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Articulate Storyline Media-Based Discovery Learning to Improve Students' Mathematical Concept Understanding Ability of Flat-Sided 3D Space

Putri Sari Mukti[1], Laila Fitriana[2*], Rubono Setiawan[3]

[1,2*,3]Faculty of Teacher Training and Education, Sebelas Maret University
Jalan Ir. Sutami No. 36, Surakarta, Central Java, Indonesia
[2*]*lailafitriana_fkip@staff.uns.ac.id*

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Abstrak

Penelitian ini bertujuan untuk mengembangkan dan menilai apakah media pembelajaran berbasis discovery learning berbantuan Articulate Storyline valid, praktis, dan efektif dalam meningkatkan pemahaman konsep matematika siswa terkait materi bangun ruang sisi datar. Penelitian ini merupakan jenis penelitian pengembangan (R&D) yang mengikuti langkah-langkah model pengembangan ADDIE. Subjek penelitian adalah siswa kelas VIII D di SMP Negeri 23 Purworejo. Metode pengumpulan data yang digunakan adalah observasi, wawancara, kuesioner, dan tes. Analisis data menggunakan perhitungan persentase untuk analisis kevalidan dan kepraktisan, serta uji N-Gain dan Wilcoxon Sign berdasarkan hasil pre-test dan post-test untuk menilai keefektifan produk. Hasil uji validitas menunjukkan skor rata-rata 78,33% dari ahli materi dan 80,43% dari ahli media; hasil uji praktikalitas menunjukkan skor rata-rata 84,75% dari penilaian siswa dan 80,56% dari penilaian guru; dan hasil uji tanda Wilcoxon menunjukkan bahwa skor post-test lebih tinggi dari skor pre-test, dengan rata-rata N-Gain 0,44, yang termasuk dalam kategori peningkatan sedang. Kesimpulannya, media pembelajaran yang dikembangkan valid, praktis, dan efektif dalam meningkatkan pemahaman konsep matematika siswa terkait materi bangun ruang sisi datar.
Kata Kunci: ADDIE, articulate storyline, kemampuan pemahaman konsep matematis, media pembelajaran.

Abstract

This study aimed to develop and assess whether the discovery learning-based learning media, supported by Articulate Storyline, is valid, practical, and effective in improving students' understanding of mathematical concepts related to flat-sided space buildings. This research is a type of development study (R&D) that follows the ADDIE development model steps. The research subjects were students of class VIII D at SMP Negeri 23 Purworejo. Data collection methods included observation, interviews, questionnaires, and tests. Data analysis involved percentage calculations for validity and practicality analysis, as well as N-Gain and Wilcoxon Sign tests based on pre-test and post-test results to assess the effectiveness of the product. The validity test results showed an average score of 78.33% from material experts and 80.43% from media experts; The practicality test results showed an average score of 84.75% from student assessments and 80.56% from teacher assessments; and The Wilcoxon sign test results indicated that the post-test score was higher than the pre-test score, with an average N-Gain of 0.44, which falls under the moderate improvement category. In conclusion, the developed learning media is valid, practical, and effective in improving students' understanding of mathematical concepts related to flat-sided space buildings.
Keywords: ADDIE, articulate storyline, mathematical concept understanding ability, learning media.

I. INTRODUCTION

In 2022, Indonesia began implementing the Merdeka Curriculum as the National Curriculum as an effort by the government to overcome the learning crisis caused by the COVID-19 pandemic. This independent curriculum is hoped to be a solution when learning loss occurs due to the pandemic's impact and to allow students to grow and develop individual abilities of interest (Marlina, 2022). Understanding mathematical concepts is a learning loss for pupils when learning mathematics.

Accordingly, one of the goals of mathematics education in the Merdeka Curriculum (Kemendikbudristek, 2022) is to enable students to comprehend mathematical content—including facts, concepts, principles, operations, and relationships—and to apply this knowledge flexibly, accurately, efficiently, and precisely in solving problems (developing mathematical understanding and procedural skills). Given that mathematics is an abstract subject relying on symbols, conceptual understanding is essential for effective learning. This ability allows students to understand concepts and apply them effectively in solving mathematical problems (Nursaadah et al., 2018).

