



Development of Interactive Multimedia to Improve Computational Thinking Skills of Elementary School Students

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Abstract: This study aimed to develop valid, practical, and effective Macromedia Flash-based interactive multimedia to improve elementary school students' computational thinking skills on the topic of Indonesian Cultural Wealth. The study employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The participants were fourth-grade students of SDN 05 Sawahan and SDN 01 Sawahan, Padang Timur District. The results showed that the developed multimedia was highly valid, with validation scores of 90.48% from material experts, 90.79% from language experts, and 87.50% from media experts. The practicality test indicated very practical criteria, with teacher and student response scores of 89.28% and 91.08%, respectively. The effectiveness test revealed a significant difference between pretest and posttest scores in the experimental class ($t = 15.499 > 1.711$; $\text{Sig.} = 0.000 < 0.05$), indicating an improvement in students' computational thinking skills. The N-gain results were 0.64 for the experimental class and 0.48 for the control class, both categorized as medium. The novelty of this study lies in the integration of computational thinking components—decomposition, pattern recognition, abstraction, and algorithmic thinking—into interactive multimedia through animations, simulations, and educational games tailored to elementary school students. Therefore, the developed multimedia can serve as an effective learning medium in elementary education.

Keywords: Computational thinking; Interactive multimedia

Introduction

Curriculum development and teacher quality are crucial for educational advancement. The use of various learning media has been influenced by technological advances in education in the current period (Liao et al., 2018; Qureshi et al., 2021; Triana et al., 2021). There is a demand in the world of education to always follow technological developments in order to improve the quality of education in the learning process (Depita, 2024; Munandar et al., 2024). This is a challenge for teachers, especially in terms of being more creative and innovative in delivering material so that learning feels more enjoyable and motivates students (Ismail et al., 2021; Santos et al., 2021). Digitalization in schools in various countries with the use of available technologies has been going on for a long time, it is clear that the use

of this digital technology has produced various impacts on students, of which the positive impacts are certainly more dominant than the negative impacts (Sitorus, 2024). Therefore, teachers should develop media that can be used effectively and efficiently in learning. The learning media developed must consider several criteria, including accuracy with learning objectives, support for the content of the teaching materials, and ease of access to the media (Afifah et al., 2022; Nurhasanah, 2023).

However, the current problem is that many learning activities are still student-oriented. Other research also indicates that many teachers still use the lecture method, which makes students bored (Maula et al., 2020). Based on observations and interviews with fourth-grade teachers at SDN 05 and 01 Sawahan, it was also seen that the media used by teachers when teaching

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science subjects (Natural Sciences and Social Sciences) were concrete media, including objects in the surrounding environment. Digital media frequently used were PPT (Power Point Presentations) and videos related to the material displayed using LCDs and projectors. Students felt enthusiastic when teachers used digital media, but teachers still rarely used digital media in learning. This was caused by limited time to prepare digital media before it could be used, especially because teachers' work at school was not only teaching but also taking care of school administration. The lack of use of interactive and diverse media caused students to feel bored. In the learning process, students were not directed to problems that they had to solve related to the material being studied at that time. Students focused on exercises in student books and limitations in LKS. With the demands of the 21st century, children must be able to develop their computational thinking patterns in dealing with learning materials. So children were challenged to think about the answers. In addition to observations, the author conducted a curriculum analysis and also gave questionnaires to children to analyze the need for learning materials in the learning process. This study aims to develop valid, practical, and effective interactive multimedia problem-based learning to improve the computational thinking skills of fourth-grade elementary school students.

Learning practices aimed at improving students' problem-solving abilities are scarce. Problem-solving skills are a crucial 21st-century skill for students to master in preparation for the Industrial Revolution (Fuad et al., 2025; U. Khasanah et al., 2025; Muliyadi et al., 2023). An approach that can be applied to train students' problem-solving skills is computational thinking.

Computational thinking is becoming an essential skill in the 21st century. Computational thinking is thinking logically, step by step, and making decisions when faced with two different options. It can also be defined as solving complex problems in a simple way (Città et al., 2019; Prayitno et al., 2025; Taupik et al., 2023). According to Zhang et al. (2023) Computational thinking is not just a technical skill, but also a systematic thinking strategy that can be applied in various learning contexts. Several studies have shown that implementing computational thinking in the elementary school curriculum can improve students' problem-solving skills and digital literacy (Han et al., 2022; Irfan et al., 2025). Computational thinking is the ability to solve problems systematically with a logical and algorithmic approach, which is not only relevant to information technology learning, but can also be integrated into various subjects (Arvi et al., 2025). Through computational thinking, students are encouraged to analyze, develop solutions, and develop critical and

creative thinking patterns when facing real-life problems. This low ability is caused by students' lack of understanding of the problem (Nasiba, 2022).

