Development of Interactive Multimedia to Improve Spatial Thinking Ability of Students in High School

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Abstract. Learning multimedia is needed to attract students' interest in learning. This R&D research aims to develop interactive multimedia to improve the spatial thinking skills of high school students in learning geography. Development used the ADDIE model, which stages: analysis, design, development, implementation, and evaluation. The subjects of this study were high school students in the experimental and control classes at State-1 Senior High School Karanganyar, Central Java. Data collection techniques in this study were interviews, questionnaires, and tests. The stages of product development are (1) analyzing students' needs for learning multimedia, (2) designing and developing multimedia that contains material descriptions equipped with pictures, maps, and videos, and evaluation questions; (3) conducting a quasi-experiment to determine the effectiveness of multimedia in improving students' spatial thinking. The results showed: (1) learning multimedia is very much needed by students, especially in distance learning, (2) the developed multimedia is considered very feasible by media validators and material validators; (3) based on a t-test with a significance level of 5% the interactive learning multimedia improved spatial thinking skills, with T-calculation = 3.229 > T-table = 1.998, which explained that interactive multimedia is effective.

Keywords: Interactive Multimedia, Research & Development, Spatial Thinking Ability

1 Introduction

A key element in raising the standard of future human resources will be students' quality of education. Teachers must enhance the learning environment in the classroom [1]. Every person needs to learn about their cognitive, emotional, and psychomotor development. Learners must comprehend the most acceptable ways to learn in order to succeed. It has referred to as a learning style [1] Every instructor has a unique learning approach.

Learning media have impacted the learning process since the invention of computers and the internet [2]. The media can be seen as a tool for disseminating messages and

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information. It has been demonstrated that e-Learning technology combined with learning media improves the quality of the learning process for both teachers and students [3,4].

In order to avoid severe complications while employing new educational technology in the classroom, students are increasingly more focused on contemporary technology that has been utilized from an early age [5]. The majority of kids use contemporary multimedia learning tools at school, according to [6]. The extent of educational technology's influence is more thoroughly researched in the cognitive aspects [7,8]. When utilizing educational technology, teachers should consider the tools and applications they utilize, how helpful the knowledge they receive is, how these tools improve student participation in learning and the overall benefits of their utilization. Several authors [9,10] Encourage teachers to place more emphasis on software that has five features that can have an impact on students: (a) educational value, (b) manipulating students' involvement in learning, (c) ease of use, (d) interaction between students and programs, and (e) the potential for tracking a child's development through software.

To assist in the design of educational technology integration that can benefit students and foster technology-based learning, teachers must possess the necessary expertise and keep up with the most recent technical advances [11] If we create mental representations by fusing text and graphic elements following the type of learning, multimedia learning can be beneficial [12]. The accessibility of learning multimedia at any time and from any location is another benefit [13].

In order to understand concepts in many higher education disciplines, such as geography, spatial thinking, as a set of cognitive skills that "comprises of knowing spatial concepts, using tools of representation, and reasoning processes," is crucial [14,15]. The three components of spatial thinking: spatial imagery, spatial orientation, and spatial relationships are critical cognitive abilities for spatial thinking [16]. The mental skill of manipulating, rotating, or reversing visually presented stimuli is known as spatial visualization. Understanding how visual inputs form patterns of elements, maintaining composure in the face of orientation shifts, and determining spatial relationships are all parts of spatial orientation.At the same time, spatial is the ability to see the visual world spatial and visual accurately and visualize changes in perception. These three elements, when combined, will produce spatial thinking skills. In geography learning, activities to make it easier to study geosphere phenomena can be assisted by using proper learning media.

Spatial thinking ability is a form of thinking accumulated from cognitive skills. The key to spatial thinking combines three constructive elements: space, representational tools, and reasoning processes [13,14] Spatial thinking skills are essential to improve because they have evolutionary and adaptive importance and are in line with the demands of the 21st century. Also, spatial abilities help to reason in existing domains, surfaces, and space.