Despite the pressing need for students to grasp mathematical concepts, a large number of junior high school students need help with these concepts. This is demonstrated by the student's comprehension of mathematical ideas in class VIII-A SMP Negeri 1 Toma, which is more prevalent in the Less (K) group, according to research by Bohalima (2022). One of the schools where most students need more concept-understanding skills is SMP Negeri 23 Purworejo.

Researchers conducted observations and interviews and documented the results of daily tests of VIII grade students in SMP Negeri 23 Purworejo. According to the findings of the interviews conducted with math teachers, pupils in the VIII grade still struggle to comprehend mathematical ideas. Some of the conditions behind this statement are that students often need help working on problems that deviate from the example problems the teacher gave. In addition, teachers need to provide explanations repeatedly until students understand them. Certain students are seen to often memorize formulas without understanding their underlying meaning, which makes it challenging to apply them in different contexts. This reliance on memorization can cause students to forget when facing new material, making them have to repeat the concepts they have learned before. In addition, the inability to use mathematical knowledge in real-life situations shows students' lack of concept understanding ability. Based on the findings of student work on the subject of triangular and quadrilateral flat space as documented in the interviews and documents with the problem "A rectangular room is 5 m × 4 m in size. If the floor of the room is to be covered with tiles measuring 25 cm × 25 cm, determine how many tiles are needed?" obtained one of the student's work as follows:

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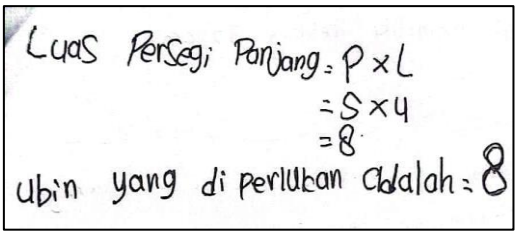

Figure 1. Student Work Results on Triangle and Quadrilateral Materials.

When given the problem, some students still questioned how to solve the problem. If students are given a stimulus by saying that solving the problem uses the concept of area, they can repeat it easily. However, students have yet to be able to use the idea to solve mathematical problems algorithmically. Consequently, pupils need a higher comprehension of mathematical ideas regarding the flat triangular quadrilateral.

The material of triangular and quadrilateral flat space is one of the prerequisite materials that students must have before learning Flat-Sided Spatial Buildings material (Edy et al., 2017). Students' comprehension of mathematical ideas has to be improved because they need to demonstrate a higher level of understanding of the required material, particularly in the area of Flat Side Spaces.

Based on the literature review, several studies explain the causes of the lack of students' concept understanding abilities, namely the lack of student learning concentration, irregular learning habits, and the learning methods used are less interesting (Umam & Zulkarnaen, 2022). Meanwhile, according to (Darwani et al., 2023), Due to instructors' continued usage of the traditional learning process, wherein the teacher assumes a more significant role and students participate less in the process, making students appear passive and their knowledge of mathematical concepts is low. From some of these opinions, one of the causes of students' low ability to understand mathematical concepts is that the learning methods used are less interesting. In line with this, based on the results of observations, interviews, and documentation show that monotonous mathematics learning methods cause students to need more understanding of mathematical concepts. Teachers' reliance on the lecture and question-and-answer approach limits the diversity of learning approaches. The absence of a specific learning model also results in students not being involved in the learning process. The passive role of students, who only receive information from the teacher, prevents students from actively participating and understanding mathematical concepts deeply. Therefore, this shows that students need more concept-understanding skills overall.

Speaking of the independent curriculum and learning mathematics, a suitable model for the independent curriculum is the Discovery Learning learning model because it has features that can help students learn independently and actively understand what they are learning (Widyaningrum & Suparni, 2023; Lesmana & Afriansyah, 2024). Additionally, students who utilize the discovery learning model for their education show greater development in their understanding of mathematical concepts than students who use traditional learning methods (Murwanto, Qohar, & Sa'dijah, 2022; Rohayati et al., 2023).

In a learning process, the desire and motivation to learn are needed so that students can absorb more information and try to always continue their curiosity in the lessons they do in class. To achieve this, fun and meaningful learning can be created. To realize the goal of learning mathematics that is fun and meaningful, a learning media can be developed to increase student's interest and motivation in learning and assist teachers in directing students to find mathematical concepts. Learning media is a physical support tool in delivering subject matter. Learning media is a means of communicating message carriers from message sources to message recipients to support the learning process (Hapsari et al., 2020; Nofriyandi et al., 2024).