In this era of globalization, there is potential to integrate more than one type of media. The combination of several media to form a complete learning medium is often referred to as multimedia (Muliyadi et al., 2026; Oktarina et al., 2021; Wibowo et al., 2020). Interactive multimedia is a type of multimedia equipped with a control device that can be operated by the user. This allows the user to choose the next step according to their wishes. The use of technology in education involves the implementation of computer-based media using software such as Macromedia Flash (Hotimah et al., 2021; Huda et al., 2021). Macromedia Flash is an application or software that can help teachers create interactive learning media or interact with each other. Furthermore, Macromedia Flash has other advantages, including high consistency in producing animations and images, maintaining good image quality, creating interactive programs, and ease of animation creation, among other aspects (Fitriana et al., 2021).

Integrated interactive learning multimedia not only provides a more holistic learning experience, but also enables the development of various skills, especially computational thinking skills, which are needed in the 21st century (Nisyaa et al., 2025).

The need for media in the context of learning has been studied by previous researchers. Previous research has shown that the use of multimedia in learning can help students understand the material more easily (N. L. P. J. Dewi et al., 2021; Jannah, 2020). Other research also reveals that multimedia-based learning can increase students' learning motivation, thus increasing student enthusiasm and involvement during the learning process (I. G. A. A. S. S. Dewi et al., 2019; Rofiq et al., 2019). In addition, a study on the development of Macromedia Flash-based thematic learning media shows that the use of this media can significantly improve student learning outcomes (B. U. Khasanah et al., 2019; Syabrina et al., 2020). Macromedia Flash-based interactive media can activate and stimulate students' thinking, enabling them to manipulate concepts and transform abstract concepts into tangible objects (Doyan et al., 2020; Taher et al., 2024). Based on these findings, it can be concluded that the application of Macromedia Flash-based learning media is effective in improving student learning outcomes with a level of improvement that is in the moderate category. The advantages of Macromedia Flash are not only focused on its ability to produce interactive learning media, but also on its ability to combine various multimedia elements such as text, video, sound, graphics, and animation in an integrated manner. The novelty of this research lies in the development of interactive learning media based on

Macromedia Flash designed to improve elementary school students' computational thinking skills through animation activities, simulations, and interactive educational games. This media not only functions as a means of delivering material, but also trains students in aspects of decomposition, pattern recognition, abstraction, and algorithmic thinking gradually according to the characteristics of elementary school children's cognitive development. In addition, this research strengthens the integration of learning technology with computational thinking which is still rarely applied in learning at the elementary school level, especially through the use of interactive media that is interesting, easy to use, and centered on students' problem-solving activities. The integration of these various elements makes the presentation of material more interesting, communicative, and easy to understand by students. Therefore, this study aims to develop interactive multimedia based on Macromedia Flash on the material of Indonesian cultural wealth to support a more effective and meaningful learning process.

Method

This research uses a research and development (R&D) method. Research and development is a scientific process that involves examining, designing, producing, and testing the validity of a developed product. These activities can also be referred to as the 4Ps (research, design, production, and testing) (Sugiyono, 2022). This research and development was conducted using the ADDIE Model, which consists of five phases, namely analyzing, designing, developing, implementing, and evaluating (Anggrayni et al., 2025; Oktarina et al., 2023).

