DEVELOPMENT OF GIS-BASED LEARNING MULTIMEDIA TO IMPROVE SPATIAL THINKING ABILITY OF SOCIAL STUDENTS IN HIGH SCHOOL

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ABSTRACT

Distance learning that occurred during the Covid-19 period caused problems. Learning geography, which should provide a good quality of spatial thinking, finally gets a problem. Multimedia learning is a representation tool needed in online learning. These conditions improve students' spatial thinking skills by applying Geographic Information Systems (GIS). The development of the learning multimedia uses a 4-D (Four-D) product development model consisting of the phases: define, design, development, and dissemination. Assessment parameter evaluation improves students' spatial thinking skills, considering comparing values between the experimental and control classes using the Independent Sample T-test = 0.05. The results of this study are that GIS-based learning multimedia is feasible to use with the validity test and trial being a score of 4 or is effectively used to improve students' spatial thinking skills with the result = 5,850 > T-table (2,035)

Keywords: Four-D Model; Multimedia learning; Spatial Thinking Ability

INTRODUCTION

The Covid-19 case in Indonesia entered in March 2020, causing activities that indicate large crowds must be abolished first, especially regarding education. Changes in learning strategies that were initially carried out more with face-to-face models and methods must eventually change to using several communication platforms that can provide convenience in learning. The development of online-based learning has been carried out and implemented before, but the Covid-19 pandemic accelerated the adoption of virtual learning. In addition to seeing the weaknesses and challenges that emerged from this incident, the Covid-19 pandemic has become an opportunity to encourage the development of online learning methods, opening opportunities for innovation, creating rethinking and discussion regarding the potential and function of physical buildings in education and administration (Stoller, 2020).

This condition eventually led to teachers' negative perceptions of online learning. It encouraged the idea that students had difficulty implementing distance learning, but what happened was that students viewed distance learning more positively than teachers (Yau et al., 2022). This positive view of distance learning is due to confidence in using learning media, which is driven by several factors, such as intrinsic motivation, parental support, and self-efficacy (Zhao et al., 2022). The convenience of learning is a need for students at this time, and this experience has been obtained through a system in learning media that has been designed using learning content (Yuan et al., 2021). Learning at this time is also not enough to only focus on the teacher to gain knowledge; a tool is needed to provide efficiency and effectiveness in the learning process (Chen & Tsai, 2021). Using multimedia as an intermediary in online learning can improve student learning performance because the learning media developed is made in the form of a system consisting of various kinds of media in it. This technology can encourage creativity and expand students' cognitive functions (Jahnke & Liebscher, 2020). Ultimately, the Covid-19 crisis resulted in a change in pedagogy from a traditional approach to a modern approach to teaching-learning, which encouraged rethinking to change and redesign existing education (Mishra et al.,2020).

Geography is related to the ability to think spatially and often experiences problems due to these conditions. Learning is often a knowledge transfer and cannot help students develop spatial thinking skills. Lack of habituation of critical and systematic thinking makes students give conclusions directly without selecting information. Even though this ability is future-oriented learning that can prepare students to face uncertain conditions (Leal et al., 2016), the ability to think spatially has encouraged individuals to model the real world, construct problems, and communicate solutions. (Metoyer et al., 2015). The ability to think spatial consists of cognitive skills, which consist of knowledge of spatial concepts, representational tools, and reasoning processes (National Research Association, 2006; Lee & Bednarz, 2012). Research conducted by Jo & Bednarz (2009) shaped spatial thinking skills into a taxonomy of spatial thinking skills, which includes concepts, cognitive processes, and representations (**Figure 1**).
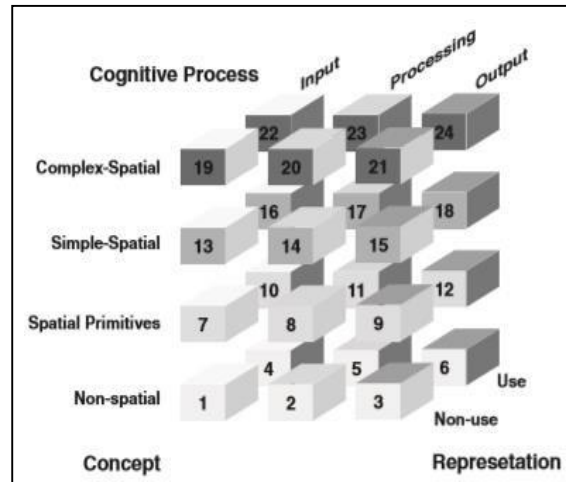
Figure 1. Spatial Thinking Ability Taxonomy
Source: Jo & Bednarz, 2009

