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Development of Digital Teaching Materials through a Realistic Mathematics Approach used by Autograph Software to Improve Students' Problem-Solving and Mathematical Communication Abilities

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Abstrak

Penelitian ini bertujuan untuk mengetahui; menghasilkan bahan ajar digital melalui pendekatan Matematika Realistik berbantuan software Autograph yang valid,praktis dan efektif; menganalisis peningkatan kemampuan pemecahan masalah matematis siswa; dan menganalisis peningkatan kemampuan komunikasi matematis siswa setelah penerapan bahan ajar tersebut. Penelitian ini merupakan penelitian pengembangan (development research) dengan model pengembangan 4-D oleh Thiagarajan yang meliputi tahap define, design, develop, dan disseminate. Hasil penelitian menunjukkan bahwa: Bahan ajar digital memenuhi kriteria valid, praktis dan efektif; Terdapat peningkatan kemampuan pemecahan masalah matematis siswa dengan nilai rata-rata N-Gain sebesar 0,77 yang termasuk dalam kategori tinggi. Terdapat peningkatan kemampuan komunikasi matematis siswa dengan nilai rata-rata N-Gain sebesar 0,62 yang termasuk dalam kategori "Sedang". Implikasi penelitian ini membuka peluang bagi peneliti berikutnya untuk mengembangkan bahan ajar digital dengan mengintegrasikan teknologi pembelajaran yang lebih mutakhir, seperti aplikasi berbasis web, mobile learning, atau kecerdasan buatan.

Kata Kunci: *Autograph, Bahan Ajar Digital, Komunikasi Matematis, Matematika Realistik, Pemecahan Masalah.*

Abstract

This study aims to determine: produce digital teaching materials through a Realistic Mathematics approach assisted by Autograph software that is valid, practical, and effective; analyze the improvement of students' mathematical problem-solving abilities; and analyze the improvement of students' mathematical communication abilities after the implementation of the teaching materials. This research is a development research with a 4-D development model by Thiagarajan, which includes the stages of define, design, develop, and disseminate. The results of the study indicate that: The digital teaching materials meet the criteria of being valid, practical, and effective; There is an increase in students' mathematical problem-solving abilities with an average N-Gain value of 0.77, which is included in the High category; There is an increase in students' mathematical communication abilities with an average N-Gain value of 0.62 which is included in the Medium category. The implications of this study open up opportunities for subsequent researchers to develop digital teaching materials by integrating more

advanced learning technologies, such as web-based applications, mobile learning, or artificial intelligence.

Keywords: Autograph, Digital Teaching Materials, Mathematical Communication, Realistic Mathematics, Problem Solving.

A. Introduction

Learning requires teaching materials to help students understand the topic. Learning fails without them (Efuansyah and Reny Wahyuni, 2021). Teaching materials are the centre of learning and a strategic tool for both teachers and students. To enable ongoing learning, we need innovative and engaging instructional tools (Maskur, 2022). However, reality contradicts theory. State that math teaching materials are abstract, focusing on formulae and problems. Therefore, these materials don't assist students' thinking, making math instruction useless. (Maskur, 2022)) adds that mathematics professors employ tedious, inadequate materials for their students.

Mathematics teaching resources include content and student exercises, according to (Panjaitan, H. R., Ginting, M. O., 2026). However, these teaching tools use mathematical concepts that don't match student characteristics. Many pupils seem to lack a grasp of the curriculum because the concepts are too sophisticated. It also happens at Budi Mulia Middle School, Pematang Siantar. Most mathematics teachers view lesson plans (RPP), teacher handbooks, student books, learning outcome examinations, and student activity sheets as administrative obligations and do not prepare thoroughly for the learning process. Students have trouble learning arithmetic since it's distant from their lives. Students, especially slower learners, need relevant maths instruction (Mayani, 2022).

The Realistic Mathematics Education approach, or PMR in Indonesian, can be used to generate instructional materials that relate mathematical issues to students' real-world experiences. (Zulhendri, 2023) defines PJK as a teaching method that starts with real-world things, emphasizes process skills in mathematics, discusses and collaborates, debates with classmates, and uses mathematics to solve problems individually and in groups. The Realistic Mathematics Learning Approach (PMRI) uses students' personal experiences to solve problems, according to (Manullang, 2021). Students can discover ideas, concepts, and principles, or mathematical models by solving genuine, contextual situations. The Realistic Mathematics Learning approach emphasises real-world situations and student-constructed mathematical knowledge (Nasriyah., 2021).

In teacher-led group learning, children play more and solve difficulties, according to (Hartuti, 2024) Some pupils still depend on their peers. Teachers have trouble controlling students, especially in noisy environments. Lectures are preferred by teachers for this reason. (Atikah, H. F., Sarifah, I., & Yudha, 20024) State that various issues contribute to subpar student achievement, notably in mathematics, which may be driven by low motivation. Students' attitudes during learning activities show that many are still not actively participating in the teacher's learning or working on teacher-given questions independently. Instead, they wait for answers from friends or the teacher.

In addition to selecting a learning approach or model appropriate to the mathematics learning process, another equally important factor is selecting appropriate media. In Indonesia, efforts to improve spatial skills in geometry learning with abstract concepts can be achieved through technology integration. Besides selecting a learning approach or model appropriate for the mathematics learning process, another equally important factor is selecting the right supporting media. In Indonesia, efforts to improve spatial skills in geometry learning with abstract concepts can be achieved through technology integration. The integration of mathematics learning, in accordance with the Independent Curriculum, responds to and accommodates developments in ICT to improve the quality of learning. This accommodation is achieved by integrating ICT into all subjects, allowing teachers to optimize ICT

resources both inside and outside the classroom. A teacher's high level of ICT skills does not guarantee effective integration of ICT into learning (Yulianti & Novtiar, 2023).