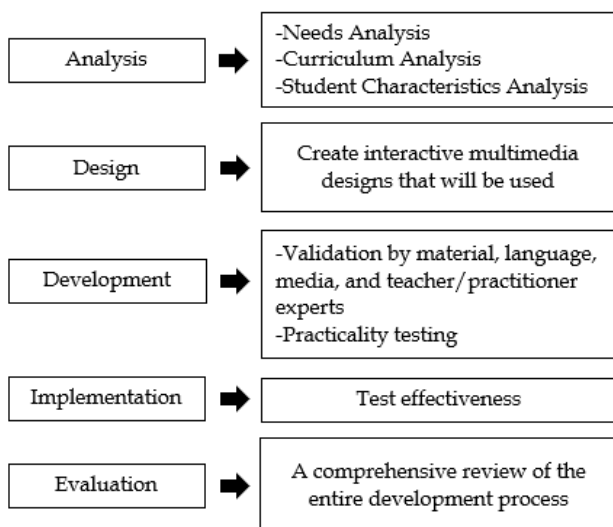


Figure 1. Research design scheme

The first stage of this research is the analysis stage. At this stage, the researcher identified the remaining needs and existing problems related to media and student learning outcomes (Husna, 2025). The results were obtained from a preliminary study, field observations, and interviews with teachers and students conducted at two elementary schools in Padang City, namely teachers and fourth-grade students at SDN 05 Sawahan and SDN 01 Sawahan. The second stage is the design stage. This stage is carried out systematically, starting from determining the material to creating the developed interactive multimedia product. The third stage is the development stage. The purpose of this stage is to validate the product, which is carried out by three experts: a material expert, a language expert, and a media expert. Validation is also carried out with a practitioner or teacher. After the product is declared feasible by the experts, the product is tested in three stages: individual trials, small group trials, and limited group trials. The next stage is implementation. This stage is carried out to determine the effectiveness of the product's use in two classes: the control class and the experimental class. The final stage is evaluation, which reviews the effectiveness of the product's use in two classes: the control class and the experimental class.comprehensively over the entire development process to ensure the quality and effectiveness of the interactive multimedia being developed.

The subjects in this study were fourth-grade students of SDN 05 Sawahan and SDN 01 Sawahan. The object of this research is the development of interactive multimedia in the form of macromedia flash to improve computational thinking skills in science subjects. The techniques used to collect data were observation, interviews, documentation, questionnaires, and learning outcome tests. Observation and interview methods were used to collect data in the field. The documentation method was used to collect documentation in the form of photos and videos of research activities carried out. The questionnaire method was used to collect data in the form of assessments given by experts and teachers. The test method was used to collect data in the form of a pre-test before using the media and a post-test after using the developed multimedia (Mustikawati et al., 2024; Syaefudin et al., 2024).

Result and Discussion

The product of this research is interactive multimedia in the form of Macromedia Flash for fourth-grade elementary school science lessons. This interactive multimedia was developed using the ADDIE model: Analysis, Design, Development, Implementation, and

Evaluation. The following are the results of each stage of development:

Analysis Stage

The initial step taken at this stage was to conduct preliminary research to gather information using various techniques including preliminary study observations, teacher interviews, student interviews, and a prepared questionnaire. Based on all the initial activities carried out at SDN 05 Sawahan and SDN 01 Sawahan, it can be concluded that new innovations are needed to support learning activities, where interactive multimedia is appropriate for implementation in elementary schools. This development also considers its suitability to student characteristics. In addition, researchers also conducted an analysis of learning outcomes that analyzed each keyword in the outcomes and then derived it into learning objectives and continued to the flow of learning objectives. The selected material was the Social Sciences material in Chapter 6. The selection of this material was based on interviews with teachers.

Design Stage

The design phase was conducted based on the findings from the analysis phase, which indicated the need for interactive and engaging digital learning media to support the learning of Chapter 6 with the main material of Indonesian Cultural Wealth in grade IV of elementary school. At this stage, interactive multimedia was designed using the Macromedia Flash 8 application integrating images, animations and interactive features suitable for elementary school students.

Step the initial phase involves determining learning objectives and aligning them with the Independent Curriculum, particularly for science and science subjects. Content is mapped based on Learning Outcomes (CP) and Learning Objectives (TP), with the goal of enhancing students' understanding of Indonesia's cultural richness. These learning objectives are translated into storyboards that guide the development of multimedia content.

The final result of the design phase is the preparation of a detailed storyboard and flowchart that serves as the main guideline in the interactive learning media development process. The storyboard is prepared to clearly describe each screen display, the presentation of learning materials, the types of interactions used, the dialogue or narrative displayed, as well as the navigation flow and transitions between pages in the multimedia. Meanwhile, the flowchart is used to systematically show the flow of program usage, making it easier for developers to understand the structure and working mechanisms of the media to be created. The design document is then used as a reference in the

development phase to realize interactive multimedia using Macromedia Flash 8 so that the media creation process runs in a directed, efficient, and in accordance with the formulated learning objectives. At this stage, the product design also goes through a validation process by media experts to obtain assessments related to aspects of appearance, interactivity, ease of use, and the design's suitability to effective learning principles. Input and suggestions from validators are used as a basis for making initial revisions so that the media design is not only visually appealing, but also meets pedagogical and technical standards before proceeding to the overall product development stage.