Integrating geospatial technology, such as geographic information systems (GIS), into the classroom is a pedagogically effective strategy to enhance the challenging learning process of spatial thinking, according to empirical data from numerous research. [17,18]. Research by [19] shows that students' low spatial thinking skills can be improved using appropriate multimedia. [20] Also, interactive multimedia-based E-

Learning learning media enhances learning outcomes and students' spatial thinking skills. This research is important because there are still many less-than-optimal schools using interactive multimedia to improve learning outcomes, especially spatial thinking skills. According to [21] relevant research explains that students' spatial thinking skills can be improved using digital games that describe shapes, aspects, and positions. The difference between the research, according to [21] with this research is the use of the developed media to improve spatial thinking skills. The media developed in this study is a learning application that consists of several learning features, including materials, games, and practice questions, and is supported by a good background. This research aims to develop interactive multimedia learning to increase the spatial thinking skill of Senior High School students.

2 Methods

This study employed the ADDIE development paradigm as part of its research and development methodology. Dick and Carry came up with the development paradigm known as ADDIE. [20] states that the stages of creating the ADDIE model involve analysis, design, development, implementation, and assessment. The State High School 1 Karanganyar served as the site for the needs analysis and small-scale trials. In contrast, the computer lab at Universitas Sebelas Maret served as the location for the product application development process. Steps in research and development include:

1. Analysis

The analysis stage includes analysis of the needs of students, analysis of teacher needs, and analysis of the needs of students' spatial thinking skills. Data collection using a questionnaire compiled in google form.

2. Design

This stage is done by designing what the material will be delivered, equipped with pictures, maps, animations, and videos that follow the material and research objectives. The design stage ends with the creation of storyboards.

3. Development

The multimedia development process is developing and inserting materials, media, and evaluations into the application. After the finished multimedia has been developed, its feasibility is assessed by media and material experts.

4. Implementation

The implementation stage was performed with quasi-experiments to determine the effectiveness of multimedia in improving students' spatial thinking abilities.

5. Evaluation

All stages of development are evaluated to find the shortcomings and plan improvements in further research.

The study's data collection was done in November and December 2021. The study used interviews to gather data on the environment, tactics, and ways of learning. The questionnaires used are a needs analysis questionnaire, a questionnaire from a media expert, a material expert, and a questionnaire from a user were all employed in this study. The test used in this study evaluates the effectiveness of multimedia learning in helping high school students develop their spatial thinking abilities. The test was administered twice: once as a pretest and once as a post-test. The pretest was administered prior to the use of learning multimedia by the students.

The independent sample T-test was utilized in this study's data analysis to evaluate how interactive multimedia learning improved students' spatial thinking abilities. Post-test data from the experimental class and the control class were used in the efficacy test. Before doing a test on a product's effectiveness, a precursor test must be completed. The homogeneity test and the normalcy test are components of the preconditioning test.

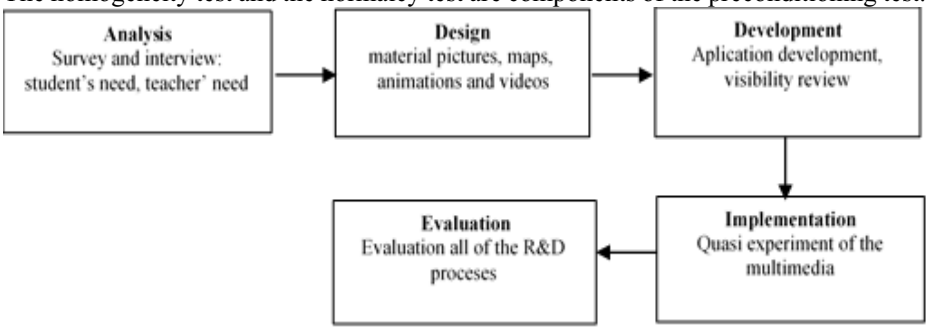

Fig. 1. Steps of the research

3 Result

The steps of the ADDIE model will be used to illustrate how this research developed. The analysis stage, the design stage, the development stage, the implementation stage, and the evaluation stage are the stages of the ADDIE model.

