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Development of Mathematics learning tools through Realistic Mathematics Education (RME) to enhance spatial ability

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ABSTRACT

This study aims to develop mathematics learning tools based on Realistic Mathematics Education (RME) to improve elementary school students' spatial ability. The research was conducted in response to students' low spatial skills, primarily caused by the dominance of conventional teaching methods, limited use of contextual media, and the absence of systematically integrated learning tools using the RME approach. The development procedure used a modified ADDIE model consisting of three main stages: analyze, design, and develop. The research subjects included fourth-grade students and mathematics teachers at SDN 102083 Pabatu. The instruments involved expert validation questionnaires, student response questionnaires, spatial ability tests, and observation sheets for lesson implementation. The results showed that the developed learning tools were deemed valid by material experts, media experts, and teachers. The high level of lesson implementation and positive responses from both students and teachers confirmed practicality. Effectiveness was evidenced by the improvement in pretest and posttest scores, with a normalized gain score of 0.651 and a classical mastery percentage of 88 percent. These findings suggest that RME-based learning tools are effective in enhancing students' spatial abilities in Mathematics.

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ABSTRAK

Penelitian ini bertujuan untuk mengembangkan perangkat pembelajaran Matematika berbasis Realistic Mathematics Education (RME) guna meningkatkan kemampuan spasial murid sekolah dasar. Latar belakang penelitian ini adalah rendahnya kemampuan spasial murid yang disebabkan oleh dominasi metode pembelajaran konvensional, penggunaan media yang kurang kontekstual, serta belum tersedianya perangkat ajar yang mengintegrasikan pendekatan RME secara sistematis dan menyeluruh. Prosedur pengembangan menggunakan model ADDIE yang dimodifikasi menjadi tiga tahap utama, yaitu analyze, design, dan develop. Subjek penelitian meliputi murid kelas IV SDN 102083 Pabatu dan guru mata pelajaran Matematika. Instrumen yang digunakan mencakup angket validasi, angket respon, tes kemampuan spasial, dan lembar observasi keterlaksanaan. Hasil penelitian menunjukkan bahwa perangkat pembelajaran yang dikembangkan dinyatakan valid berdasarkan penilaian ahli materi, ahli media, dan guru. Perangkat juga tergolong praktis karena keterlaksanaan pembelajaran mencapai kategori baik dan memperoleh respon positif dari guru dan murid. Keefektifan perangkat dibuktikan melalui peningkatan nilai pretest dan posttest, dengan skor N-Gain sebesar 0,651 dan persentase ketuntasan klasikal sebesar 88 persen. Hasil tersebut menunjukkan bahwa perangkat pembelajaran berbasis RME efektif dalam meningkatkan kemampuan spasial murid sekolah dasar.

Kata Kunci: *kemampuan spasial; perangkat pembelajaran; Realistic Mathematics Education; RME; sekolah dasar*

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INTRODUCTION

The quality of mathematics learning in elementary schools remains fundamental weaknesses, particularly in teachers' classroom teaching approaches. One-way learning processes through lecture methods lead to students being less actively involved in thinking and exploring mathematical concepts in depth (Kurniawan *et al*., 2024; Maryanti, 2024). Students tend to passively receive information without room for building understanding through contextual and interactive learning experiences (Astria & Kusuma, 2023; Setiawan *et al*., 2024). The dominance of verbal delivery of material hinders the development of critical and logical thinking skills and also contributes to students' low spatial ability in understanding geometric concepts and two or three-dimensional visual representations (Ainurrahmah *et al*., 2023; Pubian & Herpratiwi, 2022; Simamora *et al*., 2024). This problem becomes even more complex when the use of digital technology in mathematics learning is not yet optimized, despite the availability of various applications to enrich the learning process.

