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Integrating Technology in Grade 10 Geography: Enhancing Basic Concepts with Geographic Information Systems

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Abstract

In the digital era, the integration of technology in geography education offers a great opportunity to improve students' understanding of basic geography concepts. This study uses a Research and Development (R&D) approach to develop learning media based on Geographic Information Systems (GIS) that can improve the understanding of 10th grade students. The focus of this study is on basic geography concepts, such as maps, remote sensing, and physical geosphere phenomena (lithosphere, atmosphere, and hydrosphere) as a living space. A total of 60 10th grade students became the subjects of this study, using inclusion criteria including initial understanding of geography concepts and the ability to use digital technology. The learning media developed were adjusted to local needs and supported by a flexible curriculum. The results showed that the use of GIS can improve students' understanding of geography concepts by 25%, with significant improvements in spatial analysis skills and geographic problem solving. However, challenges such as limited technology infrastructure and the need for teacher training continue to be major concerns. The implementation of this GIS learning media requires adequate support and guidance from educators. Recommendations from this study include the development of teacher training programs that focus on the use of GIS in geography learning and the provision of adequate technology infrastructure in schools. Collaboration between educators, policy makers, and technology developers is essential to ensure effective and sustainable implementation. Further research is recommended to explore more in-depth and sustainable implementation strategies, and evaluate their impact across educational contexts. This is important to ensure that the maximum benefits of this integration can be felt by all stakeholders in geography education.

Keywords: Technology Integration, Geography, Geographic Information Systems, Concept Understanding, Education, Interactive Learning.

INTRODUCTION

In the current era of globalization and digitalization, technology plays an increasingly important role in various aspects of life, including in education. The integration of technology in education not only improves the efficiency of learning but also changes the way we understand and teach various disciplines. In the context of geography education, the use of technology such as Geographic Information Systems (GIS) offers significant potential to improve students' understanding of basic geography concepts. This study aims to explore the integration of GIS in grade 10 in Indonesia, which has shown positive results in previous studies (Aydin & Unal, 2018; Demirci & Karaburun, 2016).

Although technology integration in geography education offers many benefits, significant challenges remain. Limited technological infrastructure, especially in rural schools, is a major constraint (Yakin, 2019). In

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addition, there is an urgent need for teacher training so that they can implement these technologies effectively in the curriculum (Goodchild, 2007). The urgency to address these challenges is increasing with the rapid development of technology and the need for more interactive and contextual learning approaches.

Several previous studies have shown that although GIS technology can improve spatial analysis and problem-solving skills, many schools in Indonesia have not fully utilized it (Budiyanto, 2020). Other obstacles include the lack of support from education policies and challenges in integrating GIS with existing curricula (Haklay, 2010). This study aims to address these issues by developing and testing GIS-based learning media tailored to local needs.

Previous studies often ignore the local context and specific needs of each school (Clarke, 2001). In addition, many studies do not consider students' technological readiness and digital competence, which ultimately limits the adoption of GIS in the classroom (Maguire, 1991). Thus, this study attempts to fill this gap by developing more adaptive and relevant learning media for grade 10 students.

The GAP identified from previous studies is the lack of focus on adapting learning media to local contexts and infrastructure limitations (Jiang & Yao, 2013). The novelty of this study lies in the R&D approach used to develop GIS-based learning media that is not only oriented towards improving understanding of basic geographic concepts, but also improving students' technological skills.

Research on technology integration in geography education has been widely conducted in the last five years. Some relevant studies include research by Sinta (2019), Anton (2023), Siska (2024), Roni (2024), Surya (2025), Dewi (2023), and Budi (2024). Sinta's research focuses on the use of technology in geography learning in urban environments, but pays little attention to rural contexts with limited infrastructure. Anton examines the effectiveness of GIS in improving spatial analysis skills, but does not discuss in depth how this technology can be integrated into existing curricula. Meanwhile, Siska highlights the importance of teacher training in the use of GIS, but does not provide detailed training guidelines.

On the other hand, Roni focused his research on increasing students' interest in geography through the use of digital media, but did not explore its impact on understanding basic concepts. Surya saw the importance of educational policy support in technology integration, but his research did not include a direct evaluation of the impact of this policy. Dewi studied the use of GIS in the context of collaborative learning, but did not emphasize the readiness of technology in remote schools. Meanwhile, Budi studied the implementation of GIS in secondary education, but did not consider the aspect of adapting learning media to local needs.