Different kinds of learning media exist (Saputo et al., 2024). Modern learning media is one type of learning medium that can be utilized. Modern learning media is usually interactive; this model of learning media usually uses electronic devices such as cell phones or laptops as a tool or intermediary (Hafiedz et al., 2023a). Articulate Storyline is one program that can create interactive learning materials. (Amiroh, 2019) states that Articulate Storyline is an authoring tool that can be used to build interactive learning materials that integrate text, graphics, images, sound, animation, and video into one cohesive piece of media. One of the previous studies related to articulate storyline software is research conducted by Dirgantara et al. (2023), which developed learning media for flat-sided spaces based on articulate storyline 3 in class VIII mathematics subjects at Undiksha Lab Junior High School. The results showed that the media developed were declared valid and practical. In the study, the media presentation was only used to adjust to the problem-based learning model stage, so the media could not be used for other learning models.

Furthermore, previous research shows that no learning media has yet been developed using Articulate Storyline software specifically designed around the discovery learning approach. This is appropriate because articulate storyline software can combine text, graphics, images, sound, animation, and video into one. These advantages can be utilized in the learning process, especially in concept discovery through the discovery learning model. Researchers are interested in creating learning media with well-written narratives based on discovery learning, based on the description provided above. The purpose of the media designed to help students better understand mathematical concepts on flat-side 3D shape material. This research is important to find a new breakthrough by developing a new learning media and assessing whether the learning media that has been developed is valid, practical, and effective to improve students' mathematical concept understanding ability on flat-sided space building material as a solution to existing problems.

II. METHOD

This study employs a Research and Development (R&D) approach, using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The

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developed product is a discovery learning-based instructional media, supported by Articulate Storyline, aimed at enhancing students' understanding of mathematical concepts in the Flat-Sided 3D Space topic. The research took place at SMP Negeri 23 Purworejo, on March, 2024, with the participants being eighth-grade students from class VIII D, selected through simple random sampling. Data were collected using several methods, namely interview and observation methods to analyze the needs of learning media, questionnaire methods to test the validity and practicality of the developed media, and test methods to test the effectiveness of the developed media in improving students' mathematical concept understanding abilities on Flat-Sided 3D Space.

The data analysis used in this study is a percentage calculation for validity analysis and practicality analysis using the formula:

$$P = \frac{R}{SM} \times 100\%$$

Description:

P: Practical value

R: Number of grades earned

SM: Maximum number of points

The criteria for the validity and practicality of learning media using the average value analysis are presented in Tables 1 and 2 below:

Table 1
Practicality Score Criteria

Percentage (%)	Validation Criteria
85-100	Very Practical
70-84	Practical
55-69	Moderately Practical
50-54	Less Practical
0-49	Not Practical

Table 2.
Validation Criteria

Percentage (%)	Validation Criteria
76-100	Valid
56-75	Moderately Valid
40-55	Less Valid
0-39	No Valid

In addition, the effectiveness of the developed learning media was analyzed using the N-Gain test and the Wilcoxon Sign test based on the pre-test and post-test results.

III. RESULT AND DISCUSSION

A. Result

The steps of developing learning media in this study using the ADDIE development model are carried out in the following stages.

1. Analyze Stage

In the ADDIE development model, the analysis stage comes first. This phase is crucial as it serves as the foundation for creating learning media that will be made. The analysis stage is carried out in two stages: needs analysis and curriculum analysis. Based on the needs and curriculum analysis, the results show that a learning media will be developed to help the learning process. The learning media is based on a discovery learning model that can help students understand mathematical concepts, especially in 3-D space.

2. Design Stage

At the design stage, the researcher starts making learning media by first doing some preparation, which is the basis for developing learning media. The things that must be arranged before development

begins with the preparation of flowcharts and storyboards to provide an overview of the overall content and systematic flow of the learning media to be developed.