Table 1. ADDIE Model Stages

Analysis	Design	Development	Implementation	Evaluation
Needs analysis	Making assessments/tests	Develop media materials	Preparing teachers and students	Evaluate all stages
Analysis of learning instructional objectives	Selection of media form	Doing media test	Prepare the learning environment	
Develop learning objectives	Making learning strategies		Conduct media effectiveness test	

Source: [22]

3.1 Analysis Stage

According to a requirements analysis conducted by researchers with educator participants, PowerPoint and modules are frequently used to facilitate learning in classroom settings. In educational activities, teachers frequently administer tests after the learning process to review the material that has been taught.

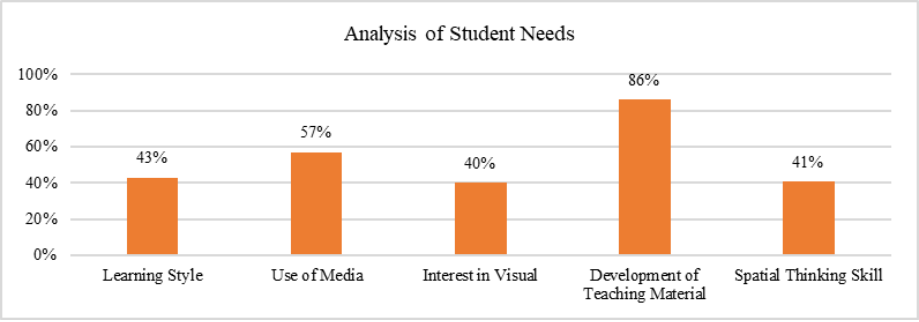

Fig. 2. Results of Student Needs Analysis

Based on the needs analysis results, as many as 43% of students have a visual learning style, 57% of students often use media to support learning, 40% of students choose blue for media display and Times New Roman font for writing in media. 86% of students agree with the development of interactive multimedia. 41% of students have high spatial thinking skills. So it can be concluded that students need interactive multimedia learning to improve spatial thinking skills.

3.2 Design Stage

Researchers will develop interactive multimedia learning based on the needs analysis that has been carried out on high school students. The multimedia design is a digital interactive learning media that can be installed on an android smartphone with achievement indicators to improve students' spatial thinking skills. Multimedia design at this stage includes application start page design, cover page design, and material page design. Designing this interactive multimedia learning uses the articulate storyline application and the web apk builder.

Fig. 3. Multimedia Page Design

3.3 Development Stage

Multimedia products that are developed need to be tested for feasibility to assess the application used in learning. The trial phase carried out on multimedia had the results; among others, the media expert test was 90% in the very feasible category, and the material expert test was 84% in the very feasible category. The small group trial was 77.5% with the appropriate variety, and the class trial was 75.6 % with the eligible variety.

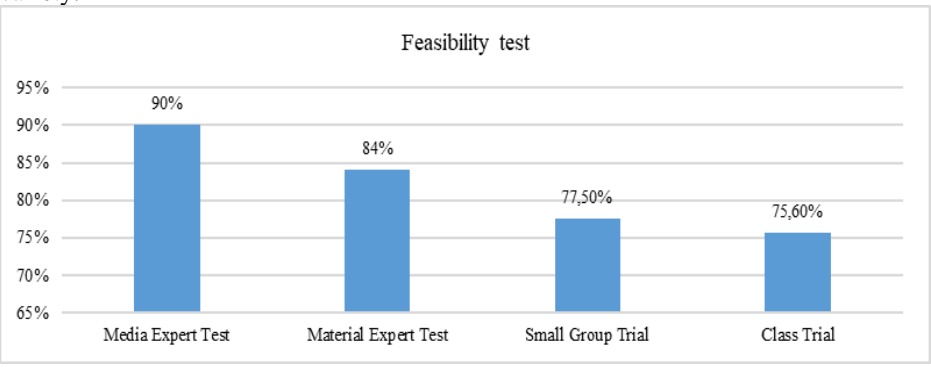

Fig. 4. Feasibility Test Results

Based on the testing stages, it can be seen that interactive multimedia is included in the feasible category so that this multimedia can be used in learning activities in high school.