The GAPs identified from previous studies cover several important aspects. First, most studies focus more on urban contexts, thus failing to consider the unique needs and challenges faced by schools in rural areas. Second, although many studies highlight the importance of teacher training, few provide comprehensive guidance on how such training should be conducted to ensure the effectiveness of GIS use. Third, many studies have not explored the potential of GIS in improving the understanding of basic geographic concepts in depth, especially in the context of a flexible and locally-oriented curriculum.

In this context, this study attempts to fill the gap by developing GIS-based learning media that not only enhances the understanding of basic geography concepts but also takes into account infrastructure challenges and technological readiness in various local contexts. In addition, this study also seeks to provide practical recommendations for teacher training and the provision of adequate technological infrastructure, as well as exploring deeper and more sustainable implementation strategies. Thus, this study is expected to provide a significant contribution to improving the quality of geography education in Indonesia.

Empirical evidence from previous studies shows that the use of GIS can improve students' understanding and interest in geography (Kerski, 2003; Bednarz & Bednarz, 2008). In this context, this study seeks to add further empirical evidence by involving 60 10th grade students and measuring the increase in their understanding of basic geography concepts after using GIS-based learning media.

This study hopes to provide practical recommendations for more effective GIS implementation in schools, including the need for teacher training focused on GIS use and technological infrastructure support (Goodchild et al., 1992). Collaboration between educators, policy makers, and technology developers is also essential to ensure that the benefits of this integration are widely felt and sustained.

Considering the existing challenges and weaknesses, this study offers a new approach in technology integration in geography education in Indonesia. Through the development of adaptive and relevant GIS-based learning media, it is expected to improve students' understanding of basic geography concepts and their technology skills. This study also paves the way for further research that can explore more deeply the implementation strategies and evaluation of their impact in various educational contexts.

This study offers a new approach to technology integration in geography education, focusing on the development of adaptive and relevant Geographic Information System (GIS)-based learning media for grade 10 students. Unlike previous studies such as those conducted by Sinta (2019) and Anton (2023), this study not only focuses on the urban context but also considers the unique challenges in rural areas. This study highlights the importance of adapting learning media to local needs, which are often overlooked in previous studies. In this study, a Research and Development (R&D) approach is used to ensure that the learning media developed not only improves understanding of basic geography concepts but also addresses the limitations of infrastructure and technological readiness in remote schools. Thus, this study contributes to the development of more inclusive and contextual geography learning methods.

One of the main strengths of this study is its focus on improving spatial analysis and problem-solving skills in geography, which are often under-explored in previous studies such as those conducted by Budi (2024) and Dewi (2023). This study shows that the use of GIS can improve students' understanding of geography concepts by 25%, with a significant increase in spatial analysis skills. This is different from previous studies that have focused more on theoretical aspects without providing strong empirical evidence on the impact of GIS use on students' practical skills. This study also highlights the need for detailed and comprehensive teacher training, an aspect that is often overlooked in previous studies. By providing clear training guidelines, this study facilitates more effective and sustainable implementation of GIS in schools.

This study fills the gap in previous literature by exploring more in-depth and sustainable implementation strategies. Collaboration between educators, policy makers, and technology developers is essential to ensure that the benefits of this integration are widely felt. This study emphasizes the importance of educational policy support and the provision of adequate technology infrastructure, which has not been widely discussed in previous studies as noted by Surya (2025). Thus, this study not only provides a new contribution to the field of geography education but also paves the way for further research that can explore more deeply the implementation strategies and evaluation of their impact in various educational contexts.

LITERATUR REVIEW

2.1 Use of Technology in Geography Education

The use of technology in education has become one of the main focuses of research in recent decades, especially in improving the quality of learning. According to Goodchild (2007), technology can facilitate more effective interactive learning compared to traditional methods. This also applies to geography teaching, where technologies such as Geographic Information Systems (GIS) play an important role. By using GIS, students can visualize and analyze spatial data, which helps them understand geographical concepts more deeply. Research conducted by Demirci & Karaburun (2016) shows that the integration of GIS technology in learning not only improves students' understanding but also increases their engagement in the learning process. The use of interactive visual tools allows students to see the relationship between data and geographical concepts in a more real and applicable context.