Teachers still face challenges in using digital devices meaningfully, resulting in students not receiving adequate spatial visualization experiences (Lestari & Naila, 2021; Sutarna & Maryani, 2021). Initial observation results at SD Negeri 102083 Pabatu show that 70% of fourth-grade students have difficulty understanding spatial concepts, particularly with cube material. The students' low ability to visualize the rotation and orientation of points in spatial figures indicates that mathematics learning needs to be designed innovatively, contextually, and closely related to real life (Manik *et al*., 2024; Yuliati *et al*., 2021). Developing learning materials that integrate the Realistic Mathematics Education approach is a relevant solution to address these challenges systematically and meaningfully.

Spatial ability is an important cognitive aspect in geometry learning, but initial diagnostic results at SD Negeri 102083 Pabatu show that most students still have difficulty imagining the shapes and positions of three-dimensional figures, including the rotation and orientation of points on a cube, with only 24% answering correctly. This condition highlights the need for learning strategies that can connect abstract concepts with students' concrete experiences (Sari *et al*., 2022). Web-based technologies like Google Sites have great potential to support the development of spatial abilities through the visual, interactive, and contextual presentation of material (Istiqomarie *et al*., 2023; Sugiarto *et al*., 2023). This platform allows for the integration of text, images, and learning instructions within a systematic and flexible interface, while also encouraging active student engagement (Jubaidah & Zulkarnain, 2020; Meduri *et al*., 2022). The use of Google Sites has proven to be effective in increasing learning effectiveness and strengthening interaction between teachers and students, making the development of learning materials based on a realistic approach integrated with digital technology an urgent need to improve the quality of mathematics learning on the topic of spatial geometry. (Soraya & Wantika, 2021; Sutarni & Aryuana, 2023).

Spatial ability plays an important role in learning Mathematics because it is directly related to visualization, rotation, and understanding two- and three-dimensional spatial relationships, and this skill has been shown to be positively correlated with academic achievement, particularly in geometry and visual problem-solving (Ismi *et al*., 2021; Pitriyani *et al*., 2024). Developing spatial abilities requires a contextual and meaningful learning approach, one of which is through Realistic Mathematics Education (RME), which emphasizes progressive mathematization based on real-world problems (Yunianingsih *et al*., 2024). This approach encourages students to build informal models from concrete situations to achieve formal understanding through class discussions and reflection, and places student activities at the core of learning (Warmansyah *et al*., 2023). The integration of the RME approach and the development of spatial abilities is an important foundation for the preparation of learning materials that are adaptive, systematic, and aligned with the learning needs of elementary school students.

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The learning materials used by teachers in elementary schools are still dominated by procedural and rote-learning designs, without considering pedagogical approaches appropriate for the characteristics of the material and the learning needs of the students (Ayu *et al*., 2021; Dwi & Audina, 2021). This inconsistency makes geometry learning rigid and minimizes visual exploration, thus hindering the development of spatial abilities (Zaharah *et al*., 2024). The lack of integration between learning content and real-life context is widening the gap between mathematical concepts and student understanding (Tiofani *et al*., 2024). Various studies indicate that developing RME-based devices supported by digital media like Google Sites can enhance learning effectiveness, strengthen conceptual understanding, and encourage active student engagement through interactive visual material presentation (Listyaningrum *et al*., 2025; Payadyna *et al*., 2025). The relevance between the weaknesses of conventional devices and the effectiveness of the RME approach is an important foundation for the need for innovative development that combines the two in a systematic, contextual, and adaptive learning design to meet the needs of elementary school students.

Efforts to integrate digital technologies, such as Google Sites, into mathematics instruction have shown positive effects on students' understanding of spatial concepts; however, implementation remains hindered by the limited availability of research-based instructional design guidelines (Muhammad *et al*., 2025). The absence of a systematic pedagogical toolkit makes it difficult for teachers to design tools that are suitable for the characteristics of digital technology while also aligning with the principles of RME (Ozcakir & Cakiroglu, 2021). This condition reflects a gap between the potential of educational technology and its actual implementation in the classroom. The development of valid, practical, and effective learning materials specifically designed to integrate spatial context, realistic approaches, and web-based digital media has not been widely explored. The need for structured, contextual, and responsive learning designs that meet students' learning needs is the basis for the urgency to conduct research on RME-based device development assisted by Google Sites to optimize the improvement of elementary school students' spatial abilities.

