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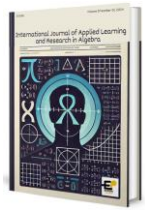

Development of Articulate Storyline 3 Learning Media for Mathematical Computational Thinking Skills

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Abstract

Mathematical computational thinking skills are essential in mathematics learning, particularly in training systematic problem-solving abilities. This study aims to develop learning media based on Articulate Storyline 3, which is designed to enhance students' mathematical computational thinking skills. The method employed in this research is Research and Development (R&D) using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The subjects of the study were high school students selected through purposive sampling. The research instruments included expert validation questionnaires, user response questionnaires, and tests to assess computational thinking skills. The study results have shown that the developed learning media has achieved a very high level of validity according to evaluations from both material and media experts.
Additionally, user responses have demonstrated high satisfaction with the interactivity and ease of media use. Field trials have revealed a significant increase in students' mathematical computational thinking skills after using the learning media. Based on these findings, learning media based on Articulate Storyline 3 has effectively improved mathematical computational thinking skills.

Keywords: Articulate Storyline, Instructional Media, Mathematical Computational Thinking Skills.

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1. Introduction

The development of information and communication technology changed the paradigm of learning in the digital era (De et al., 2023). Computational thinking skills are essential in mathematics learning to train students to solve problems systematically and logically (Mendrofa, 2024). However, conventional one-way learning was often less effective in developing these skills (Rungrangtanapol & Khlaisang, 2021). Interactive learning media provided a solution to increase student engagement and facilitate more meaningful learning (Getenet & Tualaulelei, 2023). Articulate Storyline 3, as one of the interactive learning media development software, had the potential to create dynamic and engaging learning experiences (Wahyuni et al., 2024).

Previous studies explored the use of Articulate Storyline 3 in developing interactive learning media for mathematics subjects. Khairunisa and Armanto (2024) found that using Articulate Storyline media significantly improved students' understanding of mathematical concepts at the junior high school level. Firdaus et al. (2022) also revealed that applying Articulate Storyline 3 strengthened students' mathematical representation. Azzahra and Nurharini (2024) also stated that the interactivity aspect offered by this media motivated students to become more active in the learning process. However, studies specifically focusing on developing mathematical computational thinking skills remained limited. Therefore, this study offered novelty by developing interactive learning media based on Articulate Storyline 3, specifically designed to improve computational thinking skills in mathematics. This study was expected to fill the gap in previous research and significantly contribute to innovation in mathematics learning.

Previous studies showed that the use of Articulate Storyline 3 was effective in improving understanding of mathematical concepts (Khairunisa & Armanto, 2024), strengthening mathematical representation skills (Firdaus et al., 2022), and motivating students in the mathematics learning process (Azzahra & Nurharini, 2024). However, most of these studies focused on general cognitive aspects and did not specifically examine mathematical computational thinking skills development. Computational thinking skills were crucial in the digital era for training problem-solving skills logically and systematically. This gap indicated that no research had specifically developed learning media based on Articulate Storyline 3 to improve computational thinking skills in mathematics. Therefore, this study presented novelty by designing interactive learning media to develop students' mathematical computational thinking skills. Thus, this study was expected to fill the gap in previous research and provide innovative contributions to mathematics learning.

Mathematical computational thinking skills became increasingly important in the digital era because they were needed to solve problems logically and systematically. However, the

reality showed that many students still faced difficulties developing these skills, especially when encountering complex mathematical problems. One of the leading causes was the learning method, which remained dominated by a conventional approach that was less interactive and unable to stimulate computational thinking patterns effectively. Additionally, the learning media used was static and less engaging for students. Based on these issues, the use of interactive learning media based on Articulate Storyline 3 could serve as an effective solution to improve mathematical computational thinking skills. Therefore, research was needed to develop innovative and interactive learning media to address this problem.