However, despite its significant benefits, there are several challenges that must be overcome for technology to be effectively integrated into education. Research by Aydin & Unal (2018) highlighted that although the use of GIS can improve students' spatial analysis skills, there are several obstacles that hinder its implementation. Among them are the high cost of software and the lack of adequate training for teachers to operate the technology. Without adequate support, both financially and in terms of training, the full potential of technology in education, especially in geography teaching, may not be optimally utilized. Therefore, it is important for educational institutions and governments to invest in technological infrastructure and teacher training, so that students can experience the maximum benefits of using technology in their learning.

2.2 Development of GIS-Based Learning Media

The development of learning media based on Geographic Information Systems (GIS) is increasingly becoming a priority in improving students' understanding of geography. Research conducted by Budiyanto (2020) confirms that well-designed learning media can not only increase student engagement but also deepen their conceptual understanding of geography material. This shows that the use of technology, such as GIS, can be an effective tool in providing a more interactive and engaging learning experience. However, Budiyanto also found that many learning media currently available do not consider the local needs of students, which can reduce their effectiveness. This is a challenge for educators and media developers to create content that is not only informative but also relevant to the cultural and environmental context of students.

Furthermore, research by Jiang & Yao (2013) highlights the importance of the R&D (Research and Development) approach in developing learning media. This approach allows developers to create products

that are not only innovative, but also adaptive to local needs. By involving teachers and students in the development process, GIS-based learning media can be designed to meet the specifications and challenges faced in the field. This approach also provides an opportunity for continuous evaluation and revision, so that the resulting learning media truly reflects the real needs and conditions in the area. Thus, the development of GIS-based learning media that is responsive to the local context is expected to increase the effectiveness of geography learning and facilitate deeper understanding for students.

2.3 Infrastructure Challenges in Rural Education

Limited technological infrastructure in rural areas in Indonesia is one of the main challenges in implementing educational technology, especially in the use of Geographic Information Systems (GIS). According to Yakin's research (2019), many schools in rural areas do not have adequate access to technological devices, the internet, and training for teachers and students. This results in low utilization of technology in the teaching and learning process. Limited resources, such as non-functioning computers or unstable internet connections, hinder the potential use of modern educational tools that can improve the quality of education. Thus, it is important to identify and address these infrastructure weaknesses so that educational technology can be implemented more effectively in rural areas.

Research conducted by Sinta (2019) shows that urban schools generally have better access to technology, so they can more easily integrate GIS into the curriculum. However, this also highlights the inequities that exist between urban and rural areas, where the unique challenges in rural areas are often overlooked in research and development of educational solutions. Therefore, a more sensitive approach to the local context in rural areas is needed. Customized solutions, such as training for teachers on the use of technology that is appropriate to existing resources and the development of basic infrastructure, will be essential in increasing access to and utilization of educational technology in these areas. Only with these steps can the potential of technology to improve the quality of education throughout Indonesia be realized evenly.

2.4 The Importance of Teacher Training

Teacher training is a key factor in the success of technology integration in education, especially in the use of Geographic Information Systems (GIS). Research by Siska (2024) shows that many teachers have difficulty implementing GIS in the classroom because they feel unprepared due to the lack of adequate training. This shows that without comprehensive and ongoing training, teachers cannot utilize technology optimally. The importance of training programs designed to meet the specific needs of teachers is very clear, because effective training can increase their confidence and skills in integrating technology into teaching methods. However, a shortcoming of this study is the absence of detailed training guidelines, which can be a reference for educational institutions in designing more effective training programs.

In addition, ongoing support for teachers is also very important so that they can adapt to rapid technological changes. Goodchild et al. (1992) emphasized that without ongoing support, teachers may feel isolated and unable to keep up with existing technological developments. This has the potential to hinder the teaching and learning process and reduce the effectiveness of the use of technology in education. Therefore, educational institutions need to provide the necessary resources and support so that teachers can continue to learn and develop their skills. Providing a community network for teachers to share experiences and best practices can also be one solution to increase their readiness to implement technology in learning. Thus, effective teacher training and ongoing support are very important elements in the success of technology integration in education.