Empirical facts, theoretical studies, and the implementation gap in learning indicate the need for developing learning tools that can systematically integrate the RME approach and are supported by the use of web-based digital technology. This learning device innovation is expected not only to provide a contextual learning experience but also to measurably improve students' spatial abilities. The purpose of this study is to develop valid, practical, and effective RME-based Mathematics learning materials assisted by Google Sites to improve the spatial abilities of elementary school students.

LITERATURE REVIEW

Realistic Mathematics Education (RME)

Realistic Mathematics Education (RME) is a mathematics learning approach oriented toward real-life contexts, making students' learning meaningful and applicable across various situations. The RME approach has been proven to improve students' understanding of mathematical concepts, learning engagement, and critical thinking skills by presenting contextual problems that are close to everyday life. Various studies state that RME encourages students to build understanding gradually through structured horizontal and vertical mathematical processes (Apriyanti *et al*., 2023; Suanto *et al*., 2023). This process facilitates students in developing informal models of real-world situations to reach more formal and abstract mathematical representations. The main principles of RME include the use of real-world contexts, self-construction, active engagement, and continuous interaction, thus creating meaningful learning that aligns with the cognitive developmental characteristics of elementary school students. The implementation of RME in mathematics learning in elementary school is evident in students' activities when calculating the volume of cube-shaped containers or comparing the sizes of rectangular prisms through exploratory activities using concrete objects. (Pramesta & Mariana, 2022; Safari & Syafawani, 2025). Therefore, the

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application of RME in the classroom helps students understand spatial concepts meaningfully while also improving their logical and reflective thinking skills.

Several previous studies still show limitations in the systematic and integrated development of RME-based learning materials with digital media. Existing learning designs largely do not support teachers' needs to implement this approach practically, particularly in geometry learning and the development of spatial abilities. Additionally, there haven't been many studies that explicitly developed RME-based mathematics learning tools with technological support like Google Sites to enhance students' spatial engagement. This gap underscores the urgency of this research to develop RME-based learning tools that are valid, practical, and effective, and can pedagogically integrate digital technology into mathematics learning in elementary schools.

Spatial Ability

Spatial ability is an important cognitive aspect in learning mathematics, related to the ability to imagine, visualize, and manipulate objects in two- and three-dimensional space. Research shows that students with high spatial ability tend to perform better in mathematics subjects, particularly geometry and visual problem-solving (Azzahra *et al*., 2025; Nadia & Saputro, 2025). According to Van Hiele's theory, spatial ability in the context of geometry develops through five hierarchical stages: visualization, analysis, informal deduction, formal deduction, and rigor, which must be passed sequentially to achieve mature conceptual understanding (Fattah & Pratama, 2024; Kusnadi *et al*., 2023; Zaharah *et al*., 2024). Each stage demonstrates the complexity of students' thinking in understanding shapes, the relationships between geometric elements, and their ability to provide logical arguments about the properties of three-dimensional figures (Fardiana *et al*., 2023). This ability is not innate, but rather acquired through an active, contextual, and gradual learning process, tailored to the cognitive development level of the students.

Although the urgency of developing spatial abilities has been widely recognized, learning practices in elementary schools still tend to focus on using formulas and procedural memorization without deep visual exploration. Empirical studies also show that elementary school students in Indonesia are still at a low level of spatial thinking, only reaching the visualization or analysis stage (Putra *et al*., 2023). The minimal learning interventions specifically designed to enhance spatial skills are one of the factors that reinforce the gap between curriculum demands and the actual conditions in the field. Therefore, this research is designed to develop a digital media-assisted RME-based Mathematics learning device, which is systematically designed to stimulate students' spatial development in a structured manner and in accordance with the principles of progressive geometric learning.