Developing mathematical computational thinking skills required an interactive and innovative learning approach. Learning media based on Articulate Storyline 3 proved to be an effective solution, as it presented interactive and engaging content, thereby increasing student motivation and engagement. The development of this media used the ADDIE model, which included needs analysis, relevant design, interactive content development, implementation in learning, and effectiveness evaluation. This media was expected to help students understand mathematical concepts in depth through a logical and systematic computational approach. The results of this study were expected to contribute to innovations in mathematics learning and the development of interactive media.

2. Methods

The 4-D model (Creswell, 2024) was chosen as the development procedure in this study due to its systematic and structured approach, which has been widely proven effective in creating educational products and solutions. This model offers several advantages, especially for learning development, as it allows for thorough expert validation at each stage and follows a detailed, clear-cut progression from conception to distribution. The 4-D model consists of four stages: Define, Design, Develop, and Disseminate, each of which serves distinct purposes that contribute to the overall effectiveness of the development process. The Define stage is crucial as it lays the foundation for the entire development process by identifying and articulating the core problems that need to be addressed.

This stage focuses on gathering data and feedback to ensure the development is targeted at relevant issues, resulting in a well-structured problem formulation that guides the subsequent phases. In the Design stage, initial concepts and blueprints for the learning products are created, ensuring that the content, format, and delivery methods align with the identified needs and are tailored to the target audience. This phase also includes the creation of prototypes or mock-ups, which will be refined and tested based on expert feedback regarding the design's feasibility, relevance, and effectiveness. The Develop stage then transforms the design into tangible learning materials or tools, producing all necessary content, such as lesson plans, multimedia resources, or interactive components, while incorporating validation and piloting to ensure the product functions as intended and meets the defined needs. Feedback from pilot users, including students and teachers, is critical to refining the product. Finally, the Disseminate stage focuses on distributing the developed product to a wider audience, using strategies like workshops, online platforms, printed

materials, or partnerships with educational institutions. This stage aims to ensure that the product reaches those who will benefit from it and is utilized to its full potential, with evaluations providing insights for future improvements. By following these stages, the study ensures that the developed learning products are not only effective and aligned with the identified needs but also validated and distributed to maximize their impact and usefulness in the targeted learning contexts.

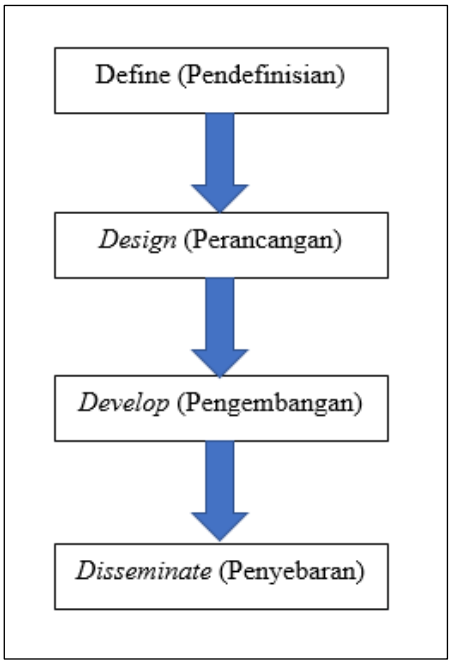


Figure 1 The 4-D: Define, Design, Develop, and Disseminate.

This study involved 30 eighth-grade junior high school students in Banten during the 2023/2024 academic year. The data collection techniques used included tests, questionnaires, and documentation. The instruments used in this study consisted of four types: (1) a media expert validation questionnaire that included 10 statements related to aspects of ease, material presentation and animation, language, writing, and media integration; (2) a material expert validation questionnaire consisting of 12 statements covering aspects of material, content, and language; (3) a student response questionnaire for the Articulate Storyline 3 learning media teaching material, totalling 10 statements focusing on aspects of ease, material presentation and animation, language, writing, and media integration; and (4) mathematical computational thinking ability test questions consisting of five essay questions administered after learning. The test questions were arranged based on the mathematical computational thinking ability types, decomposition, abstraction, algorithmic thinking, and debugging, as explained in the computational thinking ability indicators. All questions in the mathematical computational thinking ability test were declared valid, as the calculated r_{xy} value was more significant than the r_{xy} value in the table (0.361), thus meeting the validity criteria.