Mapping basic knowledge material becomes learning that can apply spatial thinking skills. These conditions encourage teachers to use learning strategies by integrating spatial thinking and geospatial technology to support better learning (Bednarz & Bednarz, 2008). The use of technology in the form of geographic information systems in this material allows the use of inquiry-based learning strategies and critical thinking that can improve students' spatial thinking skills (Jo et al., 2016). Unfortunately, the ability that should be a fundamental skill in geography has problems in the learning process. The condition of teaching resources is good, from the ability to carry out learning, the need for lesson preparation time, the condition of school infrastructure facilities, to the special syllabus in learning, which hinders learning (Singh et al., 2012). The lack of adequate representation tools, such as hardware and software, in GIS is inseparable from the constraints (Mkhongi & Musakwa, 2020). Seeing the needs of these problems, learning by improving spatial thinking skills is still needed because its usefulness can encourage the formation of higher-level thinking in students. The use of online learning media is one of the solutions that can be offered when the conditions of the Covid-19 pandemic continue and affect learning because of their effective and efficient nature in providing convenience to users. GIS-based Learning Multimedia can be used as a learning medium to encourage students to have spatial thinking skills to form skills in identifying phenomena and solving problems (Istifarida et al., 2017).

MATERIALS AND METHODS

Research and development methods are carried out using a 4-D model developed by Thiagarajan et al. (1974). The process is systematic and oriented towards learning multimedia products that will be developed, making the Four-D model can be used to determine the needs of students' learning media. This model consists of four development stages: the definition stage, the design stage, the development stage, and the dissemination stage.

The sample used in this study were students in class the first grade of social science at Senior High School 2 Karanganyar. The first stage is to identify the condition of the students through a needs analysis which consists of the learning competencies used, background experience, general attitudes towards learning topics, learning media, and language preferences. The activity aims to collect data on gaps in learning activities in class so that it is possible to develop a product. Data collection uses a needs analysis instrument consisting of initial knowledge and skills variables, learning experience variables, and learning media needs variabels (**Figure 2**).
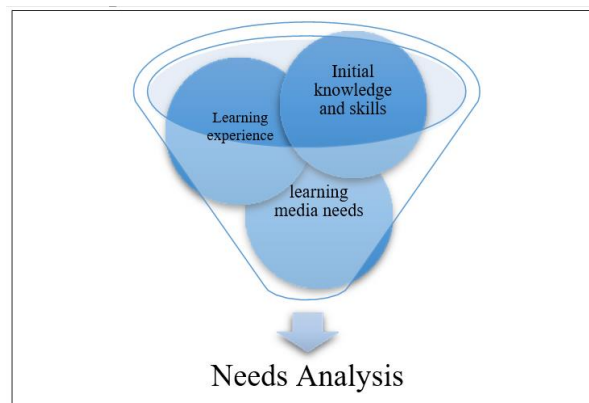
Figure 2. Variable Needs Analysis

The second stage, creating learning multimedia designs, is carried out by determining the format of learning media based on learning materials. Activities consist of designing learning multimedia content, choosing learning strategies, and determining learning resources. This step refers to the Learning Implementation Plan, which is for the first grade of social science, besides that

the media content also pays attention to the concepts and indicators developed by Jo & Bednarz (2009), the National Research Association (2006) and the model developed by the Association of American Geographers (2008). Then make modifications to produce an initial picture of learning multimedia based on GIS through flowcharts and storyboards.

Table 1. Content of Learning Multimedia

No	Category	Variabel
1.	Spatial Concept Knowledge	a. Basic Spatial Concept
		b. Simple Spatial Concept
		c. Complex Spatial Concept
2.	Use of Representational Tools	a. Use of Representational Tools (Maps/diagrams/graphs)
3.	Cognitive Process	a. Input level
		b. Processing
		c. Output level

Source: National Research Association, (2006); Jo & Bednarz, (2009); Scholz et al., (2014)

During the development stage, the product is created based on the initial design from the previous stage. This stage aims to produce a final GIS-based learning multimedia product draft. Experts evaluated the design to ensure its quality and effectiveness before it was finalized. The assessment process used an open questionnaire that considered the feasibility of the material's content, the presentation's eligibility, and the media's eligibility. (McAlpine & Weston, 1994; Conrad, 2000), while the percentage calculation of the validation score was carried out using the Likert scale. The questionnaire was filled in with five alternative answers with a score of 1, 2, 3, 4, and 5 (Harvey, 1998). The product that has been validated is then tested and limited to a small group of first-grade social science students.