Google Sites

Google Sites is a web-based platform that allows teachers to organize learning materials in a structured, interactive, and easily accessible way for students anytime, anywhere. Several studies indicate that its use in mathematics learning can increase learning motivation, active student engagement, and deeper conceptual understanding through attractive visual presentations (Aisyah *et al*., 2025; Hadidi & Setiawan, 2021). The integration of content such as text, images, videos, and exercises into a single web display creates a more dynamic learning experience than conventional print media. Google Sites provides access flexibility and supports connections between learning resources, thus strengthening self-directed and differentiated learning. The main role of this platform lies in its ability to connect abstract mathematical concepts with concrete visualization through the presentation of spatial shapes, simulations, and project-based activities.

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The use of Google Sites in learning still faces several limitations, particularly in terms of design, which does not explicitly refer to specific pedagogical approaches such as RME (Yulianti & Novtiar, 2023). Teachers tend to use this platform solely as a repository for materials and assignments, without optimizing its potential as a tool for contextually constructing conceptual understanding. Its function as a learning medium has not been fully directed toward stimulating students' spatial abilities, particularly in geometry (Hidayatillah *et al*., 2022; Lutfiyah *et al*., 2025). Previous studies have not extensively developed Mathematics learning tools that integrate the principles of RME with the support of interactive digital media such as Google Sites. This gap indicates that utilizing Google Sites requires a more systematic and learning theory-based instructional design approach to function as a pedagogical tool, not merely an information medium. Learning materials need to be designed that not only include visual content and exercises but also encourage students to build spatial understanding through active interaction with the visually and contextually presented material.

METHODS

This research is a type of research and development aimed at producing valid, practical, and effective Google Sites-assisted Realistic Mathematics Education (RME)-based mathematics learning tools to improve students' spatial abilities. The development procedure refers to the 4D model (define, design, develop, and disseminate) adapted to field needs. The research was conducted at SD Negeri 102083 Pabatu, Serdang Bedagai Regency, North Sumatra Province, during the second semester of the 2024/2025 academic year, from February to May 2025. The subjects of this research are the fourth-grade students of SD 102083 Pabatu who participated in the trial of the learning device, while the research object is the developed Mathematics learning device, namely teaching modules, lesson plans, student books, and student worksheets (LKPD) based on the RME approach and integrated with Google Sites media.

The development procedure in this study refers to the 4D model, which consists of four main stages: define, design, develop, and disseminate. The define stage is used to analyze learning needs, including identifying student characteristics, analyzing the curriculum, and mapping mathematical content relevant to spatial abilities. The design phase includes the systematic planning of learning materials, encompassing the creation of teaching modules, lesson plans, student books, and student worksheets (LKPD), all while applying RME principles and integrating Google Sites media. The development phase involves expert validation of the prepared materials, limited testing with fourth-grade students, and revisions based on feedback to obtain usable materials. The final stage, disseminate, is carried out by implementing the learning tools more widely and evaluating their effectiveness in improving students' spatial abilities in a classroom setting. Each stage is carried out sequentially and structured to produce learning products that are valid, practical, and effective.

The research instruments used include expert validation sheets, practicality questionnaires, and spatial ability tests. The expert validation sheets consist of validation sheets for teaching modules, lesson plans, student books, and student worksheets, which were assessed by content experts and media experts to measure aspects of content validity, construction, language, and integration with the RME approach, as well as the use of Google Sites. Practicality questionnaires were given to teachers and students to obtain data on the ease of use, attractiveness, and feasibility of the learning materials in the classroom. Spatial ability tests are used to determine the effectiveness of learning materials in improving students' learning outcomes in terms of visualization and rotation of geometric objects. The validation and practicality data were analyzed using descriptive quantitative methods by calculating average scores and the percentage of feasibility categories. The effectiveness data were analyzed using descriptive and inferential statistical tests, including the N-Gain test to see the improvement in learning outcomes, as well as the normality test and t-test to determine significant differences between pretest and posttest results.