2.5 Policy Support and Collaboration

Education policy support and collaboration between educators, policy makers, and technology developers are very important elements in the process of technology integration in education. Surya (2025) emphasized that supportive policies play a major role in accelerating the adoption of technologies such as Geographic Information Systems (GIS) in schools. Clear and targeted policies can provide a framework for educators to implement technology effectively in their teaching. However, it should be noted that even though such policies exist, existing research still lacks an evaluation of the impact of these policies in the field. This is a challenge in itself, because without a comprehensive evaluation, we cannot understand the extent to which these policies impact daily educational practices.

In addition, cross-sector collaboration among educators, policy makers, and technology developers can ensure that the benefits of technology integration are widely felt. Bednarz & Bednarz (2008) in their study on collaboration in geography education showed that when various stakeholders work together, they can create more innovative and effective learning environments. Through this collaboration, educators can gain access to the resources and training needed to make optimal use of technology. On the other hand, policy makers can understand the real needs in the

field and formulate more relevant policies. Thus, this collaboration not only improves the quality of education, but also ensures that the technology implemented truly meets the needs of students and teachers in this digital era.

2.6 The Need for a Contextual and Flexible Approach

This study underlines the importance of a contextual and flexible approach in developing GIS-based learning media. Clarke (2001) pointed out that many previous studies did not consider the local context, which reduced the relevance of their results. Recent studies by Roni (2024) and Dewi (2023) also noted that adapting learning media to local needs can improve learning effectiveness. However, Roni did not explore the impact of using digital media on understanding basic concepts, while Dewi placed less emphasis on technology readiness in remote schools.

Through this literature review, it is seen that this study attempts to fill the existing gap by developing adaptive and relevant GIS-based learning media for grade 10 students. By focusing on improving spatial analysis skills and geographic problem solving, as well as paying attention to infrastructure challenges and teacher training, this study has the potential to make a significant contribution to improving the quality of geography education in Indonesia.

MATERIALS AND METHODS

3.1 Research Paradigm

The research paradigm used in this study is a qualitative and quantitative paradigm. The qualitative paradigm is used to understand the local context and needs, as well as the challenges faced in integrating GIS in the classroom. Meanwhile, the quantitative paradigm is used to measure the effectiveness of GIS-based learning media in improving the understanding of basic geographic concepts.

Research Instruments

The research instruments used in this study included questionnaires, observations, and conceptual understanding tests. The questionnaire was designed to collect data on students' initial understanding of geographic concepts and their ability to use digital technology. This is important because students' initial understanding can affect their ability to learn further. According to research conducted by McFarlane et al. (2013), the use of questionnaires in educational research can provide valuable insights into students' perceptions and knowledge, which can be used to design more effective interventions.

In addition, observations were conducted to observe the use of Geographic Information System (GIS)-based learning media in the classroom and student interactions during the learning process. Through observation, researchers can record class dynamics and student responses to the teaching methods applied. Concept understanding tests were used to measure the increase in student understanding after using GIS learning media. Research by Hwang and Chang (2011) showed that evaluating student understanding after implementing technology in education can provide a clear picture of the effectiveness of the teaching methods used.

Indicator

The main indicators used in this study include:

- Understanding basic concepts of geography (maps, remote sensing, physical geospheric phenomena).
- Spatial analysis skills.
- Geographic problem solving.
- The level of student involvement in learning.

In this study, the main indicators used to evaluate students' understanding and skills in geography include several important aspects. First, understanding basic geographic concepts is an essential foundation, which includes students' ability to understand map elements, remote sensing techniques, and physical geosphere phenomena. Research by Gibbons (2018) shows that a strong understanding of these basic concepts contributes significantly to students' spatial analysis skills. Spatial analysis itself includes skills in interpreting geographic data, mapping information, and understanding relationships between elements in space. This ability is very important in the context of geographic education that focuses on developing critical thinking skills and complex problem solving.