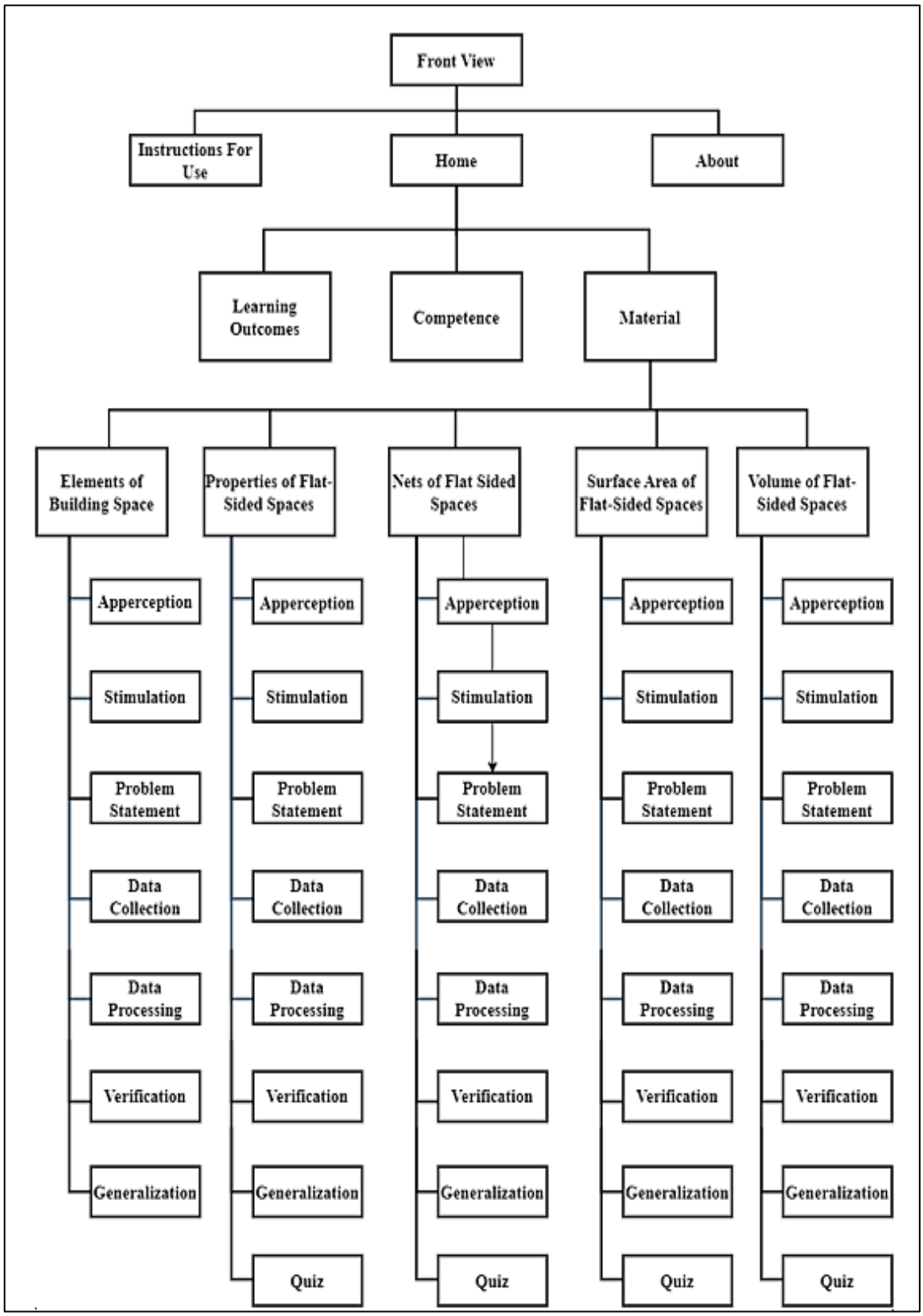

Figure 2. Media Design Flowchart

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In addition, the design of the learning media display developed is as follows.

Figure 3. Front View Design of Learning Media

The preparation of supporting elements is continued with the preparation of the syntax of the discovery learning model and the preparation of LKPD based on the concept discovery process by the discovery learning model based on material references from several sources such as the Class VIII Mathematics Student Book of the Ministry of Education and Culture of the Republic of Indonesia revised edition 2017.

In addition, researchers also designed assessment instruments to test the validity and practicality in the form of validation questionnaires for material experts and media experts, teacher practicality questionnaires, and student practicality questionnaires. On the other hand, researchers also designed research instruments to be used in this study, namely test instruments. The test instrument was prepared to test the effectiveness of the learning media that was prepared. The instrument first carried out content validation, trial testing, and item analysis until a good test instrument was obtained by having a difficulty index, differentiating power, and reliability that was classified as good.