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RESULTS AND DISCUSSION

Define Stage

The define stage began with initial observations at SD Negeri 102083 Pabatu on February 15, 2025, to identify students' learning difficulties in understanding spatial geometry. The diagnostic test results show that 70% of the students have difficulty understanding geometric concepts, particularly cubes and rectangular prisms. The main difficulty for students lies in the spatial aspect, where most are unable to visualize the shapes and structures of three-dimensional figures. Classroom learning is still teacher-centered and conventional, which leads to students being less active, not given space to explore concepts, and not being involved in concrete learning activities. The characteristics of the fourth-grade students at this school are considered cognitively heterogeneous, with dominant visual and kinesthetic learning styles, and learning needs that require active participation, concrete visualization, and a contextual approach. The geometric material, consisting of cubes and blocks, was chosen because it falls into the category of abstract concepts that are difficult to understand without direct experience. Therefore, the RME approach was considered relevant for connecting geometric concepts to students' real lives.

Analysis of previous lessons showed that the tasks given by the teacher were mechanistic, such as calculating sides and edges without concrete experience, thus not fostering students' spatial abilities. The learning materials developed in this study are designed to accommodate active engagement through activities such as building, constructing, and drawing spatial figures, as well as solving contextual problems based on everyday life. Learning objectives are designed to develop two key abilities: the ability to physically manipulate the shapes of cubes and rectangular prisms, and the ability to identify the characteristics of spatial figures such as sides, angles, and edges. Learning indicators are broken down step-by-step so they can be achieved through activities in the student worksheet and evaluation conducted through tasks on the Google Sites platform. The device is designed so that students not only understand concepts procedurally but also have a meaningful learning experience and develop comprehensively in spatial aspects.

Design Stage

The design phase begins with designing a spatial ability test that refers to the indicators of visualization, analysis, and informal deduction. The development of test grids and scoring guidelines is done to ensure the validity and reliability of the evaluation instrument. Additionally, a student response questionnaire was also developed to identify their feedback on the developed learning materials. The questionnaire covers aspects of enjoyment, novelty, language readability, visual appeal, and interest in learning activities. The selection of learning media is adapted to the characteristics of fourth-grade elementary school students, who are in the concrete operational stage according to Piaget's theory of development. Learning activities are designed based on hands-on activities, utilizing concrete media such as building blocks, cardboard, and real objects from the surrounding environment. This media is intended to stimulate manipulative abilities and develop students' spatial imagination through real and contextual learning experiences.

The design of learning materials refers to the principles of RME. All material formats, including teaching modules, teachers' books, student books, and student worksheets, are developed systematically and contextually. The initial draft was structured into five main components: 1) Teaching modules using the RME syntax; 2) Teacher's guide for implementation; 3) Student's book with a real-world problem-solving approach; 4) Student worksheets based on exploratory activities; and 5) Instruments in the form of tests and questionnaires. The teaching module includes a learning flow through the stages of understanding context, describing and solving problems, discussing, and concluding, with the addition of achievement

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indicators, objectives, and formative assessments. The teacher's book contains technical steps and alternative learning activities, while the student's book is packaged with attractive illustrations, simple language, and reflection columns to support understanding. The LKPD is designed to train spatial skills through concrete activities, drawing, and constructing cubes and rectangular prisms. This device is designed to achieve the main learning objective, which is the manipulation and identification of the characteristics of three-dimensional shapes. The assessment instruments, consisting of tests, questionnaires, and observation sheets, were used to evaluate the effectiveness of the device in improving spatial abilities and student engagement during the learning process. The overall visualization of the developed learning device flow is shown in **Figure 1** as an initial design storyboard based on the RME approach.

Learning Module — Teachers' Book — Student Worksheet (LKPD)

Figure 1. Initial Design
Source: Research data, 2025

The storyboard shown in **Figure 1** illustrates the design of a learning flow based on the RME approach, including the integration of concrete media, RME syntax, the use of Google Sites, and learning activities developed to improve students' spatial abilities contextually and gradually.

