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Integrating Scientific Approaches in Digital Learning Materials to Improve Spatial Abilities in Cube Geometry: A Research and Development

[1] Putri Tipakaden Guci, [2]Budi Halomoan Siregar
[1,2]Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences (FMIPA),
State University of Medan, Indonesia
E-mail: putritipakaden@gmail.com[1],budihalomoan@unimed.ac.id2
Correspondence: budihalomoan@unimed.ac.id
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Abstract. This research aims to determine the level of validity, practicality and effectiveness of digital teaching materials based on a scientific approach, so that they can improve students' spatial abilities in cube material. This type of research is development research with the ADDIE development model. Research instruments in the research include questionnaire validation sheets, lesson plan validation sheets, digital teaching material validation sheets, test instrument validation sheets, spatial ability tests, as well as teacher and student response questionnaires to digital teaching materials. The research results show that: (1) the scientific approach-based digital teaching materials developed have met the validity criteria based on validator assessments with the average validity of digital teaching materials for material being 3.44 and 3.82 for media in the very appropriate category; (2) the scientific approach-based digital teaching materials developed have met the practicality criteria through: a) the results of the student response questionnaire to digital teaching materials show a practicality percentage of 82.75% in the very practical category, b) the results of the teacher response questionnaire to digital teaching materials showed practicality percentage 91.67% in the very practical category; (3) The scientific approach-based digital teaching materials developed meet the effective criteria with: a) classical student learning completeness of 90%, b) more than 65% of students have achieved 75% of the learning objectives for each indicator, c) Increasing students' spatial abilities After using digital teaching materials, it can be seen from the students' average score increasing from 47.67 in the pretest to 86.50 in the posttest. The results of the N-Gain analysis which shows that students' spatial abilities have increased by 0.725, meaning they are in the high category.

Keywords: Digital teaching materials, scientific approach, spatial ability, cube.

INTRODUCTION

Humans will face various challenges, such as slow development and inability to adapt to the current era of globalization, if they do not get an education. According to Widodo (2015: 294), quality education is the key to developing competent human resources. With the spread of digital technology and the emergence of the internet, now everything can be accessed and is unlimited. This has had an impact on many parts of society in this period, including politics, art, economics, culture, and education. Using technology for learning is something that is highly recommended in the field of school education according to the 2013 curriculum. The 2013 curriculum encourages student involvement and provides sufficient space for students' interests, abilities, and creativity during the learning process. According to Permendikbud No. 65 concerning Process Standards (2013), which states that learning utilizes information and communication technology to improve the effectiveness and efficiency of learning, technology has become the center of attention in the 2013 curriculum. According to NCTM (2000), technology plays an important role in several aspects of the learning process, including mathematics learning. This is due to the fact that technology has a significant impact on improving the mathematics learning experience. All abstract mathematical objects, including generalizations about mathematical conditions, can be studied with the help of technology.

One of the components of effective education in modern times is the use of technological devices as learning aids. Students may be more engaged (both cognitively and physically), motivated, and able to use all their senses to their fullest when learning through the use of media. There is no denying that technology has the potential to enhance learning if used properly. E-books, sometimes known as video books, are one type of educational resource that is enhanced by technology. One type of learning resource that is often used today, according to Seamardi (2016), is electronic school books. As an alternative, we have e-books, which can be read on any computer. This is part of a larger effort to improve students' spatial abilities and other national learning target criteria. One of the most basic skills that a learner must have is the ability to navigate spatial relationships.

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Spatial abilities play a role in helping students imagine, compare, guess, determine, construct, present, and find information from visual stimuli in a spatial context.

This ability enables them to: describe the relationship between geometric elements, recognize and understand geometric images, conceptualize the shape or location of an object from different angles, draw and represent geometric models on a flat surface in relation to space, and conduct investigations into geometric objects (Lestari & Yudhanegara, 2015: 85).

However, the eighth grade students of SMP Swasta Muhammadiyah 1 Medan were considered to have poor spatial abilities. The findings of the diagnostic tests given to the children during the observation clearly showed this. The students' spatial skills were measured by the following indicators: (a) spatial perception; (b) spatial visualization; (c) spatial rotation; (d) spatial relationships; and (e) spatial orientation. The test included descriptive questions based on these indicators.