Figure 2. Interactive multimedia product design

Development Stage

After going through the development stage, interactive multimedia requires validation from media experts, content experts, and language experts. Validation is carried out by lecturers (expert assessment). The quality of a medium's measurement is indicated by its validity (Hendriani, 2021). The trial was conducted in stages, including one-on-one trials, small group trials, and field trials. Validation activities aimed to determine the feasibility of the developed product, while trials were conducted to assess the practicality of the media. Evaluation results from material and media experts indicated that the product was highly feasible, with the following scores.

Table 1. Validation results by Material, Language and Media Experts

Validation	Percentage	Category
Material expert	90.48	very valid
Language expert	90.79	very valid
Media expert	87.50	very valid

The results of the assessment carried out by the material, language, and media validators based on the predetermined assessment criteria, showed that the interactive multimedia developed using Macromedia Flash 8 for the topic "Indonesian Cultural Wealth" obtained an average score of 89.59%, categorized as "very feasible", and thus, can be continued to the next product trial stage.

Table 2. Practical Results

Stage	Average	Category
Individual trials	85.97	practical
Small group trials	90.76	very practical
Limited group trial	91.08	very practical

On at this stage, the developed product was tested through three stages: individual trials, small group trials, and field trials. Each stage was conducted to determine the practicality of the multimedia when used by students and teachers in real-life classroom learning

situations. The results of each trial stage are presented in the table 2.

Referring to the predetermined assessment guidelines, the average results of the practicality assessment revealed that the product developed using Macromedia Flash 8 for the science subject with the theme "Indonesian Cultural Wealth" was categorized as "very practical," so it could be continued to the next stage, namely the implementation test.

Implementation Stage

This implementation aims to test the effectiveness of interactive multimedia developed using Macromedia Flash 8 in improving computational thinking skills in the science subject with the theme "Indonesian Cultural Wealth". This stage was carried out in the control class and the experimental class by observing the pretest and posttest values, where the experimental group used the developed multimedia and the control group used conventional learning methods. The results of the pretest and posttest are presented in the table 3.

Table 3. T-Test of Computational Thinking Ability

	Paired samples test								
	Mean	Std. deviation	Std. error	95% confidence interval of the difference			t	df	Sig. (2-tailed)
				mean	Lower	Upper			
Pair 2	-26.160	8.439	1.688	-29.644	-22.676	-15.499	27	.000	
Pair 2	-21.440	7.768	1.554	-24.646	-18.234	-13.800	27	.000	

The significant value was Sig (2-tailed) 0.000 1,711. So there is a difference in the average test results of students' computational thinking skills for the experimental class pretest results with the experimental class posttest results. Furthermore, in the control class, the significance value was Sig (2-tailed) of 0.000 ttable 13,800 > 1,711. So there is a difference in the average test results of students' computational thinking abilities for

the pretest results with the posttest results in the control class.

To assess the effectiveness of the e-module, the researchers used the N-Gain test. This score is calculated based on the difference between the average pretest and posttest scores. The results of the N-gain score test can be seen in the following table.

Table 4. N-gain Score Computational Thinking Ability

Class	Average				Category
	Pretest	Posttest	N-Gain Score	N-Gain Score (%)	
Experiment	54.09	86.59	0.71	70.79	Tall
Control	44.09	82.05	0.68	67.89	Currently

Based on the results of the N-gain score test calculations, it shows that the average N-gain score for the experimental class (using interactive multimedia) is 70.79, which is included in the high category based on the N-Gain effectiveness interpretation category if the N-Gain is between 56-75, it is categorized as quite effective (Hake, 1999; Rahmi et al., 2021). Meanwhile, the average N-gain score for the control class (using conventional learning) was 67.89, which is included in the moderate category based on the N-Gain effectiveness

interpretation category. If the N-Gain is 40-55, it is categorized as less effective (Rahmi et al., 2021).