The instruments used in this study included a media and material expert validation questionnaire, observation and interview guidelines, and five essay test questions. All of these instruments have been validated by experts and users, with the results showing a significant level of validity. The results of this validation will be explained in detail in the findings section.

Data analysis techniques in this study were carried out after the data collection stage was completed. The data analysis included processing the results of media and material expert validation and teacher and student response questionnaires. This data analysis technique was used to assess validity, practicality, and effectiveness (Dinantia, 2017) (Table 1).

Table 1 - Validity Level Criteria

Presents	Validation Criteria
80%<P≤100%	Very Valid/Not Revised
60%<P≤80%	Fairly Valid/Not Revised
40%<P≤60%	Less Valid/Partially Revised
0%<P≤40%	Very Valid/Not Revised

Based on expert validation criteria, the Articulate Storyline learning media was declared quite valid and did not require revision if it obtained a percentage between 60% and 80%. Meanwhile, the learning media was considered very valid and did not require revision if it obtained a percentage between 80% and 100%.

Table 2 - Practicality Criteria

Presents	Category
84%<P≤100%	Very Practical
68%<P≤84%	Practical
52%<P≤68%	Quite Practical
36%<P≤52%	Not Practical
20%<P≤36%	Very Not Practical

(Oktavia et al, 2024)

The assessment in this study was determined by the minimum category of 'Quite Practical,' with a percentage between 52% and 68%. The Articulate Storyline learning media was declared suitable for use if the level of practicality achieved was at least in the 'Quite Practical' category. If it did not meet the minimum criteria, the Articulate Storyline learning media was revised until it met the 'Quite Practical' criteria.

Table 3 - Criteria for Effectiveness of Learning Media

Criteria	Description
80%<P≤100%	Very Effective
60%<P≤80%	Effective
52%<P≤60%	Quite Effective
36%<P≤40%	Less Effective
0%<P≤20%	Not Effective

(Pulungan & Pandapotan, 2024)

Based on the data analysis above, the learning media was declared effective in improving students' mathematical computational thinking skills and resilience if the percentage of student completion reached at least 60%. In addition, the effectiveness of the learning media was also demonstrated through the improvement of students' mathematical computational thinking skills. Thus, the learning media used effectively improved students' mathematical computational thinking skills.

Assessment scores to assess validity, practicality and effectiveness (see equation 1).

$$p = \frac{\text{number of scores obtained}}{\text{maximum score}} x\ 100\% \quad (1)$$

Table 4 - Mathematical Computational Thinking Ability Indicators

Indicator	Description
Problem Decomposition	Breaking down the parts into smaller pieces. In this section, they can be understood, completely, developed and evaluated separately.
Abstraction	Choosing something appropriate to reduce unnecessary parts so that the existing problem will be easier to create a representation of the given problem.
Thinking Algorithmically	Choosing something appropriate to reduce unnecessary parts so that the existing problem will be easier to create a representation of the given problem.
Debugging	Application of analysis and evaluation to predict and recheck students' answers, whether they are correct or there are errors.

(Irawan, 2024)

A product was declared suitable for use if it met several criteria. First, the validator declared the product valid with a minimum average in the 'quite valid' category. Second, the product was considered practical if it obtained a minimum average in the 'quite practical' category. Third, the product was declared effective if the percentage of student activity implementation in learning reached at least the 'quite effective' category. In addition, effectiveness was also determined based on the achievement of class completion standards, with a minimum of 75% of subjects completed. Students' mathematical computational thinking skills were considered reasonable if they met the minimum criteria in the moderate or high mathematical computational skills category.

3. Results and Discussion

This development research produced the following outputs: (1) web-based media (HTML5) or application files (.exe) that could be run on various devices such as laptops, tablets, and smartphones; (2) evaluation of the Articulate Storyline 3 learning media by experts in the fields of materials and design; (3) teacher responses and student opinions on the validated Articulate Storyline 3 learning media; and (4) evaluation of student activities through student worksheets, activity sheets, and question sheets. Furthermore, the findings from each research phase were discussed using the 4D model.