However, in reality, the spatial ability of grade VIII students of SMP Swasta Muhammadiyah 1 is still relatively low. This is indicated based on the results of the diagnostic test obtained 0 students (0%) who have spatial ability on the cube space material categorized as very good, 3 students (14.3%) who have spatial ability categorized as good, 3 students (14.3%) who have spatial ability categorized as sufficient, 4 students (19%) with the category of less, and 11 students (52%) categorized as very less.

In line with the results of a survey conducted by the Programme for International Student Assessment (PISA) on 15-year-old students. In 2018, the OECD stated that out of 79 participating countries, Indonesia was ranked 74th. The mathematics learning achievement score of Indonesian students was only 379 points, this value can be said to be far below the international average score, where the international average score is 486 (PISA, 2018).

Based on the results of an interview conducted by one of the mathematics teachers at Muhammadiyah 1 Private Middle School, it was found that the causes of students' low spatial abilities in the set material were caused by several things, namely: students had difficulty in interpreting symbols and notations in set operations, students had difficulty in expressing abstract material into real forms, and students also had difficulty in translating story problems into set models.

Then, several causes of low achievement of students' competency in understanding sets were found, one of which was that the available teaching materials were not equipped with active learning, but the teaching materials were still passive, only limited to reading texts, sample questions, and exercises. In addition, the use of media as a support for teaching materials is rarely used in the learning process. In fact, learning media has an important role in improving students' abilities, learning using learning media can increase students' desire to learn and make it easier for students to understand the material given. Learning media has benefits, namely that media can clarify the meaning of a material being taught, media is also not only verbalistic, learning that is carried out becomes more varied, active, and interesting.(Nurdin et al., 2019). In relation to the use of media, students of class VIII of Muhammadiyah 1 Private Middle School admitted that learning was more interesting when the teacher provided photos of learning materials along with learning videos rather than just photos of the materials.

Another problem faced by students in understanding cube material is the use of a passive learning approach using the lecture method. Often in the learning process carried out, a teacher still uses the Teacher Centered approach. The Teacher Centered approach is a passive learning approach, where learning is centered on the teacher. Through the theory of cognitive development put forward by Piaget, that to obtain knowledge should not be passive but must be active with action(Antique, 2014)Therefore, to improve the quality of the learning process, an effective learning approach is needed, namely the scientific approach. The scientific approach has advantages including developing students' thinking to be more critical, increasing students' learning motivation, encouraging students to learn independently, encouraging students' communication skills, and creating more enjoyable learning.(Sabiq, 2018).

In order for the implementation of learning to be carried out well, teachers are required to be more creative and innovative, and able to master technology (E-Learning). One effort that can be made is to develop teaching materials that are equipped with learning media and approaches that are in accordance with student needs, so that in carrying out the learning process students become more active.

Teaching materials are learning tools that are systematically arranged with the aim of improving the quality of education implementation. While learning media are learning tools used to facilitate the delivery of information provided by an educator so that students can understand the information provided easily.(Sukiman, 2012)states that learning media is a channel of information from the giver to the recipient so that it can

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encourage the learning process by stimulating the thoughts, feelings, attention and skills of students to achieve learning goals.

Digital teaching materials are teaching materials equipped with interactive multimedia designed in the form of soft copy or in other words, electronic versions. The use of digital teaching materials is one solution to enable students to understand the material well. The advantages of digital teaching materials are that they are easy to carry anywhere because digital teaching materials are in the form of soft copy which are stored on electronic devices such as cellphones, tablets, computers, hard drives and others compared to teaching materials in the form of printed media that students generally have. The writing formats for digital teaching materials include: doc, pdf, lit and html. Along with the development of the times, digital teaching materials can be accompanied by music, videos, or animations so that the appearance becomes more attractive. Interactive multimedia teaching materials are considered to be able to increase motivation and provide direct experience to students in learning the material provided.(Smaragdina et al., 2020).

Based on the description above, it is known that the use of teaching materials equipped with interactive and innovative learning media can facilitate the delivery of information to students so as to stimulate students' thoughts, feelings and learning motivation. Then, from the problems that have been explained and the advantages of digital teaching materials developed through a scientific approach, the development of scientific-based digital teaching materials was carried out on the material of cube space for class VIII of SMP Muhammadiyah 1 Medan.