3. Development Stage

Researchers use the basic design previously developed as a basis for developing learning materials throughout this development stage. To develop the product, researchers used Articulate Storyline software. The steps in this development stage consist of:

a. Media Development Stage

The first stage in developing this learning media is compiling supporting components by paying attention to the initial design that has been prepared. Supporting components that are ready are learning media backgrounds, box designs for writing content, navigation buttons, animations, videos, Geogebra software, and others. After the components are prepared, the next step is to combine all these components in the Articulate Storyline software.

The preparation of learning media is done by using Articulate Storyline software. The preparation of each component in the learning media consists of the preparation of each *slide, which is adjusted to the storyboard that was* prepared previously. The preparation of learning media starts from the preparation of the front view, which contains information on the name of the media, namely "Discovery Learning-Based Learning Media Assisted by Articulate Storyline," material description, learning media objectives, and navigation buttons to proceed to the next page such as "Menu," "About" and "Instructions for Use" pages.

Here is the front view of the developed learning media:

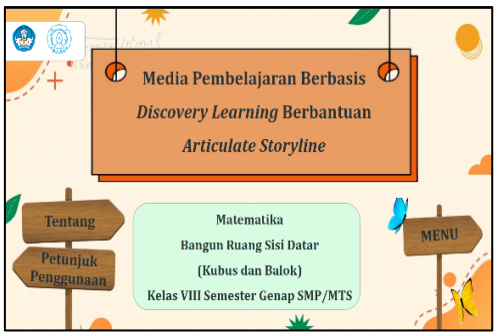

Figure 4. Front View of Learning Media

The preparation of learning media continued with the preparation for the Home (main menu) display, instructions for use page, about page, learning outcomes page, competency page, material menu page, apperception page, stimulus page, problem identification page, data collection page, data processing page, proof page, generalization page, and quiz page. Here are some initial views on the development results:

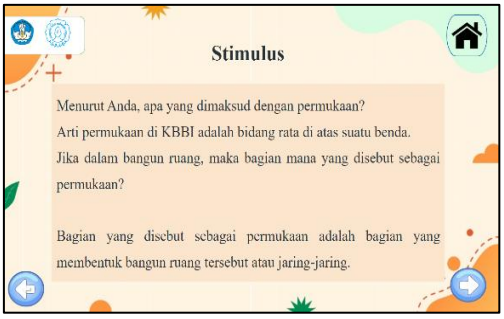

Figure 5. Stimulus Page Display

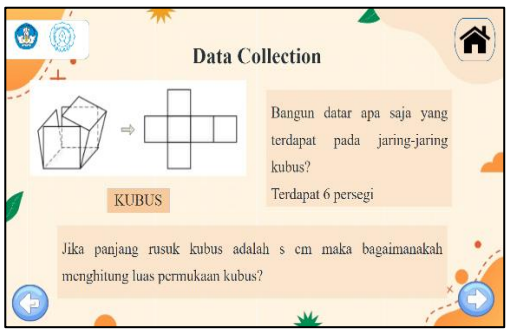

Figure 6. Data Collection View

Figure 7. Proof View

After the learning media is completed using Articulate Storyline software, the exported file of learning media results in HTML form is converted into a website that is easily accessible anytime and anywhere with a good internet connection.

b. Learning Media Validation

Validation of learning media is carried out to test whether the learning media developed is valid. Media expert validators in this study were Ario Wijaya, S.Si., M.Sc., a lecturer in mathematics education at UNS, and Desfian Dwi Cahyono, S.Pd., a grade VIII mathematics teacher. The material expert validators in this study were Sutopo, S.Pd., M.Pd. as a lecturer in mathematics education at UNS, and Nurul Khusna, S.Pd., as a grade VIII mathematics teacher.

c. Product Revision

Following validation by media or material specialists, several recommendations and comments were received regarding the created learning media. Some suggestions are converting discovery learning syntax words into Indonesian language form, the stimulus stage giving a contextual problem that can stimulate students to think critically, and the proof stage

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giving a problem to prove the initial hypothesis compiled.

