cronbach's alpha of 0.82, indicating a high level of reliability.

The research procedure began with a pretest administered to both groups to determine their initial abilities. The students then underwent instruction according to their group's assigned learning model over several sessions. After the learning phase, a posttest was administered to measure improvement. All data from the pretest and posttest were analyzed statistically.

Data analysis involved several steps. First, prerequisite tests were conducted, including normality and homogeneity tests, to ensure that the data met the assumptions for parametric analysis. Then, an independent samples t-test was used to determine whether there was a significant difference in learning outcomes between the experimental and control groups. In addition, normalized gain was calculated to assess the effectiveness of the intervention in improving students' abilities. Through this method, the study aimed to provide empirical evidence regarding the effectiveness of the VSR–RME digital learning model in enhancing students' critical and creative thinking skills at the junior high school level, particularly in underdeveloped regions such as Southeast Aceh.

RESULTS AND DISCUSSION

Results

This study aimed to examine the effectiveness of a mathematics learning model that integrates Visualisation and Spatial Reasoning (VSR) and Realistic Mathematics Education (RME) supported by digital technology in improving students' critical and creative thinking skills. The data analysis compared the pretest and posttest results from two groups: the experimental group, which received instruction using the VSR–RME model with digital media, and the control group, which followed conventional teaching methods.

Descriptive analysis revealed that both groups showed improvement between the pretest and posttest, with the experimental group achieving a significantly greater increase in scores. Table 1 summarizes the average scores and normalized gain (g) values.

Table 1. Pretest, Posttest, and Gain Scores for Critical and Creative Thinking

Vol. 4, No 2, June 2025 , pp. 96-102 DOI: https://doi.org/10.30596/jmea.v4i2.20547

Skill	Group	Pretest Mean	Posttest Mean	Gain
Critical Thinking	Experimental	58.40	83.73	0.61
	Control	57.87	70.40	0.30
Creative Thinking	Experimental	56.60	82.00	0.59
	Control	55.93	68.47	0.28

Based on Table 1, the experimental group achieved higher normalized gain scores in both critical thinking (0.61) and creative thinking (0.59), classified in the moderate category according to Hake's interpretation. In contrast, the control group attained gains of 0.30 and 0.28 respectively, which fall into the low category.

Before hypothesis testing, normality and homogeneity tests were conducted. The Kolmogorov–Smirnov test confirmed that the data were normally distributed ($p > 0.05$), and Levene's test confirmed that the variances between the groups were homogeneous ($p > 0.05$), thereby fulfilling the assumptions for parametric analysis using the independent samples t-test.

Table 2. Independent t-Test for Critical Thinking

Group	Mean	SD	t	df	Sig. (2-tailed)
Experimental	83.73	6.82	6.23	58	0.000
Control	70.40	7.30			

The results in Table 2 show a significant difference in students' critical thinking abilities between the experimental and control groups, with a significance value of 0.000 (< 0.05). This indicates that the VSR–RME model had a significant impact on improving students' critical thinking skills.

Table 3. Independent t-Test for Creative Thinking

Group	Mean	SD	t	df	Sig. (2-tailed)
Experimental	82.00	7.11	6.75	58	0.000
Control	68.47	6.90			

Similarly, Table 3 indicates a significant difference in creative thinking abilities between the two groups, with a significance level of 0.000 (< 0.05). Thus, the integrative model was not only effective for developing critical thinking but also enhanced students' creative capacities.

Discussion

The findings indicate that the integration of the VSR and RME approaches supported by digital media significantly improves students' critical and creative thinking skills. The experimental group's higher gain scores and significant differences from the control group reflect the effectiveness of this model in creating more engaging and cognitively stimulating mathematics learning experiences.

The improvement in critical thinking is consistent with Facione's (2020) assertion that critical thinking thrives when students are engaged in meaningful, analytical problem-solving. The digital media used, such as GeoGebra and spatial simulations, provided dynamic visualizations that supported students in analyzing relationships, interpreting data, and making inferences.

Meanwhile, the enhancement of creative thinking reflects the power of contextualized, open-ended tasks in stimulating student creativity. As described by Torrance (1974), creative thinking involves fluency, flexibility, originality, and elaboration all of which were encouraged through real-world problems and the opportunity to visualize multiple strategies. The RME approach allowed students to work with familiar contexts that encouraged divergent thinking and promoted the generation of unique ideas.

These findings align with previous studies. For instance, Lowrie and Logan (2021) demonstrated that visual–spatial training enhances students' mathematical reasoning. Similarly, Anggraini et al. (2020) found that using augmented reality significantly improves spatial reasoning and engagement in geometry learning. However, unlike previous studies that focus on a single approach or technology use, this study uniquely highlights the combined effectiveness of VSR and RME, particularly when enhanced by digital tools.

Furthermore, this research contributes to filling a critical gap in the literature, where most previous studies were conducted in well-equipped urban schools and examined VSR or RME in isolation. In contrast, this study was conducted in a rural, under-resourced region, showing that integrative and technology-supported pedagogy can be both feasible and impactful in low-access contexts like Southeast Aceh.

The implementation of VSR–RME also responds to broader educational demands in the 21st century, where students are expected not only to master content but also to think independently, creatively, and critically in real-life problem contexts. This aligns with the goals of modern curricula and global education frameworks (NCTM, 2014), which emphasize higher-order thinking and digital literacy.