Scientific Approach

The scientific teaching approach is part of the pedagogical approach to the application of classroom learning which underlies the implementation of scientific methods (Musfiqon, 2015).

The scientific approach is centered on students, this can be proven by the activeness of students in the learning process. Where students seek information related to the material being taught and the teacher as a facilitator of learning activities. The learning strategy used by the scientific approach is conceptual learning. The use of a scientific approach in the learning process is carried out to guide students in understanding the material being discussed through the spatiality contained therein. Mastery of concepts and subconcepts is the part that is focused on in the learning process.

According to Hudojo (2005), spatial in mathematics is an abstract idea that allows us to classify objects or events, whether or not the object or event is included in the abstract idea (Ani Minarni, et al. 2020).

Bruner believes that learning with the discovery method is in accordance with the active search for knowledge carried out by humans so that it can automatically provide good results. Bruner also suggests that in learning, students should actively participate based on concepts and principles, in order to gain experience, and conduct experiments that can make them discover the principles themselves (Trianto, 2018).

METHOD

This type of research is research and development (R&D). This research was conducted at SMP Muhammadiyah 1 Medan with the research subjects being students of class VIII of SMP Muhammadiyah 1 Medan. The development model used in this development is ADDIE. The stages of the ADDIE development model are Analysis, Design, Development, Implement, and Evaluate.

The analysis stage aims to identify and characterize the requirements for creating digital pedagogical resources. The design stage aims to create digital learning resources that are taken from scientific methods that emphasize the need to improve students' spatial abilities. At this stage, not only the product is designed, but also the lesson plan (RPP) is made with the teaching material product produced later (still conceptual) and the relevant devices are prepared.

The development stage is the product realization stage. At this stage, the product is realized so that digital teaching materials, lesson plans and other instruments are formed according to what is desired. After the digital teaching materials, lesson plans and other instruments are complete. So, the next step is the validation process by several experts on the digital teaching materials, lesson plans and other instruments that have been made. The implementation stage is the stage of implementing product trials on students to determine the practicality and effectiveness of digital teaching materials if the digital teaching materials have been declared valid by experts. The field trial design carried out in this study is the One-Group Pretest-Posttest Design. The evaluation stage is the last step taken in the ADDIE development method. This stage aims to see whether the digital teaching materials based on the scientific approach to the developed set material have met the criteria for validity, practicality and effectiveness. The evaluation stage is carried out in a formative and

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summative manner, where the evaluation in a formative manner is carried out to improve the digital teaching materials developed at each development step. While the summative evaluation is carried out after the learning process is complete. Summative evaluation is carried out to measure the final competencies of students and the responses of teachers and students.

The instruments in this study were designed to measure the validity, practicality, and effectiveness of the development of digital teaching materials and the improvement of students' spatial abilities. The instruments used in this study were the RPP validation sheet questionnaire, the material expert validation sheet questionnaire, the media expert validation sheet questionnaire, the teacher response questionnaire, the student response questionnaire to the media, and the pretest-posttest questions on the cube material.

The data analysis techniques used in this study are qualitative data analysis techniques and quantitative data analysis techniques. Qualitative data analysis techniques are carried out by analyzing descriptive data obtained from observations, interviews, and suggestions from material experts/media experts, teachers and students after using scientific-based digital teaching materials. While quantitative data analysis techniques are obtained from the results of the pretest-posttest and response questionnaires after using digital teaching materials based on a scientific approach. The success of this study is determined from three aspects, namely: validity, practicality, and effectiveness.

RESEARCH RESULTS AND DISCUSSION

Analysis Stage (Analyze)

The analysis stage consists of performance analysis, resource analysis, needs analysis, and material analysis. Performance analysis aims to identify and clarify specific performance problems experienced by students in order to provide effective and appropriate solutions. From the performance analysis, several problems were found, namely during the teaching and learning process, mathematics teachers at SMP Muhammadiyah 1 Medan still use the lecture method, seen from the results of student diagnostic tests, it shows that students' spatial abilities are still relatively low, teaching materials provided during learning are still passive learning, in addition, the use of media as a support for teaching materials is rarely used in the learning process, during learning, teachers implement learning by only providing materials and examples of questions and exercises in the book.