Changes in learning media after revision can be seen in Figures 8, 9, and 10, which are the results of revisions from Figures 5, 6, and 7.

Figure 8. Revised Stimulus Display

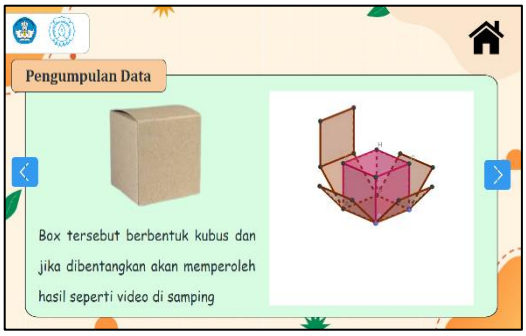

Figure 9. Revised Data Collection View

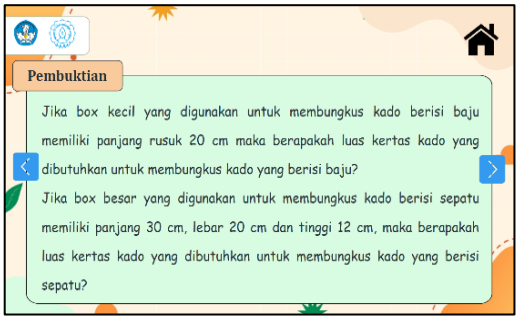

Figure 10. Revised Proof View

4. Implementation Stage

The implementation stage contains the implementation of learning media that has been declared valid from the assessment of media and material experts. The implementation stage contains product testing activities developed in the class used as the test subject. Product trials were carried out by conducting a learning process using discovery learning syntax assisted by learning media products developed starting from apperception, stimulus, data collection, data processing using LKPD, proof, generalization, and quiz work to measure understanding of mathematical concepts after the learning process. Before testing the product, students were first given a *pre-test.* If the product trial has been completed, the next stage is giving the *post-test* and student response questionnaire. To evaluate the efficacy of the learning media developed in enhancing students' comprehension of mathematical concepts on the material of Flat-Sided 3D Space(Cubes and Blocks), pre-and post-tests are administered to evaluate students' mathematical comprehension before and after product trials. The learner response questionnaire is used to assess the usefulness of the learning media for students. Researchers also provided teachers with a response questionnaire to evaluate the effectiveness of learning media for instructors.

5. Evaluation Stage

The evaluation stage includes efforts to make improvements based on the outcomes of the school-based trial of learning media products and the validation of material experts and material experts. Furthermore, at this point, a validity, usefulness, and effectiveness study of the created learning materials is done.

a. Validity Analysis

The following conclusions were drawn from the data analysis of the

material and media experts' validity tests.

Table 3.
Material Expert Validity Test Results

Assessment Aspect	(%)	Criteria
Material Presentation Aspect	76.79	Valid
Language Aspects	84.38	Valid
Aspects of Influence	75	Fairly Valid
Average	78.33	Valid

Table 4.
Media Expert Validity Test Results

Assessment Aspect	(%)	Criteria
Display Aspects Screen Design	81.25	Valid
Ease of Use Aspect	83.33	Valid
Consistency Aspect	83.33	Valid
Graphic Aspects	78.57	Valid
Usability Aspect	78.13	Valid
Average	80.43	Valid

From the information above, it can be concluded that the learning media is valid and suitable for use in the mathematics learning process.

b. Practicality Analysis

Assessment of the learning media's practicality is based on several aspects. The data analysis of the learner response questionnaire obtained the following results.

Table 5.
Results of Practicality Test for Learners

Assessment Aspect	(%)	Criteria
Learning Aspects	83.89	Practical
Quality Aspects	84.81	Practical
Function Aspect	89.35	Very Practical
Display Aspect	83.70	Practical
Average	84.75	Practical

On the other hand, the analysis of teacher response questionnaire data obtained the following results.

Table 6.
Teacher Practicality Test Results

Assessment Aspect	(%)	Criteria
Learning Aspects	75	Practical
Quality Aspects	85	Very Practical
Function Aspect	83	Practical
Display Aspect	80	Practical
Average	80.56	Practical

Based on the results of the practicality test conducted with teachers and students, the learning media developed in this study are practical for use in the mathematics learning process.

c. Effectiveness Analysis

The pre- and post-test results, before and after conducting product trials, can be used to evaluate the effectiveness of the developed learning media in improving students' understanding of mathematical topics. The effectiveness of the media is determined through hypothesis testing and N-Gain tests.