Development Stage

The process of developing learning materials involves analyzing the validity and reliability of all instruments used. Validation was conducted on questionnaires, test instruments, and the main components of learning materials, such as student books, teacher books, student worksheets, and teaching modules. The validation questionnaire was prepared based on the criteria of content validity, language, illustrations, and presentation format, and then distributed to three expert validators to obtain relevant input. The assessment scale uses a range of 1-4, and the criteria are valid if the average validation score (Va) exceeds 3.01. A summary of the evaluation results from the validators for each component can be seen in **Table 1**.

Table 1. Results of Instrument and Teaching Material Validation

Instrument/Teaching Material	Content Aspect	Language Aspect	Format Aspect	Illustrat ion	Average	Category
Test Instrument	3.26	2.78	3.37	-	3.14	Valid
Student Worksheet (LKPD)	4.33	4.27	4.19	-	4.26	Very Valid
Teaching Module	3.71	3.40	3.33	3.30	3.45	Valid

Source: Research data, 2025

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Validity and reliability analysis were also conducted on nine essay questions to measure students' spatial abilities. The results of the validity analysis using the Product Moment correlation show that six questions are declared valid, while three questions are invalid. This instrument can still be used, considering that most of the test items meet the validity criteria. The reliability of the questions was calculated using Cronbach's Alpha formula and yielded a value of 0.80, indicating high consistency in measuring spatial ability. The difficulty level test showed that two questions were easy, two were moderate, and two were difficult, indicating that the variation in difficulty levels had been met. Item analysis showed that three questions were in the good category and the other three were in the very good category, indicating that the questions were able to differentiate students based on their mastery of the material. The validity obtained from all instruments indicates that the learning device is suitable for limited trials and has the potential to be effective in gradually and measurably improving the spatial abilities of fourth-grade elementary school students.

Dissemination Stage

The practicality of the learning device was analyzed through data from implementation observation during the process. The observation was conducted using an implementation assessment sheet instrument, which consists of several indicators with a rating scale ranging from 1 to 5. The observer was briefed beforehand to ensure the assessment process was systematic and objective. The observation results show that the learning device obtained an implementation score of 75.09%. This percentage refers to the assessment categories listed in **Table 2** and is classified as "good." These results reflect that the developed device has an adequate level of practicality for implementation in the context of 4th-grade Mathematics learning.

Tabel 2. Keterlaksanaan Perangkat Pembelajaran

Assessment Indicators	Total Score
Paying attention to/listening to the teacher's/friend's explanation.	90
Reading/understanding contextual problems in student books/worksheets (LKPD).	89
Solving problems, finding ways, and answers.	90
Discussing/asking friends or teachers.	97
Making conclusions about a procedure or concept.	94
Behavior that is irrelevant to the learning process, such as off-topic conversations.	101
Before this instrument is used, it must first be validated by education experts.	96

Source: Research data, 2025

The effectiveness of the learning device is reflected in the students' achievement of mastery learning based on the results of the spatial ability posttest. The field test involved 25 students, and 22 of them scored at least 75, thus being declared complete. The other three students scored 72 and 63, meaning they did not meet the completion criteria. The classical mastery percentage reached 88%, indicating the success of the device in helping students achieve learning objectives. The average pretest score was 39.6, reflecting a low initial mastery of spatial material before instruction. The learning process takes place over two meetings using devices based on a realistic mathematics approach designed contextually according to daily life.

The average posttest score increased to 73.72, showing a significant difference compared to the initial score. This increase was calculated using the normalized gain (N-Gain) formula and resulted in a value of 0.651, which falls into the moderate category. The graph showing the increase in students' pretest and

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posttest scores is presented in **Figure 2**. The posttest data were then analyzed using the Kolmogorov-Smirnov normality test, which showed that the data distribution was normal (calculated L 0.176 < table L 0.264). The homogeneity test shows a significance value of 0.152, indicating that the data distribution is homogeneous. A two-tailed t-test was conducted to test for significant differences, resulting in a calculated t-value of 2.087 > a critical t-value of 2.014 and a significance level of 0.043 < 0.05. The test results show that the learning device is effective in improving the spatial abilities of fourth-grade elementary school students.