In the analysis of the resources used, teachers and students of SMP Muhammadiyah 1 Medan are already proficient in using technology in the form of smartphones or laptops to support learning activities.

According to Abraham Maslaw, human needs always demand fulfillment starting from the most basic stages to the highest stages. The needs analysis conducted includes analysis of student characteristics, student knowledge background, and cognitive development of students at SMP Muhammadiyah 1 Medan.Characteristics of students at Muhammadiyah 1 Medan Middle School classVIII with an average age of 13-14 years. Jean Piaget said that at this age children are classified as formal operational stage, where at this stage students' thinking begins to accept abstract and purely symbolic, in solving problems students use systematic experimentation, students can also draw conclusions from information or experiences that have been passed, and students can already imagine the results of the actions taken. In addition, students with an average age of 12-13 years are classified as generation Z. Generation Z are people who were born in the internet era and have enjoyed technology.

Then from interviews with several students it was found that students like learning that is equipped with learning videos not only in text form. In addition, online learning causes students to tend to always use smartphones so that they are accustomed to using and utilizing the internet to learn and interact. Thus, the development of teaching materials equipped with digital media is believed to be in accordance with the characteristics of students who are classified as generation Z (tech-savvy) where they are fluent in technology.

Based on the analysis above, the development of digital teaching materials with a scientific approach in improving students' spatial abilities is the right solution. Digital teaching materials based on a scientific approach emphasize mathematics learning that involves observation activities to collect information, and then process the information obtained in groups and convey the information in the form of conclusions. In addition, digital teaching materials with a scientific approach will attract students' interest in learning and develop a sense of equal performance between students through group discussions. This is reinforced by Jerome Bruner by stating that students who organize the material being studied with a final form or what is often called "discovery learning" (Mona Ekawati 2019). Thus, Jerome Bruner agrees with Piaget that in classroom learning, the child plays an active role.

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The material analysis stage aims to identify and organize the material that will be studied by students. The results of this analysis are used to design digital teaching materials and lesson implementation plans (RPP). The material to be compiled in this study is the geometric shape of flat sides (cubes) for class VIII SMP/MTs by referring to the scientific approach according to the 2013 curriculum.

Design Stage

The Design stage is the product design stage that will be developed as a solution to the problems that have been described in the analysis stage. Based on the analysis stage, the solution obtained in solving student problems is the development of scientific-based digital teaching materials that refer to improving students' spatial abilities. In addition to designing digital teaching materials, this stage also carries out a design in the form of RPP (Learning Implementation Plan), and the preparation of instruments that will be used in the development stage, implementation stage and evaluation stage.

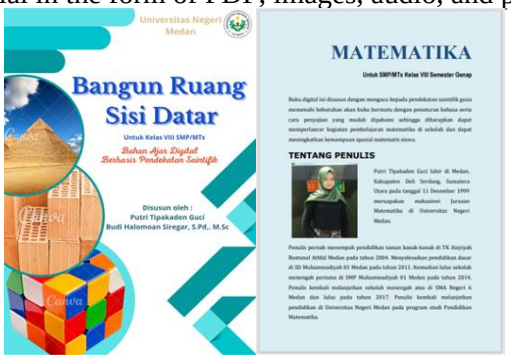
At this stage, researchers search for and use several references to design scientific-based digital teaching materials. The references used include mathematics books, e-modules, journals, articles, and so on that support the design of digital teaching materials according to the set. In addition, researchers also design the cover of the teaching materials (cover) and the contents of the teaching materials such as cube material that refers to increasing spatial abilities, learning videos, interactive practice questions, which are designed to complement the digital teaching materials to be developed.

***Development*(Development)**

The development stage is the stage of implementing everything that has been done in the design stage. The activities carried out in this development stage are preparing the necessary instruments such as questionnaires, lesson plans, test questions, and components of the media needed in digital teaching materials which are then combined into a digital teaching material, and the validation stage by experts, both media experts and material experts, for the instruments and digital teaching materials that have been created.