According to (Sinurat, M., Syahputra, E., & Rajagukguk, 2023), Current technological advances motivate teachers to deliver learning materials through engaging media. Learning using interactive multimedia that supports various aspects such as sound, video, animation, text, and graphics is more effective. One such approach is the use of Autograph. Autograph is a computer program developed by Douglas Butler (Simanjuntak, 2020). Autograph is a software-based media originating from the United Kingdom (UK) and introduced by Prof. Douglass Butler as a learning tool in mathematics (Hardianty, M., Hardianty, M., & Septian, 2021). According to (Karnasih, 2024), Autograph is a software used in mathematics learning. Autograph software can be used to learn two-dimensional (2D) and three-dimensional (3D) mathematics, statistics, transformations, geometry, equations, coordinates, differentials, graphs, algebra, and more. Autograph is a mathematical software capable of visualizing two-dimensional and three-dimensional objects, rotating them, and displaying the results of area and volume calculations for three-dimensional objects (Fauziyah, N., & Rosnawati, 2023).

Autograph, as a learning medium, emphasizes students' active role in exploration and investigation (Anim, 2021). Autograph can help students understand learning materials such as probability, statistics, and geometry because it has 2D and 3D worksheets. Thus, it can be concluded that the use of Autograph software can assist educators and students in the learning and teaching process at school (Batubara, 2023). Its reusable principle significantly helps students remember and discover mathematical concepts for themselves in geometry. The use of Autograph software in schools can improve the effectiveness and quality of teaching. It can also help mathematics teachers present material easily and improve student understanding through visual demonstrations (Simanjuntak, 2020). Autograph software can simplify mathematics learning. Autograph helps teachers maintain students' full attention on the interactive whiteboard and acts as a medium for interaction between students, or between teachers and students, with quick responses (Siregar, R dan Ramadhani, 2021). Using software like Autograph saves time and makes the learning process more effective and efficient (Karnasih, 2024). The ease of use of Autograph-math can also assist teachers and students in visualization, thanks to its dynamic images that capture students' attention during each lesson. The initial display in the form of a cube can make it easier for teachers to convey it because teachers no longer have to draw a cube as the beginning of three-dimensional learning material.

At Budi Mulia Junior High School in Pematang Siantar, teachers underuse technology in math. They only use traditional learning methods. Conventional learning typically uses passive media, limiting learning. This repetitious learning makes it challenging for students to visualize, observe, and sketch. Mathematicians study problem-solving. (NCTM, 2000) (National Mathematics and Natural Sciences Commission) states that learning mathematics should teach problem-solving. The mathematics curriculum includes problem-solving because students practice applying their knowledge and skills to tackle non-routine situations (Rofiqoh, Rochmad, 2022).

Solving problems demands higher-level thinking, according to (Harahap, 2022). High-level problem-solving helps pupils learn and grow (Helmawati, 2019). Problem-solving skills are essential to the study. Since mathematics is part of problem-solving, learning math requires problem-solving skills. Further, (Haety & Putra, 2022) defines problem-solving abilities as the ability to use previously learned concepts to solve an issue. Effective math problem-solving skills help with math learning. Students can tackle routine and non-routine issues with problem-solving skills. Non-routine problems are related to problem-solving skills because students must learn them.

However, the reality in the field is the opposite of these theories. When students solve problem-solving problems, they still have difficulty understanding the core of the problem well, are less able to understand the main topic in the problem, still have difficulty writing what is known and asked when solving the problem, are less careful in performing arithmetic operations, and do not write conclusions from the problem (Setyawati, R. D., & Ratu, 2021). Students' low problem-solving abilities can also be caused by the difficult and frightening nature of mathematics, according to students ((Fitria, Hidayani, Hendriana, 2021). In addition, in the implementation of learning activities, students are given more material information than thinking activities to solve their math problems (Manullang, 2021). Furthermore, explained that the problem-solving abilities of most students are still lacking.

This is evident from the many students who still use quick formulas in solving math problems. Not only that, but some students seem unable to understand the problem when working on math problems given by the teacher. A similar point was made by (Hendrikson R Panjaitan, 2023)who stated that students' low mathematical problem-solving abilities are generally caused by students not understanding the problems presented, due to their habit of working on routine problems. In addition, there are some students who can understand the problem and work according to the steps, but do not double-check, so the results are less accurate. Students' difficulties in solving mathematical problems, especially those that require high-level thinking, are influenced by many interrelated factors, both from within the student (internal) and from outside the student (external). Factors that occur within the student include a lack of understanding of the material being taught, being embarrassed to ask the teacher, or even not having the initiative to ask their more knowledgeable friends. Factors that occur outside the student are the learning methods used by the teacher, the tests that are still low-level, and the student's non-conducive environment.

Students need mathematical communication abilities to organize and solidify their mathematical thoughts and explore mathematical topics. Mathematics teachers help students convey concepts practically, logically, and efficiently; thus, they should be encouraged to strengthen their communication abilities using arithmetic (Oktaviani, 2022). Communication can help students understand new mathematical concepts using real-life events, visuals, objects, explanations, diagrams, writing, and mathematical symbols. Identify and overcome misunderstandings. Remembering that students and teachers share learning responsibilities is another benefit (Suparsih, 2020).

However, field reality contradicts this theory. Most pupils lack verbal and written mathematical communication abilities, according to field observations. Students struggle to discern mathematical symbols, turn real-world problems into mathematical language, and apply mathematical forms to real-world situations. Students rarely ask questions or voice comments in math class (Harahap, 2022). According to (Puspita, 2022), Students' communication abilities in converting story problems into mathematical symbols are still low, and many still get confused.