3.4 Implementation Stage

Interactive multimedia learning was implemented in 32 experimental and 32 control class students through classroom learning activities. Experimental class, students were given education using interactive multimedia. While the control class uses learning using power point assistance, the implementation phase in the class is carried out in three

meetings. The effectiveness of interactive multimedia was measured using a comparison of learning outcomes between the experimental and control classes.

Table 2. Average of Pretest and Posttest

Class	Average Value	
	Pretest	Posttest
Experimental Class	46,3	78,2
Control Class	34,7	59,5

The average posttest score of the experimental class is 78.2, and the control class is 59.5. As can be observed from the fact that courses using interactive multimedia have an average value greater than classes not using interactive multimedia, interactive multimedia products are thus more successful in enhancing students' spatial thinking abilities.

A t-test may be used to assess interactive media's efficiency after preliminary tests for normality and homogeneity. The scores of the pupils were then subjected to tests for homogeneity and normality to ascertain if the data were evenly distributed. Using Microsoft Excel, the normalcy test was conducted using the Liliefors test and a significance level of 5%, based on the results of the L table's 0.886 normalcy test. The findings demonstrated normal distribution in both the control class's pretest and post-test data sets. The control class's pretest L count was 0.179, while the experimental class was 0.091. Similarly, the post-test L counts for the control and experimental classes were both 0.088. The conclusion is that L-Calculate an L-Table to ensure that the data is normally distributed. The homogeneity test is the following procedure to do after the normalcy test. Data from the control and experimental classes' learning outcomes were utilized in the homogeneity test. The pretest item has a value of X-obs2 0.761 based on the homogeneity test with X-tabel2 3.841, while the post-test item has a value of X-obs2 2.650, including homogenous data. Based on the homogeneity test with X-tabel^2 3.841, the pretest item has a value of X-obs^2 0.761, and the post-test item has a value of X-obs^2 2.650, including homogeneous data. So it can be concluded that the pretest and post-test data are homogeneous because of X-obs^2 < X-tabel^2. After that, the product effectiveness test was carried out; the data used was the comparison data of the post-test learning outcomes of the control and experimental classes. The test will be carried out using a comparison of post-test scores between the control and experimental classes with the T-test statistical test formula and with the help of calculation applications.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S\sqrt{\left(\frac{1}{n_1}\frac{1}{n_2}\right)}} \qquad (1)$$

Table 3. Independent Sample T Test

		Independent Sample Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post-test	Equal variances assumed	3.877	.053	3.229	62	.002	18.74062	5.80364	7.13932	30.34193
	Equal variances not assumed			3.229	57.30	.002	18.74062	5.80364	7.12038	30.36087

The effectiveness of interactive multimedia learning was measured using an independent sample T-test with a significance level of 5%. From the calculation of the t-test performed, it is obtained that T-Calculate = 3.229 and T-Table = 1.998. Based on these calculations, it can be concluded that interactive multimedia learning is more effective in improving students' spatial thinking skills than PowerPoint media because of T-Calculate < T-Table. The experimental class that uses interactive multimedia learning has a higher average value than the control class that uses PowerPoint media.

3.5 Evaluation Stage

Evaluation is the last stage in the ADDIE development model. At the evaluation stage, all stages of development are assessed. It can be concluded that the ADDIE model has several advantages and disadvantages at all stages of the development process. The shortcomings of the development stage include lengthy questionnaire assessments, the material design process being quite tricky, time constraints during the implementation process in schools, and some students who have not been able to install learning applications. The development of interactive multimedia with the ADDIE model was developed because the students' spatial thinking skills have decreased as a result of distance learning; this is supported by the needs analysis that has been carried out. This multimedia has a pretty attractive design and has been tested for validity by media and material experts and field trials with categories suitable for learning. The implementation in the experimental and control classes showed an increase in the average score using interactive multimedia compared to the control class using PowerPoint media. This increase is also supported by the independent sample t-test, concluding that interactive multimedia learning effectively improves students' spatial thinking skills.