Integration of Digital Teaching Material Components

At this stage, several components that have been prepared at the design stage will be combined, namely flat-sided spatial geometry material in the form of PDF, images, audio, and practice questions.



The cover page of scientific-based digital teaching materials consists of two covers, namely the front cover and the back cover. The front cover of the digital teaching material is designed with a combination of several colors such as blue, white, green and other colors, and is equipped with images related to the cube space. In addition, the front cover of the digital teaching material also contains the title of the book, target audience, and the author's name. While the back cover of the digital teaching material is designed with a combination of blue, brown, green, black, and yellow. The back cover of the digital teaching material is also equipped with the title of the teaching material, target audience, identity of the teaching material, and the author's profile.

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The table of contents in this digital teaching material is automatic, meaning that users can go directly to the topic of the material they are going to by clicking on the title in the table of contents. This automatic table of contents aims to make it easier for users to use digital teaching materials so that they become more efficient and save time.

Digital teaching materials are equipped with text, learning videos, images, hyperlinks. The components of digital teaching material media that are prepared to support the explanation of cube material in digital teaching materials include. Text containing cube material, student activity sheets, and practice questions. Video and image media are widely used in teaching materials, as explanations and complements to the material and design of teaching materials. Digital teaching materials are equipped with learning evaluation questions in this digital teaching material consisting of multiple choice and descriptions (essays). In multiple choice questions, there are 10 questions in the form of quizzes and 5 essay questions in the form of googleform answer keys that are locked using a password so that students have no opportunity for students to copy the answers when working on the questions given.

Expert Assessment

After the integration of digital teaching material components and other instruments is complete, such as questionnaire instruments, Learning Implementation Plans (RPP), student ability test instruments, and scientific-based digital teaching materials on the cube space material. All of the instruments and digital teaching materials are validated by expert material and media expert validators.

Table 1. Validation of Digital Teaching Materials and Instruments

No	Type of instrument	Validators	Validator Average Score	Information
1	Material Expert Validation Sheet for Digital Teaching Materials	Va1 Va2	3.44	Valid
2	Media Expert Validation Sheet for Digital Teaching Materials	Vb1 Vb2	3.82	Very Valid
3	Pretest	Va1 Va2	3.00	Valid
4	Posttest	Va1 Va2	3.00	Valid
5		Va1	3.22	Very Valid

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	Teacher Response Questionnaire on Digital Teaching Materials	Va2		
6	Student Response Questionnaire on Digital Teaching Materials	Va1 Va2	3.19	Very Valid
7	Learning Implementation Plan (RPP)	Va1 Va2	3.23	Very Valid

After the digital teaching materials and all research instruments have been validated and are in the very valid category, the teaching materials are worthy of being tested.

***Implementation*(Implementation)**

Digital teaching materials and test instruments will be tested for readability first, then will be tested along with test instruments and Learning Implementation Plans (RPP). The field trial stage aims to see the practicality and effectiveness of the digital teaching materials developed. The following is an explanation of the results of the implementation stage.

Readability Test

The readability test involved 5 students of class VIII of SMP Muhammadiyah 1 Medan with the aim of seeing whether the digital teaching materials and tests that had been developed could be read clearly and easily understood. This readability test was conducted by asking students to provide suggestions and opinions related to digital teaching materials on the set and test materials. From the readability test, the results obtained were that the digital teaching materials used could be read clearly.

Field Trial

The field trial stage was carried out in six meetings, where the implementation of learning was carried out based on the RPP and the provision of pretests and posttests as well as student response questionnaires after participating in learning using scientific-based digital teaching materials. The following are the results of the analysis of practicality (student and teacher responses) and effectiveness (classical learning completion, indicator achievement, and improvement of spatial abilities based on each indicator and N-Gain analysis.

Table 2 Results of Student and Teacher Response Questionnaire Analysis

Information	Student Response	Teacher Response
Amount	20 people	1 person
Percentage of Practicality	82.76%	91.67%
Category	Very Practical	Very Practical

Based on the results of the analysis of student response questionnaires and teacher responses to digital teaching materials based on scientific knowledge on the material on cube spatial structures, the figures were 82.76% and 91.67% respectively, so that digital teaching materials can be categorized as very practical.