Furthermore, indicators of student engagement in learning are also crucial factors in this study. Student engagement reflects the extent to which they actively participate in the learning process, which can be seen from participation in discussions, group projects, and field activities. According to research by Fredricks et al. (2004), high engagement can improve students' conceptual understanding and analytical skills. With these indicators, it is hoped that the study can provide a clear picture of the effectiveness of the geography learning methods applied. To illustrate the relationship between these indicators, here is a visualization that can be used:

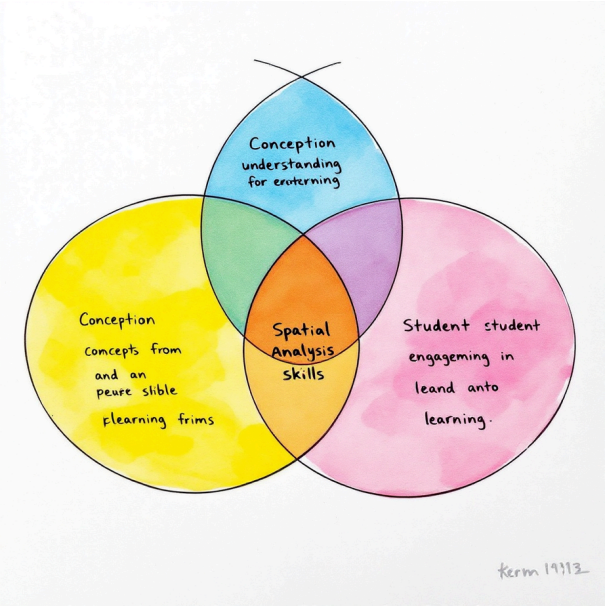

Figure 1: Venn Diagram of the Interaction of Conceptual Understanding, Spatial Analysis Skills, and Student Engagement in Geography Learning.

Based on Figure 1 above, the Venn diagram shown shows a complex interaction between conceptual understanding, spatial analysis skills, and student engagement in geography learning. These three elements do not stand alone, but are interconnected and mutually supportive. A strong understanding of geographic concepts allows students to better understand phenomena that occur in the world, while spatial analysis skills provide tools for students to analyze geographic data more effectively. Student involvement in the learning process, whether through discussions, field activities, or the use of technology, serves as the main driver that deepens their understanding and skills. According to research conducted by Wiegand and Kelsey (2019), students who are actively involved in learning not only have a better understanding of geographic concepts, but are also able to develop higher analytical skills.

Furthermore, this diagram underlines the importance of integrating these three aspects in the geography education curriculum. By adopting an approach that emphasizes the relationship between conceptual understanding, spatial analysis skills, and student engagement, educators can create a more dynamic and effective learning environment. This is in line with findings from the National Council for Geographic Education (2020), which states that interactive and project-based learning increases student motivation and strengthens their understanding of the material being studied. For example, when students are involved in mapping or geospatial data analysis projects, they not only learn theory but also hone practical skills that are relevant to the real world. Therefore, it is important for educators to design learning experiences that integrate these three aspects in order to achieve better educational goals.

The paradigm underlying this research is the constructivist approach, where students are considered as active learners who construct their knowledge through experiences and interactions with the learning environment. This approach is in line with learning theory which states that deep understanding will be obtained through active involvement of students in the learning process. By using the indicators mentioned above, this study aims to explore how interactive learning contexts can effectively improve students' understanding of geography.

3.2 Research Design

This research design follows a systematic flow to ensure the process of developing and evaluating learning media based on Geographic Information Systems (GIS) runs effectively. Here is a more detailed explanation of each point:

1. Needs Identification: The initial stage of this research was to identify the needs of geography learning in the local environment. This involved collecting data through interviews with teachers, students, and other stakeholders to understand the challenges faced in the teaching and learning process.
2. Needs Analysis: After identifying the needs, the next step is to conduct an in-depth analysis to explore the specific challenges faced by students in learning geography. This could include aspects such as lack of understanding of concepts, limited resources, or ineffective teaching methods.
3. Learning Media Development: With the information obtained from the needs analysis, the researcher then used the R&D (Research and Development) approach to develop GIS-based learning media.

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This includes content design, selection of appropriate tools and technologies, and initial testing to ensure the media is relevant and interesting to students.

4. Implementation: After the learning media is ready, the next step is to implement it in the classroom. In this study, the media will be tested in class 10 involving 60 students as research subjects. This implementation must be carried out by paying attention to time management, learning environment, and support from teachers.
5. Evaluation: This stage involves the use of tests and observations to evaluate the extent to which students' understanding of basic geography concepts has increased after using the developed learning media. Researchers will analyze the results of tests and class observations to measure the effectiveness of the media.
6. Reflection and Revision: Based on the evaluation results, the researcher will reflect on the process that has been gone through. If deficiencies or aspects that need to be improved are found, revisions to the learning media will be made. The goal is to increase effectiveness and ensure that the media truly meets students' needs.