The last activity is the Dissemination stage by conducting a final assessment in the form of validity testing. Testing the effectiveness of this learning multimedia product was carried out using control and experimental classes. The effectiveness test was carried out using the Independent sample T-test with a significance level of $\alpha = 0.05$ to compare the post-test results between the experimental and control classes. The comparison class is used as an

assessment measure to know the results of using GIS-based learning multimedia to improve spatial thinking skills. The objective tests were given before and after treatment to samples in the control class and experimental class.

RESULTS AND DISCUSSION

Integrating technology into education is essential to engage individuals in cognitive processes and enhance their cognitive abilities, thus boosting creativity (Jahnke & Liebscher, 2020).

The analysis results on initial knowledge and skills variables explained that 47% of students realized spatial thinking skills were needed in geography learning. These

Incorporating GIS-based multimedia in distance learning is expected to help students carry out distance learning by reducing distractions and technical issues and ensuring a seamless learning experience.

1. Student needs for GIS-based Learning Multimedia

Learning media needs of students are identified through needs analysis in the definition stage of the 4-D (four-D) development model. Knowledge and Skills Analysis shown in **Table 2.**

Table 2. Knowledge and Skills Analysis

Indicator	Assessment	Answer	Percentage Answers
Basic understanding of learning materials (spatial thinking skills)	Need to learn about the concept of improving spatial thinking skills	Sometimes aware of the need for spatial thinking skills	47%
	Difficulty understanding geography material	Yes, including material that is difficult to understand: . Basic Concepts of Geography . Geographical Aspects . Identify problems with formal objects and material objects	60%
	Students' Understanding of Maps	Students can make basic maps	42%
	Student understanding of Geographic Data-based Applications	Students are accustomed to using digital-based maps (gmaps/waze/etc)	50%

Source: Primary Data, 2021

Needs were related to some material that students still needed help learning. There are basic concepts of geography, and aspects of geography, to analyze a problem

using 'formal objects' and geographic material objects. Even so, understanding the use of maps and geographic data as a basis for understanding spatial thinking skills

is in a good category. Analysis of the learning experience.

Learning activities is 2-3 hours per day. Even so, 75% of students answered 'rarely' using learning applications in learning during the Covid-19 period. This condition is an opportunity to develop learning multimedia to meet the needs of students (**Table 3**).

Table 3. 'Learning Experience' Analysis

Indicator	Assessment	Answer	Percentage Answers
Learning style	Learning style	Visual	53%
Experience using 'learning media'	The time needed to study via the internet in one day	2-3 hours	39%
	Time to use social media in one day	2-3 hours	25%
	Use of online learning applications	No	75%

Source: Primary Data, 2021

Learning Media Needs Analysis can be seen in **Table 4**. The results of the analysis show that students need learning media in the form of videos/ images/ audio on a particular was carried out on the learning styles of students in general and the experience of using learning media in the form of smartphone usage habits. The analysis results explain that students' learning styles are dominated by visual learning styles, with a percentage of 53%. The use of smartphones in social media and learning activities is 2-3 hours per day. Even so, 75% of students answered 'rarely' using learning applications in learning during the Covid-19 period. This condition is an opportunity to develop learning multimedia to meet the needs of students.

System by providing much material in the form of illustrations; this is because students find it easier to understand lessons through pictures, flowcharts, and posters. This condition results from students' learning styles being dominated by visual learning styles. The habit of students looking for material or answers via the internet, with a percentage of 39%, requires learning media integrated with the internet network. Learning interactions still use the video conferencing platform to facilitate learning; this is still having problems because the internet network is not good, which ultimately reduces students' effectiveness and learning motivation. The difficulty of accessibility to the internet significantly influences students'

self-efficacy in utilizing learning media during online learning; constraints on internet networks can encourage negative perceptions of using online learning media (Yuan et al., 2021; Zhao et al., 2022).