Budi Mulia Pematang Siantar Middle School students also struggle with mathematical communication. The assessments showed that pupils' mathematical communication abilities are still low. The story problems on the test are structured according to (NCTM, 2020): (1) The ability to express mathematical ideas verbally and demonstrate and describe them visually; (2) The ability to understand, interpret, and evaluate mathematical ideas both verbally, in writing, and in other visual forms; and (3) The ability to use mathematical terms, notations, and structures to present ideas, describe relationships, According to the researcher's initial interview with Budi Mulia Junior High School instructors in Pematang Siantar, pupils' inadequate problem-solving and mathematical communication abilities were related to the teacher's mathematics learning design. To solve the foregoing issues, teachers must identify ways to improve students' problem-solving and mathematical communication abilities. Students with strong problem-solving and mathematical communication abilities can discover more than one

mathematical answer. Research on realistic mathematics-based digital teaching materials with Autograph software is expected to improve students' problem-solving and mathematical communication abilities and provide an alternative to quality learning.

B. Research Method

Developmental research was done. Researchers employed Thiagarajan's 4-D development model to create realistic mathematics teaching materials. Modules and worksheets were created for students (Sugiyono, 2018). This study was done with eighth-graders in the odd semester of the 2025/2026 academic year at Budi Mulia Junior High School, Pematang Siantar, Jalan Melanthon Siregar No. 161, Siantar Marihat District, Siantar City. Research was done in 2025.

This study examined 2025/2026 Budi Mulia Junior High School, Pematang Siantar. The first trial was in class VIII-D, and the second was in class VIII-B. This study examined realistic mathematics-based digital teaching resources on cubes and cuboids created with Autograph software. Research was conducted in two phases. The first step was creating teaching materials. Validity of the Teacher's Book, Student's Book (BS), Student's Worksheet (LKPD), Problem-Solving Ability Test (TKPM), and Student's Mathematical Communication Abilities is considered when creating teaching materials. The second stage is implementing trial-recommended instructional materials. The Thiagarajan and Semmel 4-D model define, designs, develops, and disseminates, is used to generate teaching materials. Figure 1 shows this study's development model.

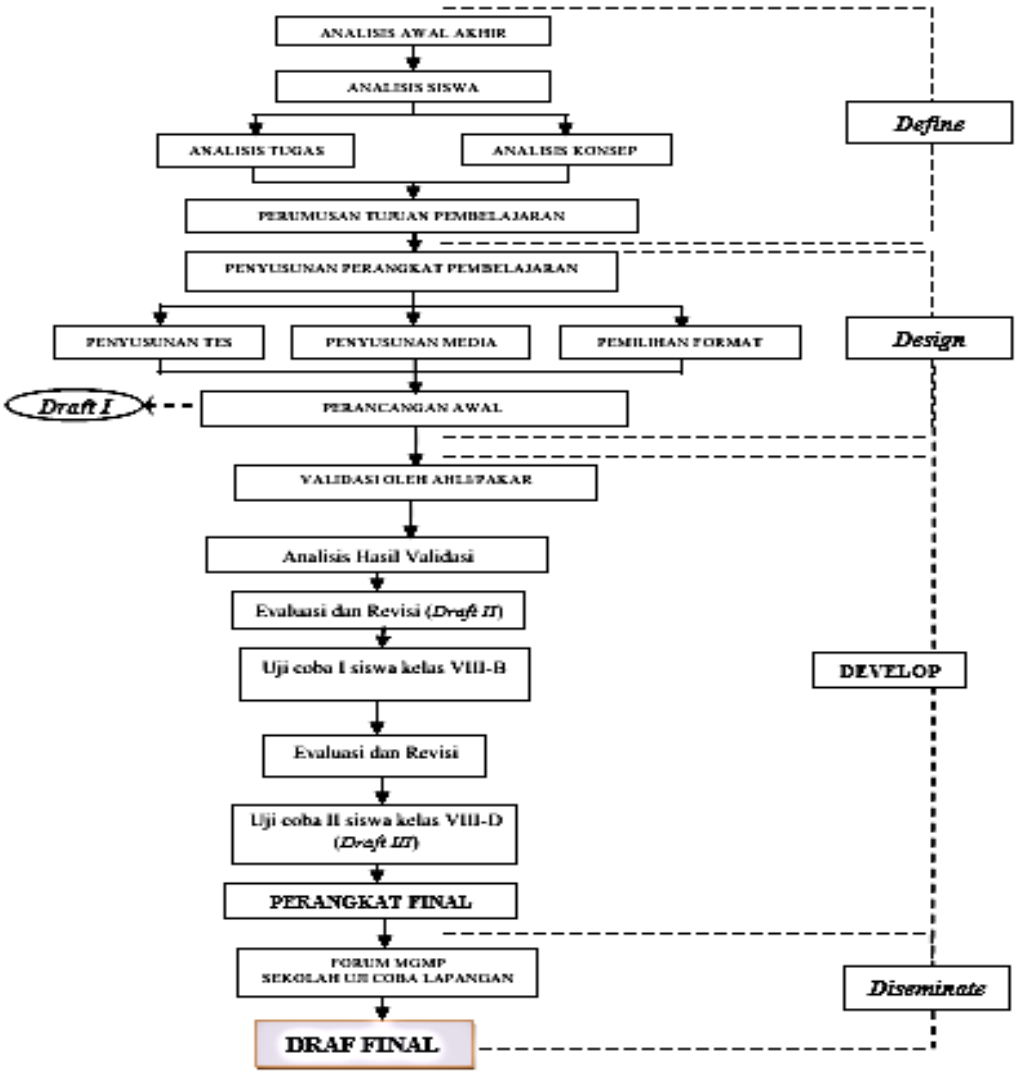

Figure 1. 4-D Model Teaching Material Development Chart

Here are the steps in creating these instructional materials:

Define

Initial and end analysis exercises uncover core maths challenges children confront through interactions with partner teachers to determine fundamental issues needed in teaching materials.