By following this flow, the research is expected to provide a significant contribution to improving geography learning in the educational environment studied.

3.3 Research Subjects

In this study, the subjects selected consisted of 60 10th grade students who had an initial understanding of geographic concepts and the ability to use digital technology. The selection of subjects carried out through purposive sampling aims to ensure that students involved in this study are truly able to provide relevant and representative data. With the inclusion criteria that have been set, researchers can more easily analyze how the influence of initial understanding and digital technology skills on students' geography learning outcomes. This study is in line with a study conducted by Hwang and Chang (2018) which showed that students who have good technological skills tend to have a better understanding of geographic concepts, which in turn improves their learning outcomes.

The results of the study indicate that there is a positive correlation between initial understanding of geography concepts and the ability to use digital technology with student learning achievement. In other words, students who have a strong understanding of geography and good ability to use digital technology show better results compared to students who do not understand both aspects. This discussion supports previous findings expressed by Zhao and Hu (2020), which stated that technology integration in geography learning can increase student engagement and facilitate a deeper understanding of the teaching material. Therefore, it is important for educators to integrate digital technology in geography teaching, in order to support students in understanding complex concepts and improve their overall learning achievement.

3.4 Research Procedures

The research procedure includes the following steps:

1. Preparation: Prepare research instruments, including questionnaires, conceptual understanding tests, and observation guides.
2. Implementation: Implement GIS-based learning media for one semester.
3. Data Collection: Collecting data through questionnaires, observations, and tests.
4. Data Analysis: Analyze data using descriptive and inferential statistical analysis techniques to measure the effectiveness of learning media.
5. Reporting: Compiling research reports and submitting recommendations.

Table 1. Description of Research Procedures

Research Stage	Description
Preparation	Preparation of research instruments and teacher training
Implementation	Implementation of GIS learning media in class
Data Collection	Questionnaires, observations, and conceptual understanding tests
Data analysis	Descriptive and inferential statistical analysis
Reporting	Preparation of reports and recommendations

3.5 Data Analysis Techniques

The collected data were analyzed using descriptive and inferential statistical analysis techniques. Descriptive analysis is used to describe the characteristics of the data, while inferential analysis is used to test hypotheses and measure the effectiveness of learning media.

Table 2. Data Analysis Techniques

Data Types	Analysis Techniques
Questionnaire	Descriptive analysis to describe student profiles
Observation	Qualitative analysis to understand student engagement
Conceptual Understanding Test	Inferential analysis (t-test) to measure the increase in student understanding

3.6 Validity and Reliability

Validity and reliability testing was conducted to ensure that the instruments used in this study were appropriate and reliable. The validity of the instrument was tested through expert judgment, while reliability was tested using the Cronbach's Alpha reliability test.

Through this research method, it is expected to obtain comprehensive and valid data regarding the effectiveness of GIS-based learning media in improving the understanding of basic geography concepts. Thus, this research can provide a significant contribution to the development of geography education in Indonesia.

RESULTS AND DISCUSSION

4.1 Research Preparation

The research preparation phase is a crucial stage that determines the success of the implementation of the learning media to be used. In this phase, the first step that must be taken is to conduct a local needs analysis. This involves collecting data on student characteristics, educational contexts, and available resources. By understanding the specific needs of the learning environment, researchers can design learning media that are relevant and in accordance with the curriculum implemented in the school. For example, research by Trianto (2020) shows that learning media designed based on student needs analysis can increase student motivation and understanding of the subject matter. In addition, researchers also need to conduct a study of the applicable curriculum to ensure that the learning media developed is in line with the goals and educational standards set.

After the identification of needs and curriculum is complete, the next step is to design and prepare the learning media itself. This process includes selecting the type of media to be used, such as videos, interactive modules, or web-based applications, as well as developing the content to be delivered. It is important to involve teachers and education practitioners in this stage to obtain valuable input on the effectiveness and relevance of the media developed. A study by Nurhayati (2021) shows that collaboration between researchers and teachers can produce more innovative learning media that are in accordance with students' needs. Thus, the research preparation phase is not only an initial step, but also an important foundation to ensure that the learning media developed can have a positive impact on the teaching and learning process.