In the define phase, the researcher conducted problem analysis, teacher and student needs analysis, concept analysis, task analysis, and formulation of learning objectives. This stage was carried out to assess the conditions in the field and define development needs. In the design phase, the researcher developed an initial product design by selecting media, formats, and preliminary designs. During the initial design stage, the researcher developed a prototype of the learning media using Articulate Storyline 3. The design activities comprised three stages: Media Selection, Format Selection, and Design. The following sections describe these three components in detail.

3.1. Media Selection

The material's characteristics and students' needs were aligned with the selection of media. The media was selected based on concept analysis, task analysis, and the characteristics of the target users. This approach helped assist students in achieving their learning objectives.

Based on the results of concept analysis, task analysis, and the characteristics of target users, it was found that students needed interesting, engaging, and easy-to-learn learning media, incorporating colorful text, images, videos, and animations. On this basis, the researcher selected Articulate Storyline 3 as the learning media.

3.2. Format selection

The selected format was aligned with the learning material. The selection of the presentation format was adjusted to the learning media used. The design of the learning content in this study was aligned with the independent curriculum. Additionally, the researcher designed media content that included text, images, audio, video, and animation using Articulate Storyline 3 software.

3.3. Initial design

The initial design of all learning devices had to be completed before the validity and development tests were conducted. The initial design aimed to produce a product design based on the results of the curriculum and material analysis. The design steps included: creating a flowchart, designing components, selecting images and music, and developing the appearance of the home page. The flowchart was created to describe the workflow of the learning media, which could be seen in the story view display in Articulate Storyline 3.

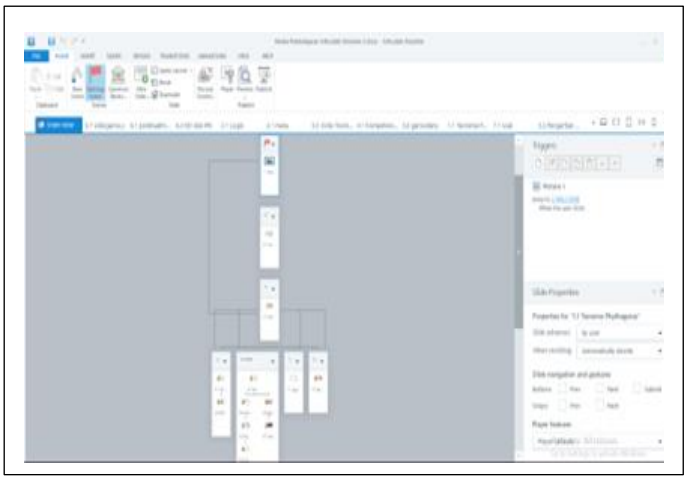


Figure 2 Learning Media Flowchart

The flowchart developed by the researcher consists of six distinct scenes: the subtitle scene, login scene, introduction scene, material scene, evaluation scene, and information scene. Each scene serves a specific function in the learning process and is designed to guide the user through a structured and engaging experience. The design process involved creating the media slide displays and carefully selecting various design components, such as images, text, and music, to enhance the learning experience. The researcher focused on ensuring that each scene effectively communicates its intended message while maintaining a smooth flow throughout the entire learning media. To achieve this, the researcher collected various design