Teachers at Budi Mulia Junior High School, Pematang Siantar, employed poor instructional materials, according to observations and analysis. The present student textbooks lacked a learning model that supported learning objectives. The student texts were likewise unsuitable. The school's texts were mostly generic, starting with a notion rather than an issue, preventing students from discovering it. Textbook questions didn't help pupils learn problem-solving and mathematical communication. Student worksheets did not support texts or activities at Budi Mulia Junior High School, Pematang Siantar. This prevented current teaching materials from reaching goals.

Design

The design stage creates a training material prototype. This stage begins when learning objectives are set. This stage involves test development, media, format, and first design. This stage includes test development, media selection, format selection, and initial design. The basis for test development is task and concept analysis outlined in the learning objectives specification. This test is a tool used to measure

changes in student behavior after learning. The test in question is a problem-solving ability test on the topic of cubes and cuboids. To design the problem-solving ability test, a question grid and scoring guidelines were created.

Media selection was carried out to determine the appropriate medium for presenting the learning material. The media selection process was adjusted based on the results of the task and concept analysis, as well as the characteristics of the students at Budi Mulia Middle School, Pematang Siantar. The media used to support learning were the Autograph software and objects around the students that support learning.

Develop

A good tool is the goal of development. Therefore, specialists will validate and field test Draft 1. Draft 1 will be amended using expert feedback and field test data. The research instrument used in this study was a mathematical problem-solving ability test consisting of three essay-style questions. Before using the research instrument, it was first piloted in a non-sample class. Next, validity and reliability tests were conducted. The goal of this stage was to produce a good research instrument, meaning it was valid and suitable for use during the field trial.

The field trial was conducted to obtain direct feedback on the developed teaching materials, resulting in a final set. The teaching materials were piloted at Budi Mulia Junior High School in Pematang Siantar to assess their effectiveness. The effectiveness of the teaching materials was assessed based on: (1) student mastery of the material as a class; (2) completion of learning objectives; and (3) relative time. The pilot test also aimed to assess improvements in problem-solving ability through the application of the developed realistic approach-based learning and to observe students' response processes in completing the problem-solving ability test.

Disseminate

Development concludes with distribution. In the distribution stage, the product is promoted to users, whether individuals, groups, or systems. Dissemination in different classrooms can determine the tool's learning effectiveness. The dissemination stage spreads the piloted educational materials. This exercise was only for teachers and students at Budi Mulia Junior High School, Pematang Siantar, where the researcher performed study.

C. Result and Discussion

This study leverages Thiagarajan's 4-D development model define, design, develop, and disseminate to achieve these goals. Each stage is systematic to create legitimate, realistic, and successful digital teaching resources for SMP Budi Mulia Pematang Siantar students and teachers. Data analysis and study outcomes from each development step follow.

Define

According to observations and analysis of teaching materials at Budi Mulia Junior High School, Pematang Siantar, teachers still use general textbooks and have not adapted them to students' needs. Because they start with concepts rather than real situations in students' lives, student textbooks don't apply a learning model that supports learning objectives. Student textbooks have repetitive, procedural problems that don't help pupils learn problem-solving and mathematical communication. Despite their ability to help students practice concepts and improve critical and creative thinking skills, student worksheets (LKPD) are rarely used in learning activities. Teacher-centered learning still emphasizes explaining material and providing instances of issues without actively engaging students in conceptual discovery. Students have less time to explain their mathematical concepts, discuss, or explore different problem-solving methods. Thus, pupils' mathematics learning results have not fulfilled the Minimum

Completion Criteria (KKM) due to insufficient mathematical problem-solving and communication abilities.

Table 1. Level of Completion of Problem-Solving Ability

Category	Number of Students	Completion Percentage
Completed	19	63,3%
Incomplete	11	36,7%
Total	30	100%

Table 2. Level of Completion of Students' Mathematical Communication Abilities

Category	Number of Students	Completion Percentage
Completed	21	70%
Incomplete	9	30%
Total	30	100%

Teachers have also underutilized technology, especially learning support software, in mathematics instruction. They use traditional methods without interactive digital technology to teach abstract math. Today's digital age requires an understanding of learning technology to improve teaching and learning. Teachers can use interactive learning software like Autograph to communicate mathematical concepts graphically and interactively, making cubes and cuboids easier to understand. Technology-integrated learning improves 21st-century competencies and encourages active student engagement in a more meaningful learning process.

Teaching materials must match student characteristics and learning objectives for realistic mathematical learning. Therefore, pupils need good and engaging teaching materials to help them contextualize mathematical concepts. This research generated digital cube and cuboid geometry teaching materials using Autograph software and a realistic mathematics approach. The research team created learning support tools, including Lesson Implementation Plans (RPP), Student Modules (BS), Student Worksheets (LKPD), and research instruments such as problem-solving and mathematical communication assessments, along with digital teaching resources.