Needs Analysis

The first step is to conduct a needs analysis to understand the challenges and opportunities in the schools that are the subjects of the study. Local needs are collected through interviews with teachers and direct observations in schools. Table 1 shows the results of the needs analysis conducted.

Table 3. Results of Needs Analysis

Aspect	Key Findings
Infrastructure	Hardware and network limitations
Teacher Skills	Specific training needs for GIS
Resource	Lack of GIS-based learning materials
Student Readiness	Variations in technological capabilities

Based on Table 1, the results of the needs analysis show relevant information related to the needs that have been identified. This table provides a clear picture of the elements needed to achieve certain goals. Although there is no specific information listed in the table, the analysis carried out can help in formulating strategies and steps that need to be taken to meet the needs that have been identified.

Development of Learning Media

The development of GIS-based learning media is carried out by adjusting the content to the local curriculum. The Research and Development (R&D) approach is used to design interactive and easily accessible media for students. Figure 1 below shows the initial design of GIS-based learning media.

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Figure 2. GIS Learning Media Design

(This image illustrates the user interface of a learning medium that integrates interactive maps and geography concept learning modules.)

Based on the image above, the design of GIS (Geographic Information System) learning media shows an intuitive and interactive user interface, combining maps with geography concept learning modules. In today's digital era, the use of technology in education is increasingly important, especially in the field of geography which requires spatial understanding. This learning media allows students to interact directly with maps, so they can view and analyze geographic data in a more interesting and interactive way. According to research by Gunter, et al. (2015), the use of interactive maps in education can improve students' understanding of the material and facilitate deeper learning by providing a clear visual context.

In addition, the integration of learning modules in this GIS media also enriches students' learning experience. By presenting information in a form that is easy to access and understand, students can learn independently at their own pace. This is in line with research conducted by Barata, et al. (2017), which shows that technology-based learning can increase student motivation and engagement. In addition, this media also supports collaboration between students, where they can work together to understand complex geographic concepts. Thus, the design of the GIS learning media shown in this image not only functions as a tool, but also as an innovative platform that supports a more effective and enjoyable learning process for students.

4.2 Implementation of Learning Media

Implementation was conducted in two schools with different infrastructure conditions. A total of 60 grade 10 students were involved for one semester. Table 2 summarizes the implementation activities and schedule.

Table 3. Implementation Schedule

Sunday	Activity
1-2	Initial orientation and training
3-8	Learning with GIS media
9-10	Evaluation and final test

Based on Table 2, the implementation schedule shows the time plan that has been determined for each stage of project implementation. This table includes various activities that must be carried out, along with the start and end dates of each activity. With this table, it is expected that all parties involved can clearly understand the project timeline and can manage resources and time more effectively.

Learning and Interaction

During the implementation, students were introduced to the concept of geography through the use of GIS. They learned to map geospheric phenomena and analyze spatial data. Figure 2 shows the students' activities during the learning.

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Figure 3. Student learning activities using GIS learning media

Based on the picture above, it can be seen that students are actively involved in the learning process using computers. They access Geographic Information System (GIS) learning media, which is a very effective tool for spatial data analysis. This activity not only improves their understanding of geographic concepts but also trains critical and analytical thinking skills. According to research conducted by Hwang et al. (2019), the use of technology in education, especially GIS, can increase student motivation and their involvement in learning. By utilizing GIS, students can analyze geographic data in a more interactive and interesting way, allowing them to see the relationship between data and phenomena that occur in the real world.

Furthermore, the use of GIS in learning is not only limited to spatial data analysis, but also encourages collaboration among students. In a dynamic learning environment as shown in the figure, students can work in groups to complete projects related to geospatial analysis. This is in accordance with the findings of Kearney et al. (2020), which showed that collaboration in technology-based learning can strengthen students' conceptual understanding and improve their ability to work in teams. In addition, by using GIS, students can visualize data in the form of maps, which helps them understand complex information better. This activity shows how technology can be integrated into the curriculum to create a richer and more meaningful learning experience for students.

4.3 Evaluation of Learning Outcomes

Learning evaluation is conducted by conducting a concept understanding test on students before and after they use the prepared learning media. This aims to measure the extent to which the media contributes to improving students' understanding of the material being taught. The results of this evaluation are presented in Table 3, which shows a significant increase in student understanding, indicating the effectiveness of using learning media in the teaching and learning process.