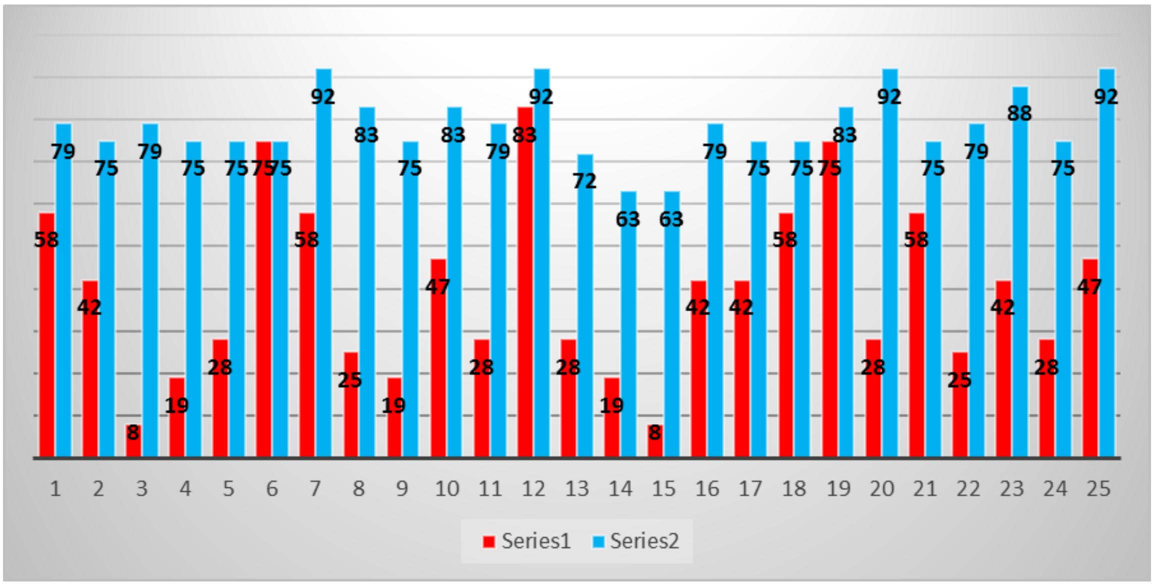

Figure 2. Pretest and Posttest Percentage Graph
Source: Research data, 2025

Analysis of the response questionnaire showed that the learning device received a rating percentage of 75.12% based on student responses. This result indicates relatively strong acceptance of the device, particularly with respect to appearance, content, and the material's relevance to the real learning context. Teacher responses also support this finding, with scores of 80% for Teacher 1 and 78.3% for Teacher 2. The assessments provided covered aspects of usability in learning activities, material alignment with the curriculum, and the ease of using the device in the classroom. This result indicates that the developed device is not only well-received by students but is also considered practical and supportive of the learning process from the teachers' perspective.

Discussion

The quality of the developed learning materials is reflected in the content, language, illustration, and contextual relevance to learning outcomes. These findings are consistent with the results of previous research showing that the development of digital LKPD based on RME is proven feasible for use in elementary schools. Expert validation in previous studies indicated that the content quality, appearance, and readability of the LKPD met the eligibility standards (Selian *et al*., 2023). The success of this development is also strengthened by the effectiveness of the device in improving understanding of mathematical concepts based on contextual problems (Hidayat *et al*., 2020). The application of a realistic approach in student worksheets also enhances students' visual representation and mathematical connections (Hidayati *et al*., 2023). Validation results showing an average score above the eligibility criteria were also found in the development of Google Form-based e-LKPD (Asni & Hidayat, 2023). The reliability of the content and its relevance to the local context are strengthened by the development of ethnomathematics-loaded student worksheets that received a valid category (Manik *et al*., 2024). This

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comparison shows that the developed device aligns with previous findings in terms of content feasibility, media, and learning achievement effectiveness.