Design

According to observations and analysis of teaching materials at Budi Mulia Junior High School, Pematang Siantar, teachers still use general textbooks and have not adapted them to students' needs. Because they start with concepts rather than real situations in students' lives, student textbooks don't apply a learning model that supports learning objectives. Student textbooks have repetitive, procedural problems that don't help pupils learn problem-solving and mathematical communication. Despite its ability to help students practice concepts and improve critical and creative thinking skills, student worksheets (LKPD) are rarely used in learning activities. Teacher-centered learning still emphasizes explaining material and providing instances of issues without actively engaging students in conceptual discovery. Students have less time to explain their mathematical concepts, discuss, or explore different problem-solving methods. Thus, pupils' mathematics learning results have not fulfilled the Minimum Completion Criteria (KKM) due to insufficient mathematical problem-solving and communication abilities.

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Teaching materials must match student characteristics and learning objectives for realistic mathematical learning. Therefore, good and engaging teaching materials are needed to help pupils contextualize mathematical concepts. This research generated digital cube and cuboid geometry teaching materials using Autograph software and a realistic mathematics approach. Along with digital teaching resources, learning support tools, including Lesson Implementation Plans (RPP), Student Modules (BS), Student Worksheets (LKPD), and research instruments like problem-solving and mathematical communication assessments, were created.

The developed student module contains contextual problems that must be solved in groups and independently. This module contains important information related to the concepts being taught. For more details, the student book contains the following:

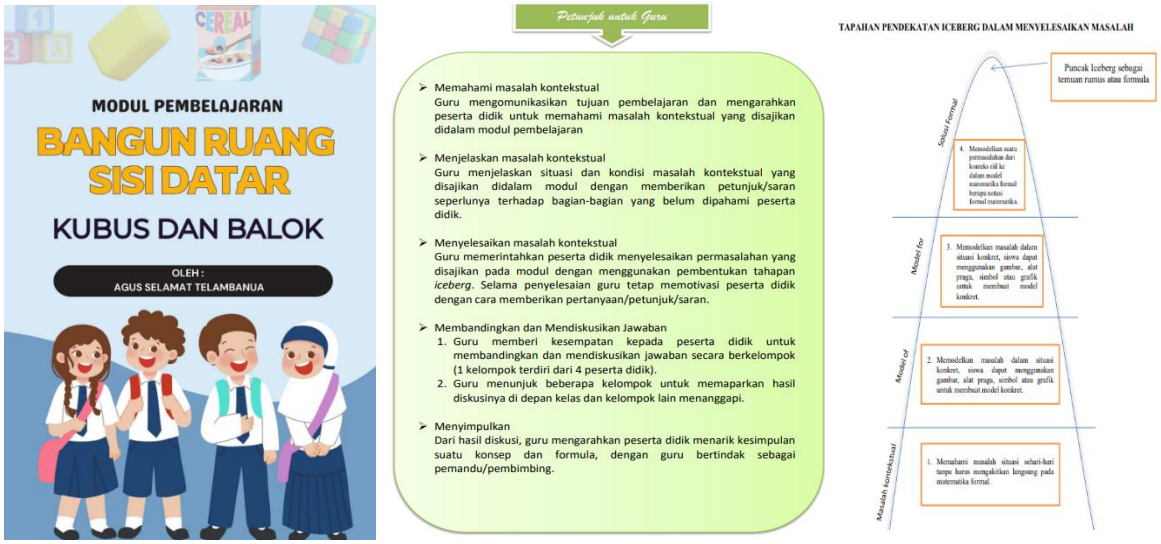

Figure 2. Design Module

Figure 2 illustrates the overall structure of the developed student module. The module begins with contextual problems closely related to students' daily experiences, followed by guided exploration activities that encourage students to construct mathematical concepts independently. The integration of the Iceberg stages enables students to progress gradually from informal reasoning toward formal mathematical understanding. Throughout the learning process, Autograph software provides interactive three-dimensional visualizations that support conceptual understanding of cubes and cuboids. As a result, students not only learn mathematical formulas but also understand the underlying concepts through meaningful exploration and discussion.

Develop

Draft I of the teaching materials was created during the definition and design. Development began with expert validation of Draft I, then field trials. Expert content validation encompassed all teaching materials from the Draft I design phase, resulting in a usable Draft II. The expert validation results were used to improve teaching and research materials. Format, content, images, and language were checked.

Validation is essential to teaching materials development since it corrects design flaws. UNIMED mathematics education lecturers validated this study. Digital teaching materials using a realistic mathematical approach, supported by Autograph software, research instruments, and validation sheets, were submitted to validators for review and assessment. Digital teaching materials built utilizing a realistic mathematical approach and backed by Autograph software were validated.

Table 3. Expert Validation Results

No.	Rated aspect	Average	Category
1	Lesson plan	4,18	Valid
2	Student Worksheet	4,19	Valid
3	Student Module	4,19	Valid
4	Research Instruments	4,15	Valid

Based on Table 3, the expert validation results concluded that this research instrument met the required quality standards in terms of construction, content, language, and the accuracy of its indicators. With a total average within the valid category, this instrument has good credibility for use as a data collection tool. The use of this validated instrument is expected to ensure the validity of the research results and provide an objective picture of student improvement after the learning process.

This analysis of student responses, both from the analysis of student abilities and from responses to the use of digital learning materials, was conducted. The purpose of the implementation was to determine the extent to which the improvements made could increase the practicality and appeal of the developed learning materials. Therefore, the analysis of the trial not only assessed student responses to the improved version of the learning materials but also ensured that the revisions had a positive impact on the learning process and outcomes. The results of student responses after participating in the learning process are shown in Table 4.