4 Discussion

This study uses the ADDIE development model, which has five stages of development. Learning multimedia products were developed with the help of the Articulate Storyline application and the Website Apk Builder. The final goal of this development research is to determine the effectiveness of multimedia products on students' spatial thinking skills. The first stage in the ADDIE development model is analysis. Based on the needs analysis results, the majority of students have a visual learning style, 43%. Although the visual learning style is dominant, it is also necessary to pay attention to the learning styles of other students so that the interactive multimedia products developed can be packaged into interactive media by combining text, images, maps, audio, and video. This multimedia is then given additional visualization of the dominant blue and white colors on the initial display and visualization of black color on the writing. Data on students' media use shows that most students often use media in daily activities. However, with different intensities, it can be concluded that students will have no difficulty using the Interactive Multimedia developed during the trial. Students are also very enthusiastic about developing this multimedia, as seen from the data on the development of teaching materials, with 86% of students agreeing to develop interactive multimedia. This multimedia development also aims to improve spatial thinking skills because most students have a low level of spatial thinking skills, around 59% or 53 students, while 41% or 37 students have high spatial thinking skills. So students need a learning media that integrate spatial thinking skills.

Interactive Multimedia is designed with the help of the Articulate Storyline application, with the final result in HTML form. The Website APK Builder application is needed to be directly inserted into the smartphone. Interactive Multimedia has several pages, including the front application page, class selection menu, material selection menu, games, learning videos, games, and quizzes. The content in Interactive Multimedia at the design stage will be rechecked to determine whether it is running according to the design concept and is suitable for the material so that the Multimedia developed can attract attention and improve students' spatial thinking skills. Interactive Multimedia is validated by a team of experts in the form of material experts and media experts.

Furthermore, Interactive Multimedia was tested on small groups of 7 students, and a class trial of 21 students was conducted. From the validation results of material and media experts, Interactive Multimedia obtained an average result of 87% with a very feasible category. As for the results of small-scale and class trials, an average of 76.55% was obtained with a decent category. Researchers will use the results of the validation by media and material experts as a reference in perfecting Interactive Multimedia.

The next stage in development is implementation. The implementation phase is carried out to determine the process of increasing students' spatial thinking skills. Students' spatial thinking skills are skills in solving problems in a spatial environment. This skill is important to be taught to students because it is this skill that helps a person to able to decide on a problem quickly and precisely according to the space he faces. The results of the pretest and post-test show that Interactive Multimedia products are more effective in improving students' spatial thinking skills. The average value of the class that uses Interactive Multimedia is higher than the class that does not use Interactive Multimedia.

The effectiveness of the use of Interactive Multimedia at a significance level of 5% obtained a t-count of 3,229 while t table of 1,998, which means Ho is rejected, meaning that there is an increase in students' spatial thinking skills by using Interactive Multimedia for food, industry and energy security.

Evaluation is the last stage in the ADDIE development model. Interactive Multimedia was measured using seven aspects, including aspects of ease of use of media, interactive aspects, aspects of ease of understanding material, aspects of spatial thinking skills, aspects of the media display, writing aspects, and color aspects. The average percentage of all aspects obtained is 81.5% with very good criteria, so the response from students to the developed Multimedia is positive. Interactive Multimedia used by students gets a good response, certainly inseparable from the benefits of multimedia to help students hone their spatial thinking skills and also help students learn independently from home.

5 Conclusion

Based on the research and development work findings, it is possible and efficient to employ interactive multimedia in learning activities that may contribute tangible assets to the security of food, industry, and energy. With a score of 90%, media experts verified the viability of Interactive Multimedia items, placing them in the highly practicable category with material experts (84%), product trials (76.55%), and material experts (84%) who also certified the viability of the same products. Eligible group. Based on calculations using the Independent Sample T-Test, it can be seen that Interactive Multimedia is more successful at enhancing students' spatial thinking abilities than T table (1.998) and T count (3.229). Students' spatial thinking abilities may be strengthened through interactive multimedia, which can be applied to creative learning. Additionally, interactive multimedia learning resources that include various information, including movies, photographs, maps, and intriguing content, improve learning effectiveness and efficiency fun and enhancement of spatial thinking abilities in line with geography education.

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