From the normality and homogeneity tests performed on the

pre- and post-test data, it was found that the samples did not come from a normally distributed population, but the population had homogeneous variance. As a result, hypothesis testing was conducted using the Wilcoxon signed-rank test. The results of the Wilcoxon Sign Test hypothesis test calculation obtained a value of $z = 4.37$. With $z = 4.37$ obtained the value of $p = 0.0000$. Since hypothesis testing is done with one-way submission by assuming group one is smaller than group two, the decision criteria for the hypothesis are if $p < \alpha$ then H_0Is rejected. With the value of $p = 0.0000 < \alpha = 0.05$ then H_0 rejected and H_1accepted so that the *post-test value is* greater than the *pre-test* value, or it can be concluded that there is an increase in students' ability to understand mathematical concepts.

B. Discussion

This study employs the Research and Development (R&D) approach, commonly referred to as development research. The specific model used is the ADDIE model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. This research led to the development of learning media based on discovery learning, supported by Articulate Storyline. Following the stages of the ADDIE model, the resulting learning media was found to be valid, practical, and effective in enhancing students' understanding of mathematical concepts in Flat-Sided 3D Spaces. This finding is consistent with previous research by Saputro & Lumbantoruan (2020) and Dirgantara et al. (2023), which also developed Articulate Storyline-based mathematics learning media for Grade VIII Flat-Sided Spatial Buildings material, and concluded that the media was valid and appropriate for use in teaching. Additionally, Audry (2023) conducted research on RME-based learning media assisted by Articulate Storyline, which proved effective in improving students' critical thinking skills.. Research by Rohayati (2023) found that students who learned using the discovery learning model showed greater improvement in understanding mathematical concepts compared to those who learned through conventional methods. Thus, it can be concluded that learning media based on the discovery learning model, supported by Articulate Storyline, is valid, practical, and effective for enhancing students' understanding of mathematical concepts, especially in Flat Side Spaces. This conclusion aligns with prior research, indicating that Articulate Storyline-assisted learning media is a valid, practical, and effective tool, and that the discovery learning model significantly enhances students' ability to grasp mathematical concepts.

IV. CONCLUSION

After completing the development stages using the ADDIE model, the resulting product—a discovery learning-based learning media supported by Articulate Storyline for Flat Side Spaces material—achieved a score of 78.33% (Valid category) based on the material expert's evaluation

and a score of 80.43% (Valid category) based on the media expert's assessment. Additionally, the student response questionnaire received a score of 84.75% (Practical category), while the teacher response questionnaire scored 80.56% (Practical category).

Furthermore, the Wilcoxon signed-rank test revealed that the post-test score was significantly higher than the pre-test score, indicating an improvement in students' understanding of mathematical concepts. According to the N-Gain test, three students showed high improvement, 18 showed moderate improvement, and seven showed low improvement. Based on these findings, it can be concluded that the discovery learning-based learning media, assisted by Articulate Storyline, is valid, practical, and effective in enhancing students' understanding of mathematical concepts related to Flat-Sided 3D Spaces in Class VIII at SMP Negeri 23 Purworejo.

Suggestions for future researchers are that learning media designs can be arranged more interestingly by adding better animations, such as 3D animations so that the learning media developed are more interactive and attract students' attention. Learning media can be arranged more complexly so that the appearance of learning media is more attractive and interactive. Product trials are carried out on a larger scale, such as conducting product trials for several schools. It can serve as a guide when creating educational media using additional resources.

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AUTHOR'S BIOGRAPHY

Putri Sari Mukti

Born in Bandung, February 11, 2002. S1 study program in Mathematics Education, Sebelas Maret University.

Laila Fitriana

Born in Surakarta on July 1982. Lecturer at Mathematics Education, Sebelas Maret University. Completed a Bachelor's degree and Master's degree in Mathematics Education at Sebelas Maret University, ; and Doctoral degree in Mathematics at Yamaguchi University, Japan, graduating in 2016.

Rubono Setiawan

Born in Kudus. Lecturer at Mathematics Education, Sebelas Maret University.