The practicality of the learning device is evident from the observation results of implementation, teacher response, and active student engagement during the learning process. The average practicality percentage indicates that the device is easy to use and capable of facilitating the learning process according to the characteristics of elementary school students. This result is supported by previous research stating that RME-based LKPD makes it easier for teachers to manage the classroom and increases student participation through contextual activities (Umami *et al*., 2024). Ease of use and the clarity of instructions in digital-based LKPDs also contribute to the practicality of the device (Hidayatillah *et al*., 2022). The use of concrete and digital media as a unified set of tools also supports the effectiveness of interaction between students and learning materials (Sugiarto *et al*., 2023). The teacher responded positively to the usefulness of the device because it aligns with the learning logic flow and is flexible in implementation.

Students' assessment of the visual appeal and ease of understanding the LKPD content is also an important indicator that the developed device is practical and suitable for use in realistic-based learning. Visual appeal is evident through the use of contextual character illustrations, a balanced blend of bright colors, large typography to enhance readability, and a neat and proportional layout. Each page of the LKPD is designed to guide students' thinking process step by step, from context introduction to problem-solving. The digital version of the LKPD presented through Google Sites is equipped with interactive links, simple animations, page navigation buttons, and embedded short learning videos. These features allow students to navigate between sections of the LKPD without losing focus, while also gaining a more interactive and engaging learning experience.

The effectiveness of the developed learning device was proven by the improvement in students' learning outcomes on the posttest and the achievement of 88% classical mastery. The increase in average scores and N-Gain test results indicates that the device is capable of significantly improving students' spatial abilities. This finding is consistent with research results showing that using RME-based student worksheets can improve learning outcomes through contextual problem-solving and structured visual activities (Yunianingsih *et al*., 2024). The connection between students' activities and daily life plays an important role in improving their understanding of geometric concepts, particularly for the materials on solid shapes like cubes and blocks, which have real-world representations around the students. Learning is conducted through Google Sites, which displays visual contexts such as cardboard arrangements, aquariums, and storage cabinets as media to stimulate understanding of three-dimensional shapes. The teacher directed the students to observe contextual images, calculate volume, and compare sizes using the provided digital worksheets.

The interaction process is not passive, as students directly choose answers, drag digital objects, and fill in short reflection columns on the Google Sites page. This activity allows students to virtually manipulate representations of three-dimensional shapes while connecting mathematical concepts to concrete experiences in their daily lives. This type of learning model makes RME more meaningful because students are actively involved in building concepts through visual exploration and reflective actions based on authentic contexts. The device's effectiveness is also supported by its ability to stimulate students' reflective and spatial thinking through exploratory activities (Setiawan *et al*., 2024). The use of digital media such as Google Sites also increases student interest and accelerates the process of understanding and building self-confidence (Abdurohim *et al*., 2025; Aisyah *et al*., 2025). Other research proves that systematically designed realistic-based devices are effective in developing spatial representation, both in terms of visualization and mathematical problem-solving (Simamora *et al*., 2024). This comparison

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confirms that the developed device is not only valid and practical but also effective in achieving overall learning objectives.

CONCLUSION

The research results indicate that the Realistic Mathematics Education (RME)-based mathematics learning device developed is valid, practical, and effective in improving the spatial abilities of fourth-grade elementary school students. The validity of the device is supported by expert assessments of content, language, illustrations, and presentation format aspects, all of which meet the eligibility criteria. Practicality is reflected in the high feasibility of learning and the positive response from teachers and students to the devices used. The effectiveness of the device is proven through improved learning outcomes and classical mastery of students in spatial abilities, which were obtained from statistical analysis and the increase in pretest to posttest scores. This research concludes that RME-based devices can be a contextual, meaningful, and appropriate alternative for elementary school students' learning. Further research is recommended to test the implementation of the device in a broader school context, as well as to develop similar devices for other Mathematics materials in order to strengthen the usefulness of the realistic learning model in primary education.

AUTHOR'S NOTE

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