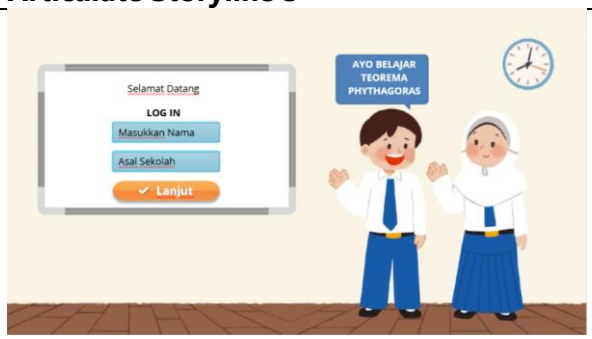
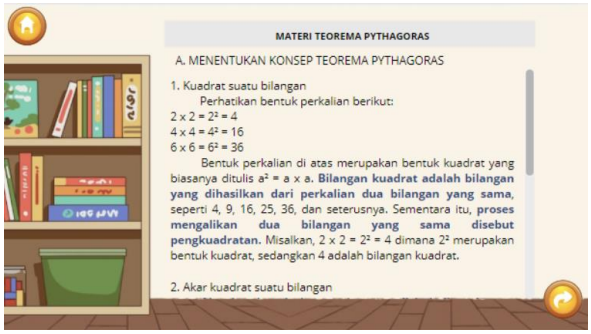
components, including images and music, that aligned with the learning objectives and the desired tone of the media. The following displays several of the image components used by the researcher in developing the learning media, showcasing how these elements were integrated into the final product to support both the aesthetic and functional aspects of the design.

Figure 3 Image Components Used in Learning Media

The music components used by the researcher in the learning media included background music and sound effects. The writing components prepared consisted of font types aligned with the learning media design concept. The researcher designed the appearance of the initial page (intro), which displayed the title of the learning media. Among other features, a button was included to start the student login process. The appearance of the initial page of the learning media is shown below.

Table 5 - Articulate Storyline 3 View

No	Articulate Storyline 3	Information
1		Learning Media Home Page View

No	Articulate Storyline 3	Information
2		Login Page View
3		Media Home Page View
4		Material Explanation View
5		Evaluation Question View
6		Information Page View

In the development phase, the Articulate Storyline 3 learning media, which the researcher had developed during the design stage, was then validated by experts (material experts and media experts). The validation process involved submitting the developed learning media design results and validation sheets to the validators. The following are the results of the validation by material and media experts.

Table 6 - Recapitulation of expert material validation results

Aspect	P%	Criteria
Material	90,00%	Very Valid
Contents	88,00%	Very Valid
Language	90,00%	Very Valid

Based on Table 6, the results of the validation by material experts, consisting of two individuals—mathematics education lecturers and mathematics teachers—on the Pythagorean theorem material in the Articulate Storyline 3 media were very valid. With 10 questions, each question received a positive response. The validation conducted by the Grade VIII mathematics subject teacher also yielded a positive response, where each part of the Pythagorean theorem material in the Articulate Storyline 3 learning media was found to align with the learning objectives.

Table 7 - Recapitulation of media expert validation results

Aspect	P%	Criteria
Convenience	93,00%	Very Valid
Appearance	80,00%	Very Valid
Writing	90,00%	Very Valid

Based on Table 7, the results of the media expert validation by two individuals—mathematics education lecturers and mathematics teachers—on the Articulate Storyline 3 learning media were very valid. With 12 questions, each question received a positive response. However, there were criticisms and suggestions from the material and media experts, which are presented in the following table.

Table 8 - Revision from Material and Media Experts

No	Before revision	After revision
1		
	Change the independent curriculum material. There are no sound effects and the play button is very small	The material has been changed. There are sound effects on the buttons and the play button is adjusted to the size of the other buttons.

No	Before revision	After revision
2	 Each button is not the same in color and size.	 Each button is in harmony between color and size.
3	 The appearance of the main menu button model has been changed and the close button is not below.	 The appearance of the main menu button model has been changed and the close button is not below

Based on the material and media validation results, the learning media was considered 'very valid.' Furthermore, it was tested on 30 grade VIII junior high school students in Serang City. This trial was conducted to determine the validity, practicality, and effectiveness of the developed Articulate Storyline 3 media.