Table 4. Practical Results of Student Responses

No	Statements	Total score
1	Feelings towards learning	88,17%
2	Perspectives on learning components	86%
3	Benefits of learning	95,5%
4	Interest and desire to continue learning	91,5%
	Overall average	90,29%

Overall, the results of these student responses indicate that digital teaching materials using a realistic mathematics approach assisted by Autograph software are suitable for use in mathematics learning in junior high schools. Revisions made from trial I to trial II have proven to be able to improve the quality of the teaching materials, both in terms of content and presentation. Students felt that the learning activities were clearer, more contextual, and helped them connect mathematical concepts with real-life situations. Therefore, it can be concluded that the developed teaching materials not only meet the effectiveness criteria based on student responses but also have great potential to improve the quality of the mathematics learning process and outcomes overall.

Description of the Effectiveness of Digital Teaching Materials Through a Realistic Mathematics Approach Assisted by Autograph Software

The outstanding pilot test results show that a more tailored educational strategy has reduced cognitive obstacles observed in the initial phase. The high concentration of "Very High" scores for both key

competencies suggests that the learning tools increased conceptual comprehension and procedural and mathematical expression skills. These results show that the learning approach is successful and suitable for wider use, with average class scores considerably exceeding the minimum completion criteria.

Table 5. Level of Mastery of Problem-Solving Skills

Interval	Category	Number of Students	%
0 ≤ KPM < 50	Very low	-	-
50 ≤ KPM < 65	Low	2	6,7%
65 ≤ KPM < 80	Currently	3	10,0%
80 ≤ KPM < 90	Tall	3	10,0%
90 ≤ KPM ≤ 100	Very high	22	73,3%

Table 2 demonstrates that most Trial II students scored very well in problem-solving mastery. 22 students (73.3%) got 90-100 KPM out of 30. After using digital learning materials and Autograph software to teach realistic mathematics, pupils' problem-solving skills improved significantly. Students understood challenges, designed solutions, and interpreted findings better. This shows that digital learning resources help students apply mathematical principles to real-world circumstances, increasing logical and systematic thinking.

Three pupils (10%) were classified as high (80 ≤ KPM < 90) and three as intermediate (65 ≤ KPM < 80). Despite their small sample size, these findings suggest that individual competence levels demand attention in learning. Students' beginning talents, topic comprehension speed, and Autograph program engagement may explain these discrepancies. Student achievement in high and medium categories was positive, with no very low pupils and only two (6.7%) in the low category (50 ≤ KPM < 65).

The table shows that Budi Mulia Junior High School, Pematang Siantar pupils' problem-solving skills have improved due to the use of digital learning materials and Autograph software in realistic mathematics. The majority of students in the very high category suggest that contextual and interactive learning resources help improve mathematical comprehension. This shows that a realistic approach and learning technologies can help junior high students acquire mathematical problem-solving.

After discussing the results of the problem-solving ability analysis, the results of the analysis of students' mathematical communication abilities in Trial II will be presented. A description of the level of mastery of students' problem-solving abilities in the trial is shown in Table 6.

Table 6. Level of Mastery of Students' Mathematical Communication Abilities Results

Interval	Category	Number of Students	%
0 ≤ KPM < 50	Very low	-	-
50 ≤ KPM < 65	Low	1	3,3%
65 ≤ KPM < 80	Currently	5	16,7
80 ≤ KPM < 90	Tall	7	23,3
90 ≤ KPM ≤ 100	Very high	17	56,7
Amount		30	100,00%

Based on Table 6, the level of students' mathematical communication abilities mastery in the second trial results shows a positive distribution, with the majority of students in the very high category. Of the 30 students who participated in the trial, 17, or 56.7%, fell into the very high category, 7 students, or 23.3%, fell into the high category, and 5 students, or 16.7%, fell into the medium category. Only 1 student, or 3.3%, fell into the low category, and no students fell into the very low category. This distribution demonstrates that the majority of students achieved a satisfactory level of mathematical communication mastery after participating in the realistic mathematics approach-based learning with the assistance of Autograph software. This improvement demonstrates that the applied learning approach is able to help students express their mathematical ideas clearly and logically, whether in writing, symbols, or visual representations.

The high percentage in the very high category indicates that the use of the developed digital teaching materials has had a positive impact on students' mathematical communication abilities. During the learning process, students are not only asked to solve problems procedurally but are also encouraged to interpret contextual problems, relate them to real-world experiences, and communicate their reasoning. With the help of Autograph software, students can visualize mathematical concepts and relationships interactively, making it easier to grasp the meaning of each step in the solution process. This aligns with the principles of Realistic Mathematics Education, which place conceptual understanding and mathematical communication as integral parts of meaningful learning. Therefore, the results of the second trial confirmed that the combination of digital teaching materials and a realistic approach significantly improved mathematical communication abilities.

Furthermore, the low proportion of students in the low category and the absence of students in the very low category demonstrate the effectiveness of the digital teaching materials in reaching nearly all student ability levels. This indicates that the developed teaching materials are able to accommodate individual differences, both in terms of initial abilities, learning styles, and level of conceptual mastery. Through reflection activities and group discussions integrated into the learning, students practice presenting arguments, explaining solution steps, and constructively assessing the correctness of their peers' answers. Therefore, it can be concluded that the results of this second trial illustrate a significant increase in the mathematical communication abilities of students at Budi Mulia Middle School, Pematang Siantar, which reflects the success of implementing a realistic mathematics approach assisted by Autograph software in the context of digital-based learning.