Table 3 Percentage of Student Learning Completion by Class

Information	***Pretest***		***Posttest***	
	Number of Students	**Percentage**	**Number of Students**	**Percentage**
Completed	4	20%	18	90%
Not Completed	16	80%	2	10%
Amount	20	100%	20	100%

The table shows that there are 4 students (20%) who have completed or exceeded the KKM limit (75), while 16 students (80%) were declared to have failed because they obtained a score below 75. Meanwhile, the post-test results show an increase in the number of students who obtained a score above the KKM, namely 18 students (90%) and 2 students (10%) were declared to have failed. Because the number of students who obtained a score ≥ 75in the class as many as the total number of students, then class VIII is declared to have completed their studies.≥ 85%

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Table 4 Improvement of Students' Spatial Ability in N-gain Analysis in Field Trial

The Size of Gain	Category	Many Students	Percentage	Average Gain
$g > 0{,}7$	Tall	13	65%	0.725
$0{,}3 \leq g \leq 0{,}7$	Currently	7	30%	
$g < 0{,}3$	Low	0	0 %	

Table 4 above shows that the average gain obtained is 0.725 which is categorized as high. Based on the calculation of the increase that has been done previously, it can be concluded that students' spatial abilities in the field trial have increased through the application of learning devices in the form of scientific-based digital teaching materials that have been developed. Thus, it can be said that the use of scientific-based digital teaching materials has an impact on increasing students' spatial abilities meeting the criteria for effectiveness. According to Akker (1999) "effectiveness refers to increasing experiences and intervention results that are consistent with the intended purpose".

***Evaluation*(Evaluation)**

The stages of the evaluation are carried out formatively and summatively. At the evaluation stage, errors and deficiencies that occur during the research process are analyzed and then used as material to improve all learning devices that are developed. In general, errors and deficiencies that need to be corrected include: Lack of systematic Learning Implementation Plan (RPP), Deficiencies and errors in writing test instruments (pretest and posttest) especially in the Venn diagram image, Several deficiencies in material and media creativity based on suggestions and comments from expert material validators and media experts.

There are several relevant studies conducted by previous researchers that are in line with the development of teaching materials or mathematics learning tools with a scientific approach, including:

Aminullah, (2018) with the title "Development of Problem-Based Mathematics Learning Devices with a Scientific Approach to Geometry Subjects for Grade X High School Students". The results of this study in general the learning devices developed are valid, practical, and effective. The validation results of the geometry learning devices are 85%, the completeness of the THB results is 85.7%, student activity> 80%, and positive student responses are 97.8%.

Trisna Rukhmana & Al Ikhlas (2019), with the research title "Development of Learning Devices Based on a Scientific Approach to the Pythagorean Theorem Material". The results of this study show that the learning devices developed with a scientific approach are valid, practical, and effective. The learning devices developed, namely RPP, student books and LKS, are categorized as very valid with a value of (3.6). For the practicality of this development, it has a degree of implementation with a category of being fully implemented (2.0) and its reliability is in the reliable category (1.00), so that the effectiveness of the devices developed has met the criteria for effectiveness.

Dona Dinda Pratiwi (2019), with the title "Development of Linear Algebra Materials Based on Islamic Values with a Scientific Approach". From the results of the study obtained by the researcher, the results of the validation of material experts were obtained with a percentage of 84% with a very feasible category, for media expert validation, 76% were obtained with a feasible category, and religious expert validation was obtained with a 76% feasible category. Furthermore, the results of the analysis carried out after the student response trial obtained a percentage of 88% in the very feasible category.

CONCLUSION

The results of this study indicate that scientific-based digital teaching materials have met the criteria of being valid, practical, and effective and improving students' spatial abilities. In terms of validity, the developed digital teaching materials have met the criteria of validity based on the average percentage score of the material expert validator of 3.44 with a very valid category and the average percentage of the media expert validator of 3.82 with a very valid category. In terms of practicality, the results of the student response questionnaire percentage were 82.67%, and the results of the teacher response questionnaire were 91.67%, both of which were classified as very practical. While the effectiveness aspect was obtained from the results of classical learning completion of 87.5%, there was an increase in the average value of students' spatial abilities by 38.33 and the Gain analysis results were 0.725.

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