In the next stage, after the Articulate Storyline 3 media was revised based on feedback and suggestions from material and media validation experts, a formative evaluation was conducted to assess the practicality and effectiveness of the Articulate Storyline 3 learning media in enhancing computational thinking skills. The trial involved 30 students, who were asked to observe, use the Articulate Storyline 3 media, fill out questionnaires, and complete mathematical computational thinking skills tasks. The students were given test questions on mathematical computational thinking skills, which included four questions addressing indicators such as problem decomposition, abstraction, algorithmic thinking, and debugging. The questionnaire contained 10 questions aligned with the indicators of ease, material and animation, language, writing, and integration. The results of the student response questionnaire regarding the use of the Articulate Storyline 3 learning media on the Pythagorean theorem material are presented in Table 9.

Table 9 - Student response questionnaire results

Aspect	P%	Criteria
Convenience	81,00%	Very Valid
Material & Animation	78,00%	Very Valid
Language	83,00%	Very Valid
Writing	88,00%	Very Valid
Integrity	84,00%	Very Valid
Avarange	**82,80**%	Very Valid

Based on Table 9, the results of the student response questionnaire indicated that the product trial conducted on 30 grade VIII students yielded an average score of 82.8%. This result placed the Articulate Storyline 3 learning media within the 'Very Practical' category. Students provided positive feedback regarding the interactivity and visualization of concepts, facilitating their understanding.

Next was the dissemination stage, during which the product was categorized as valid and practical and distributed to the target audience by providing it to mathematics teachers in schools as practitioners. The learning outcomes of students using the Articulate Storyline 3 learning media, focusing on mathematical computational thinking skills for the Pythagorean theorem material, were then evaluated.

Table 10 - Student response learning outcomes

Aspect	**P%**	**Criteria**
Student Effectiveness	80,00%	Sangat Efektif
Avarange	**80,00**%	

Based on Table 10, the student test results revealed that the learning completion percentage reached 80%, categorizing the developed learning media as 'effective.' Therefore, the learning media was considered effective. Observations of student learning activities during one of the sessions on the Pythagorean theorem material showed that students were highly engaged with using Articulate Storyline 3 media. They eagerly interacted with the content, observing and using the media enthusiastically. Furthermore, it was noted that teachers had not previously used this technology in their lessons, which led to strong support for developing teaching materials that are compatible with this technology.

Figure 4 Students Activity use Articulate Storyline 3

Based on Figure 4, students appeared highly interested and enthusiastic throughout the learning process as they observed and engaged with applying Articulate Storyline 3. Several shortcomings were identified based on the implementation and results of the development research. These limitations stemmed from the constraints faced by the researchers in both

product development and the research process itself. In line with previous studies (Khairunisa & Armanto, 2024; Firdaus et al., 2022; Azzahra & Nurharini, 2024), it was noted that Articulate Storyline 3 learning media needs to be further developed for other materials by subsequent researchers. Additionally, teachers should consider the condition of their students and determine whether it is necessary to adapt the media or tools to align with the specific characteristics and needs of the students. Furthermore, observations of student learning activities indicated improvements in students' spatial abilities.

The final product of the study was the result of the development process, presented in the form of Articulate Storyline 3 learning media, designed as a source of mathematics learning for junior high school grade VIII students. A significant improvement in the post-test results indicated that the interactive learning media developed effectively enhanced students' understanding of the Pythagorean theorem. This suggests that incorporating visualization and interactivity in the learning media facilitated students' comprehension of abstract concepts. The high level of student satisfaction further suggested that the interactive media successfully increased student engagement and motivation to learn. Using interactive elements like questions and simulations provided students with a more enjoyable and profound learning experience.

4. Conclusions

The results of the research data analysis indicated that the interactive learning media, Articulate Storyline 3, was successfully produced and developed to enhance mathematical computational thinking skills in the Pythagorean theorem material. This product met the criteria of validity, practicality, and effectiveness. Furthermore, the Articulate Storyline 3 learning media had a positive impact, as students demonstrated a quicker understanding of the Pythagorean theorem concept and showed increased motivation to learn mathematics, particularly the Pythagorean theorem. The findings of this study can serve as a model for future mathematics education research. It is recommended that further research be conducted on other materials, focusing on developing more attractive display designs that teachers and students in mathematics learning can effectively utilize.

Conflict of Interest

The authors declare no conflicts of interest.

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