Discussion

The validation results show that the digital instructional resources meet content, construction, and language validity standards. A realistic mathematics approach and contextual learning that actively engages students make this teaching material acceptable for use in the learning process. High validity suggests that Autograph-assisted digital teaching tools can help students see and engage with cube and cuboid solids. Thus, this teaching material may boost junior high math learning, particularly problem-solving and mathematical communication. Several prior studies have shown that Realistic Mathematics Education (RME) teaching materials are valid and adequate for learning. (Gea, 2022) found that the teaching material product received expert validation with an average of 3.37 in the "valid" category. This study also found that Autograph-supported digital teaching materials were valid based on expert judgements of format, content, language, curriculum, and student compatibility. A 93.8% approval score from material specialists and 93% from design and language experts made (Atikah, H. F., Sarifah, I., & Yudha, 20024)'s research "very valid." These findings demonstrate that realistic mathematical techniques can create valid content and presentation in digital education tools.

The practicality of the digital teaching materials in this study was examined by observing learning implementation during two trial periods. The average learning implementation score in Trial I was 2.97, which is "poorly implemented." Several learning activities, such as presenting the problem context, managing time, and students using Autograph software, were not fully implemented. This study supports other earlier studies that found realistic mathematical teaching materials or Autograph software for mathematics learning to be valid and practical. (Karnasih, 2024) found that teachers and students found realistic mathematics-based digital teaching resources "practical" following a trial, with favourable practicality questionnaire ratings.

Trial I showed that students' mathematical problem-solving skills averaged 72.67 with a classical completion rate of 70% and their mathematics communication ability was 71.78 with 73.33%. It appears that both talents fail the standard completion criteria of 85%. Trial II and digital teaching material modifications led to considerable improvements. An average score of 85.50 and a classical completion rate of 90% boosted mathematical problem-solving ability, whereas 84.78 increased mathematical communication ability. These results show that digital teaching materials with a realistic mathematics approach and Autograph software can improve students' mathematical problem-solving and communication abilities by moving learning outcomes from incomplete to classically complete.

A previous study confirms these conclusions. A realistic mathematics method helps students understand topics in real-life circumstances, encouraging mathematisation and fostering critical thinking and problem-solving, according to (Zulkardi, & Putri, 2022). This study found that students' problem-solving abilities improved from 72.67 with a 70% completion rate in the first trial to 85.50 with a 90% completion rate in the second. A realistic mathematics method also improves high-level thinking skills by teaching students to analyse problems, devise solution strategies, and explain conclusions logically, according to (Saragih, S., & Surya, 2022).

D. Conclusion

Based on the analysis and discussion in this study, the following conclusions are presented. Digital teaching materials using a realistic mathematics approach, assisted by Autograph software, to improve problem-solving and mathematical communication abilities of students at Budi Mulia Junior High School, Pematang Siantar, have met the criteria of validity, practicality, and effectiveness. There has been an improvement in students' problem-solving and mathematical communication abilities using the digital teaching materials, using the realistic mathematics approach, assisted by Autograph software. Based on the research results and conclusions above, it is recommended that the digital teaching materials using the realistic mathematics approach, assisted by Autograph software, meet the aspects of validity, practicality, and effectiveness. Therefore, it is recommended that mathematics teachers utilize them in the learning process to improve students' problem-solving and mathematical communication abilities, particularly at the junior high school level.

References

Anim. (2021). Peningkatan Kemampuan Komunikasi Matematis Siswa Menggunakan Model Problem Possing Berbantuan Software Autograph. *Jurnal Matematics Pedagogic*, *3*(1).

Atikah, H. F., Sarifah, I., & Yudha, C. B. (20024). Analisis Kemampuan Literasi Matematika Dalam Pandangan PISA 2022. *Literasi: Jurnal Ilmu Pendidikan, 15(2)*, 152-161.

Batubara, I. . (2023). Peningkatan Kemampuan Pemahaman Konsep Melalui Metode Penemuan Terbimbing Berbantuan Software Autograph Pada Mata Kuliah Kalkulus Peubah Banyak Di FKIP