Learning Media Needs Analysis is also done by determining the required learning multimedia visualization, including the type of font, the size of the letters, colors, and writing content. Even though the determination of color is returned to the maker of learning media products, this determination must still pay attention to the terms and conditions to fit the purpose (Nugroho, 2008). Using language adapted to student conditions can also improve students' interest and attention to the learning provided (Wegener, 2022).

2. Design of GIS-based Learning Multimedia to Improve Spatial Thinking Skills

The design of GIS-based learning multimedia is made in the form of flowcharts and storyboards first. Activities in the product are divided into four sections, including 1) Main Page Section; 2) Module Section; 3) Material Section; and 4) Educational Games Section. The use of the variables contained in Table 1 is carried out in the Materials and educational games section. This section divides the basic competencies into four sub-materials, including basic knowledge of mapping, remote sensing, image interpretation, and geographic information systems. Variable The concept of space is used in the material contained in learning multimedia.
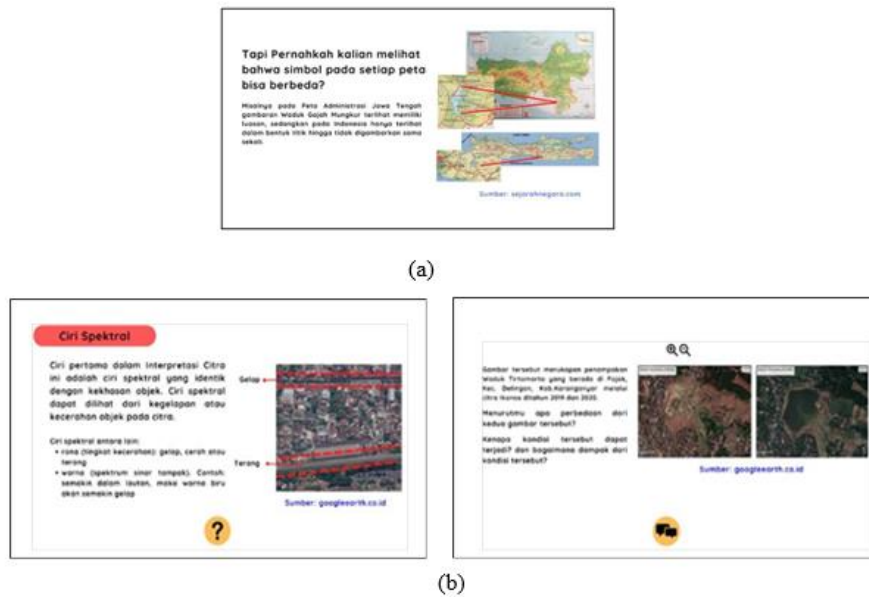
a. Basic Spatial Concept

Material development is carried out by discussing basic knowledge of mapping and understanding geographical features and orientation. Cognitive processes are mainly carried out in the apperception section or practice questions.

b. Simple Spatial Concept

Lessons are developed into several indicators, including understanding the components of image interpretation, the influence of one place on another, and understanding spatial information. As with simple spatial concepts, cognitive processes are also more in discussing questions (**Figure 3**).

(a)

(b)

Figure 3. (a) Lesson for Basic Knowledge of Maps, (b) lesson with Simple Spatial Concept

c. Complex Spatial Concept

This concept pays attention to several indicators, including Performing 3D visualization, comparing map information and non-map information, and understanding data fusion (overlay); for indicators of using representational tools, the material is provided outside of multimedia so that to access students are required to press specific tools (**Figure 4**).
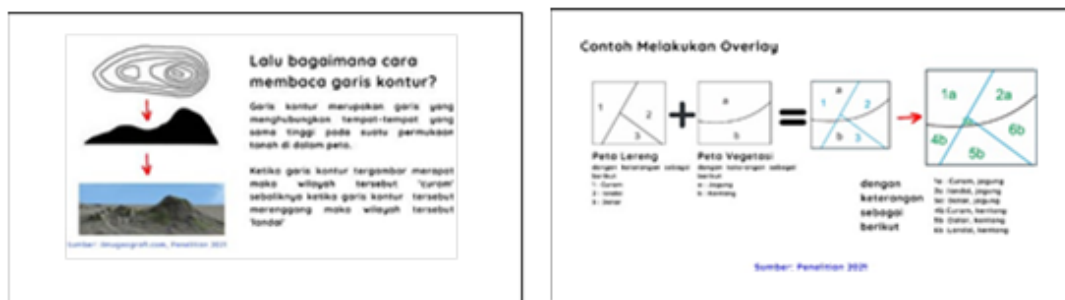
Figure 4. Lesson for Complex Spatial Concepts