Therefore, it can be concluded that the development of interactive multimedia using Macromedia Flash 8 in the science subject with the theme "Indonesian Cultural Wealth" for fourth-grade elementary school students is effective for use in the learning process. This multimedia has been proven to support the improvement of students' computational

thinking skills and provide a more contextual and engaging learning experience.

Evaluation Stage

In the evaluation stage, a comprehensive review of the entire development process was conducted to ensure the quality and effectiveness of interactive multimedia developed using Macromedia Flash 8. This activity involved reflection on input from validators, teachers, and students as trial participants, as well as analysis of the results of the learning implementation that had been carried out. Based on the validation results, the product received a very feasible category from media experts and material experts, which indicated that the media had met the standards of content feasibility, appearance, and learning suitability. In addition, practicality assessments by teachers and students showed that the interactive multimedia was classified as very practical for use in classroom learning activities.

The implementation results also showed a significant increase in student learning outcomes in the experimental class using interactive multimedia compared to the class using conventional learning. This finding confirms that the developed media is effective in supporting the learning process and improving student understanding. This evaluation phase ensures that the final product meets the requirements of validity, practicality, and effectiveness, making it suitable for wider application. Various weaknesses and suggestions obtained during the implementation phase also served as the basis for final product revisions and improvements before the dissemination phase.

Discussion

The development of interactive multimedia using Macromedia Flash for science learning in elementary schools was carried out to address the needs of teachers and students for innovative learning, especially to improve students' computational thinking skills. Based on the analysis stage, it was found that most teachers still rely on printed teaching materials and conventional media due to limited time and digital resources. This is supported by research conducted by Makda (2025), which emphasizes the importance of providing digital teaching materials that are easy to use, efficient, and aligned with the needs and demands of the current curriculum. This product was created to support students' computational thinking skills. Computational thinking is recognized as a critical component of student success in the digital age. Many argue that integrating computational thinking into the core curriculum is the surest method for providing all students with access to problem-solving processes (Kite et al., 2021).

The product developed has gone through a validation process by media experts and material

experts with the assessment results being in the very suitable category. A research product that is said to be valid is a research product that can be interpreted as a product that is correct, precise, legitimate and authentic (Happy & Bondan Widjajanti, 2014). This indicates that the content, visual appearance, level of interactivity, and technical functions of multimedia have met the standards required for use in classroom learning activities. Furthermore, the results of the practicality test involving teachers and students from three different schools also obtained a very practical category. These findings indicate that interactive multimedia is easy to operate, engaging for students, and effective in supporting the science learning process in improving students' computational thinking skills.

Product implementation includes individual trials, small group trials, and limited group trials showing a significant increase in students' computational thinking skills in the experimental class using interactive multimedia compared to the control class. Based on the pretest and posttest conducted in the two classes, the N-Gain value for the experimental class was 70.79, with a high category, and for the control class, 67.89, with a medium category. This N-Gain score is used to see the effectiveness of learning.

Conclusion

Based on the research results, it can be concluded that the Macromedia Flash-based interactive multimedia developed on the topic of Indonesian cultural richness has met the criteria of being valid, practical, and effective for use in science learning in elementary schools. The level of media validity is demonstrated through the results of assessments by material experts, language experts, and media experts, all of which are in the very valid category. In addition, the results of the practicality test based on teacher and student responses indicate that the media is easy to use, interesting, and supports the learning process optimally. The effectiveness test results also showed an increase in students' computational thinking skills, as indicated by the experimental class's N-gain value, which was higher than the control class's, and was in the moderate category. The novelty of this research lies in the integration of computational thinking skills, namely decomposition, pattern recognition, abstraction, and algorithmic thinking, into interactive multimedia through animation, simulation, and educational games designed according to the characteristics of elementary school students so that the media not only functions as a means of delivering material, but also as a means of developing computational thinking skills. However, this research has limitations in the relatively limited number of samples, the cover material that only focuses on

Indonesian Cultural Wealth, and the use of the Macromedia Flash platform which is currently less relevant to the development of learning technology. Therefore, further research is recommended to develop more modern digital platform-based learning media and test them on various learning materials and different educational levels in order to obtain broader and more comprehensive findings regarding the development of students' computational thinking skills.

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M. contributed to the introduction, data analysis, and writing of the article. A.Z. and N.A. acted as field implementers of the research and acted as developers of the interactive multimedia.

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Conflicts of Interest

The authors declare no conflict of interest.

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