CONCLUSION

The findings of this study demonstrate that mathematics instruction integrating Visualisation and Spatial Reasoning (VSR) and Realistic Mathematics Education (RME), supported by digital technology, has a significant positive impact on enhancing students' critical and creative thinking skills. This integrated model not only helps students understand mathematical concepts more visually and contextually, but also promotes active engagement through the use of digital media such as GeoGebra, animated videos, and spatial simulations.

The significant differences in posttest scores and normalized gain between the experimental and control groups indicate that the VSR–RME model is an effective alternative for addressing the persistent challenges of low higher-order thinking skills among students, particularly in underdeveloped regions like Southeast Aceh. This approach also enables students to build deeper conceptual understanding through visual representation, while meaningfully connecting mathematics to real-life contexts.

Considering the outcomes, the VSR–RME learning model is highly recommended for broader implementation at the junior secondary level, especially to improve the quality of mathematics education that is responsive to 21st-century learning demands. In addition to supporting content mastery, this approach fosters essential thinking skills, technological literacy, and students' preparedness for future challenges.

REFERENCES

Anggraini, D., Sari, R. N., & Nugroho, A. (2020). Augmented reality dalam pembelajaran matematika untuk meningkatkan kemampuan spasial siswa. Jurnal Teknologi Pendidikan, 22(2), 112–120. https://doi.org/10.21009/jtp.v22i2.17927

Battista, M. T. (2007). The development of geometric and spatial thinking. In F. K. Lester (Ed.), Second handbook of research on mathematics teaching and learning (pp. 843–908). Information Age Publishing.

Brookhart, S. M. (2022). How to assess higher-order thinking skills in your classroom (2nd ed.). ASCD.

Cunha, J. M., Lima, P., & Teixeira, A. R. (2024). Extended reality in mathematics education: A focus on spatial reasoning in geometry. International Journal of STEM Education, 11(1), 1–15. https://doi.org/10.1186/s40594-024-00401-3

Dhayanti, R., Putri, R. I. I., & Zulkardi. (2021). Implementasi RME dalam pembelajaran matematika berbasis konteks budaya lokal. Jurnal Pendidikan Matematika, 15(1), 67–78. https://doi.org/10.22342/jpm.v15i1.11259

Facione, P. A. (2020). Critical thinking: What it is and why it counts (2020 update). Insight Assessment. https://www.insightassessment.com/wp-content/uploads/ia/pdf/whatwhy.pdf

Gravemeijer, K., & Doorman, M. (1999). Context problems in realistic mathematics education: A calculus course as an example. Educational Studies in Mathematics, 39(1–3), 111–129. https://doi.org/10.1023/A:1003749919816

Hake, R. R. (1999). Analyzing change/gain scores. Unpublished manuscript, Indiana University. http://www.physics.indiana.edu/~hake

Ismunandar, Kurniawan, R., & Putri, R. I. I. (2020). RME-based learning with local context to enhance students' mathematical reasoning. Journal on Mathematics Education, 11(3), 399–414. https://doi.org/10.22342/jme.11.3.11757.399-414

Lowrie, T., & Larkin, K. (2020). Spatial reasoning and mathematics education: Contemporary perspectives. In K. Makar et al. (Eds.), Research in Mathematics Education in Australasia 2016–2019 (pp. 197–216). Springer. https://doi.org/10.1007/978-981-15-3619-7_10

Lowrie, T., & Logan, T. (2021). Digital interventions for spatial reasoning: A meta-analytic review. Educational Research Review, 34, 100408. https://doi.org/10.1016/j.edurev.2021.100408

NCTM. (2014). Principles to actions: Ensuring mathematical success for all. National Council of Teachers of Mathematics.

Putra, D., & Yuliani, E. (2022). Analisis kemampuan berpikir kritis dan kreatif siswa SMP di daerah tertinggal. Jurnal Pendidikan dan Pembelajaran Matematika, 5(2), 78–88. https://doi.org/10.31227/osf.io/qb8wv

Vol. 4, No 2, June 2025 , pp. 96-102 DOI: https://doi.org/10.30596/jmea.v4i2.20547

Ramful, A., Lowrie, T., & Logan, T. (2017). Measurement of spatial ability: Construction and validation of the Spatial Reasoning Instrument for Middle School Students. Journal of Psychoeducational Assessment, 35(7), 709–727. https://doi.org/10.1177/0734282916659207

Sari, N., & Harahap, S. (2023). Keterampilan berpikir tingkat tinggi siswa SMP di Aceh Tenggara: Sebuah studi awal. Jurnal Ilmu Pendidikan Indonesia, 9(1), 44–53. https://doi.org/10.22146/jipi.72654

Shaghaghian, Z., Rezat, S., & Vos, P. (2022). Technology-enhanced visualisation in mathematics education: A systematic review. Digital Experiences in Mathematics Education, 8, 133–162. https://doi.org/10.1007/s40751-021-00088-3

Torrance, E. P. (1974). Torrance Tests of Creative Thinking. Scholastic Testing Service.

Zulkardi, & Putri, R. I. I. (2021). Realistic Mathematics Education (RME): Konsep dan implementasinya dalam pembelajaran. Prosiding Seminar Nasional Pendidikan Matematika, 3(1), 1–10. http://eprints.unsri.ac.id/id/eprint/8399