UMSU. *Jurnal MES*, *4*(1).
Efuansyah dan Reny Wahyuni. (2021). Pengembangan Bahan Ajar Matematika Berbasis PMRI pada Materi Kubus dan Balok Kelas VIII. *Jurnal Derivat.*, *5*(2).
Fauziyah, N., & Rosnawati, R. (2023). Analisis kualitas soal pilihan ganda berbasis taksonomi Bloom revisi. *Jurnal Pendidikan Dan Evaluasi*, *11*(1), 70–82.
Fitria, Hidayani, Hendriana, A. (2021). Analisis Kemampuan Pemecahan Masalah Matematik Siswa SMP Dengan Materi Segitiga dan Segiempat. *Jurnal Edumatica*, *8*(1).
Gea, R. dan M. (2022). Pengembangan Bahan Ajar Digital Berbasis RME untuk Meningkatkan Kemampuan Pemecahan Masalah Matematik dan Kemandirian Belajar Siswa SMP Gajah Mada Medan. *Jurnal Cendikia*, *6*(2).
Haety, N. I., & Putra, B. Y. G. (2022). Analisis Kemampuan Pemecahan Masalah Matematis pada Materi Statistika: Implementasi Model Problem-Based Learning. *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, *7*(2), 97–116. https://doi.org/10.23969/symmetry.v7i2.6713
Harahap, E. R. dan E. S. (2022). *Kemampuan pemecahan masalah matematis siswa kelas VII dalam menyelesaikan persamaan linier satu variabel*. Jurnal Semnastika.
Hardianty, M., Hardianty, M., & Septian, A. (2021). Analisis Faktor Penyebab Kesulitan Belajar Matematika pada Siswa SMA terhadap Implementasi Kurikulum 2013. *Union: Jurnal Ilmiah Pendidikan Matematika*, *7*(3), 257–266.
Hartuti. (2024). Penerapan Model Pembelajaran Kooperatif Tipe Stad Setting Reciprocal Teaching Untuk Meningkatkan Hasil Belajar Matematika SMP Negeri 10 Poleang Selatan, Bombana. *Jurnal Penelitian Pendidikan Matematika*, *4*(1).
Helmawati. (2019). *Pembelajaran dan Penilaian berbasis HOTS*. PT Remaja Rosdakarya.
Hendrikson R Panjaitan. (2023). Analisis Kemampuan Berpikir Kreatif Siswa Melalui Penerapan Model Problem-Based Learning Di Smp Jenderal Sudirman. *JOURNAL PREVALENT MULTIDISCIPLINARY*, *1 No 3*, 23.
Karnasih, I. dan A. R. (2024). Integrasi Software Dinamis Autograph Dalam Pembelajaran Matematika Menggunakan Pendekatan Penemuan Terbimbing. *Jurnal Admathedu*, *4*(2).
Manullang, F. R. (2021). Peningkatan Hasil Belajar Matematika Materi Bangun Datar Melalui Pendidikan Matematika Realistik Indonesia (PMRI). *Jurnal PGSD Musi*, *1*(2).
Maskur, R. (2022). Pengembangan Bahan Ajar Matematika Berbasis Rhythm Reading Vocal Pada Materi Konsep Pecahan Kelas VII SMP. *Jurnal Kreano*, *11*(1).
Mayani, S. dan S. R. (2022). Pengembangan Bahan Ajar Berbasis Pendidikan Matematika Realistik (PMR) Pada Materi Program Linear. *Jurnal Aksioma*, *5*(1).
Nasriyah. (2021). Penerapan Pembelajaran Matematika Realistik untuk Meningkatkan Hasil Belajar Matematika pada Siswa Kelas VI SDN Parung Panjang 02 Kecamatan Parung Panjang. *Jurnal Pedagogiana*, *5*(8).
NCTM. (2000). *Principles and Standards for School Mathematics*. NCTM.
NCTM. (2020). *Principles and Standards for School Mathematics*. The National Council of Teachers of Mathematics, Inc.
Oktaviani, D. dan M. (2022). Pengaruh Penerapan Model Problem-Based Learning Terhadap Kemampuan Komunikasi Matematis dalam Pembelajaran Matematika SMPN 1 Lunuk Alung. *Journal of Residu*, *3*(14).
Panjaitan, H. R., Ginting, M. O., & Z. (2026). Efforts To Improve Students' Mathematical Communication Abilities By Implementing The Think-Talk-Write (Ttw) Learning Strategy On Plane-Sided Space Topics Of Elementary School Students. *Algebra : Jurnal Pendidikan, Sosial Dan*

Sains, *6*(1), 51-57.

Puspita, G. T. (2022). Pengaruh Aktivitas Siswa Dalam Model Pembelajaran Cooperative Script Terhadap Kemampuan Komunikasi Matematis Siswa. *Jurnal JES-MAT*, *4*(1).

Rofiqoh, Rochmad, K. (2022). Analisis Kemampuan Pemecahan Masalah Siswa Kelas X Dalam Pembelajaran Discovery Learning Berdasarkan Gaya Belajar Siswa. *Journal UJME*, *5*(1).

Saragih, S., & Surya, E. (2022). *Pembelajaran Matematika Realistik untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi Siswa* (UNIMED Press. ed.).

Setyawati, R. D., & Ratu, N. (2021). Lapisan Pemahaman Konsep Matematika Dalam Soal Pisa Pada Siswa Sma Kelas X. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *8*(1), 193–204.

Simanjuntak, T. D. L. (2020). Analisis Kemampuan Berpikir Kritis serta Disposisi Matematis Siswa melalui Model Pembelajaran Cooperative Type Jigsaw pada Siswa Kelas X SMA Global Prima. *Tesis*.

Sinurat, M., Syahputra, E., & Rajagukguk, W. (2023). Pengembangan Media Pembelajaran Matematika Berbantuan Program Flash Untuk Meningkatkan Kemampuan Matematik Siswa SMP. *Jurnal Pendidikan Tabularasa*, *12*(2).

Siregar, R dan Ramadhani, R. (2021). Analisis Kemampuan Komunikasi Matematis Siswa Pada Proses Pembelajaran Daring Selama Masa Pandemi (COVID-19). *MAJU.*, *8(2)*, 257.

Sugiyono. (2018). *Metodologi Penelitian Pendidikan (Pendidikan Kuantitatif, Kualitatif dan R&D)*. Alfabeta.

Suparsih. (2020). Pengembangan Perangkat Pembelajaran Penemuan Terbimbing untuk Meningkatkan Kemampuan Berpikir Kritis dan Komunikasi Matematis. *Jurnal Pendidikan Matematika*, *1 No. 3*(ISSN 1978-4538 (print), ISSN 2527-421X).

Yulianti, V., & Novtiar, C. (2023). Pengaruh Penggunaan Bahan Ajar Berbasis Google Sites dengan Pendekatan Realistic Mathematics Education untuk Meningkatkan Pemahaman Matematis Siswa pada Pembelajaran Materi Penyajian Data. *JPMI: Jurnal Pembelajaran Matematika Inovatif*, *6*(5), 2035–2044. https://doi.org/10.22460/jpmi.v6i5.17582

Zulhendri. (2023). Peningkatan Hasil Belajar Matematika Siswa Melalui Pendekatan Matematika Realistik Pada Operasi Hitung Di Kelas IV SD Negeri 20 Sitiung. *Jurnal Residu*, *3*(13).

Zulkardi, & Putri, R. I. I. (2022). *Pendidikan Matematika Realistik Indonesia (PMRI) dalam Pembelajaran Matematika*. Universitas Sriwijaya Press.