3. Feasibility of GIS-based Learning Multimedia to Improve Spatial Thinking Ability

The feasibility of learning multimedia consists of validity testing by material experts and media experts by assessing the content of

the material, learning design, competence in spatial thinking skills, and the appearance of the learning multimedia that has been developed. Small group tests are conducted to get suggestions the cause-effect relationship and should be supported by a theoretical framework. There is a link between the results obtained and the basic concepts; "what else?" compare the results of your research with other research, suggested to provide implications for theoretical and applied research results (**Table 4**).

Table 4. Validation Test Results

No	Validation Test Phase	Mode
1.	Validation Test Results by Material Experts	5
2.	Validation Test Results by Media Experts	4
3.	Small Group Test	4
4.	Field Test (Large group test)	4

Source: Data Processing Research, 2021

From the **Table 4**, it is explained that the validation test results are dominated by the mode value, which is 4; this explains that the assessment of learning multimedia is good and falls into the proper category with several revisions. The obstacle occurs during the installation or use of learning multimedia due to differences in the series and screen resolution of the Smartphone used.

4. Effectiveness of GIS-based Learning Multimedia to Improve Spatial Thinking Skills

Product effectiveness comes from validity tests on GIS-based learning multimedia products. The assessment uses the control class and the experimental class from the sample (**Figure 5**).
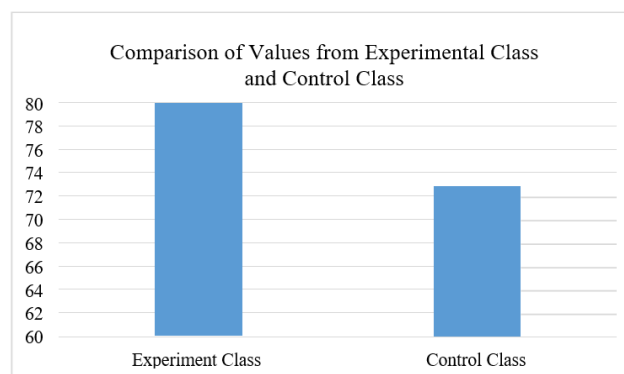
Figure 5. Comparison of Values from Experimental Class and Control Class

The post-test results explained that the most significant improvement was in the experimental class using GIS-based learning multimedia, with an average score of 82. In contrast, the control class got an average score of 73. This condition explains that GIS-based learning multimedia improves thinking skills spatially compared to students who do not use the learning multimedia. The assessment results by paying attention to spatial knowledge also show an improvement from the pre-test to the post-test results. The number of questions that students can answer occurs in the experimental class, with the percentage of Basic Spatial Concepts being 81% and Complex Spatial Concepts at 83%; even so, Simple Spatial Concepts can be answered more by students in the control class with a percentage of 74% compared to with experimental class.

The effectiveness assessment of GIS-based learning multimedia used the Independent Samples T-Test with a significance level of $\alpha = 0.05$, with the result being Sig. (2-tailed) = 0.00 <0.05, explaining that there is a difference in the average learning outcomes of students in using GIS-based learning multimedia, while the results of T-count = 5.850 > T-table (2.035) explain that there is a significant difference between students who use GIS-based learning multimedia and those who do not use the learning multimedia. So, in other words, GIS-based learning multimedia is effective in improving students' spatial thinking skills. These learning multimedia has lessons in the form of exercises based on goals and indicators of spatial thinking ability, and this is an advantage in learning multimedia products that have been developed.

CONCLUSIONS

GIS-based learning multimedia developed with a 4-D (Four-D) can meet the learning needs of students by improving spatial thinking skills. The analysis formulated the required learning objectives, indicators, concepts, and multimedia learning formats. The assessment of learning multimedia stated that it was feasible with a score of 4 or was in a good category with several revisions.-based learning multimedia is GIS effective for improving students' spatial thinking skills. The Independent

Samples T-Test results with a significance level of = 0.05 are Sig. (2-tailed) = 0.00 < 0.05 with the result of T-count = 5.850 > T-table (2.035). The improvement in the score between the pre-test and post-test in the experimental class was 17%, while the control class was 7%.

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