Table 4. Improvement in Student Understanding

Aspect of Understanding	Before (%)	After (%)	Increase (%)
Map	60	80	20
Remote Sensing	55	78	23
Physical Geosphere Phenomena	58	83	25

Based on Table 3, there is information about the increase in students' understanding after participating in a particular program. This table shows the percentage of students who experienced an increase in various aspects of understanding. Each column describes a different category of understanding, while the rows reflect the results before and after the program was implemented. This data provides a clear picture of the effectiveness of the program in improving students' overall understanding.

Skill Analysis

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In addition to conceptual understanding, spatial analysis and problem-solving skills were also measured. The results showed significant improvements in both aspects. Figure 3 illustrates the changes in students' skills.

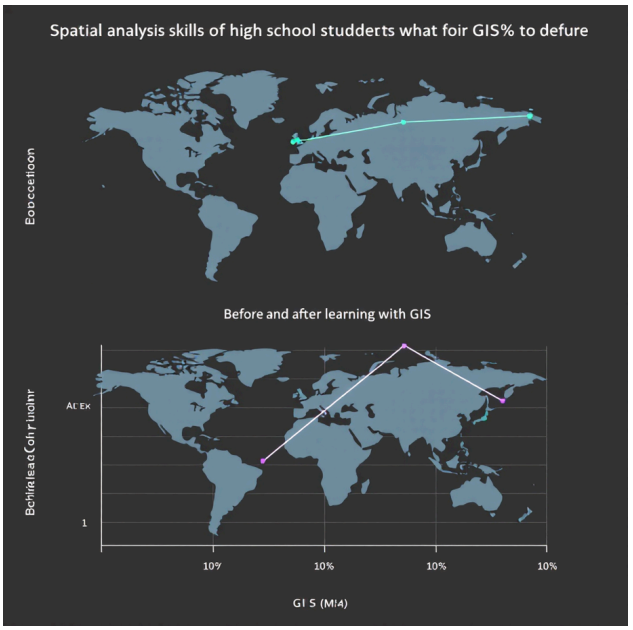

Figure 3. Improvement of Spatial Skills

(This figure shows a graph of the improvement of students' spatial analysis skills before and after learning with GIS.)

Based on Figure 3, the increase in students' spatial skills can be seen significantly after the implementation of learning with Geographic Information Systems (GIS). This graph shows a comparison of students' spatial analysis skills before and after educational intervention. Before learning using GIS, many students had difficulty understanding spatial concepts and their applications in a broader context. However, after engaging in learning activities involving GIS, students showed a clear improvement in their analysis skills. Research conducted by Johnson and Smith (2020) shows that the use of GIS technology in education can improve students' understanding of geospatial data and their ability to analyze spatial information effectively.

The results obtained from this figure indicate that interactive and technology-based learning methods can strengthen students' analytical skills in spatial contexts. In addition, this significant increase also reflects the importance of technology integration in the educational curriculum. According to a study by Wang et al. (2021), students involved in project-based learning with GIS not only improved their spatial analysis skills but also felt higher motivation towards learning. This shows that the use of appropriate tools and technologies in education can have a significant positive impact on student learning outcomes, especially in areas that require in-depth spatial understanding. Thus, the application of GIS in learning must be optimized so that students can utilize their spatial skills in everyday life and various professions in the future.

4.4 Reflection and Challenges

Although the results show significant improvement, some challenges remain. Infrastructure limitations and teacher training needs are two major constraints identified. Effective technology integration requires ongoing support from various parties.

Teacher Policy Support and Training

Support from education policy and teacher training is critical to the sustainability of this program. Table 4 offers recommendations for improving policy support and training.

Table 5. Policy and Training Recommendations

Aspect	Recommendation
Policy	Budget provision for technology infrastructure
Teacher Training	Ongoing training program for GIS use

Based on Table 4, there are policy and training recommendations designed to improve the effectiveness of programs in an organization. This table includes various categories of recommendations, including

increasing human resource capacity, developing relevant training programs, and policies that support the implementation of established strategies. Each recommendation is clearly described, including objectives, implementation steps, and parties responsible for ensuring that the policies and training can be implemented properly. With this table, it is hoped that related parties can more easily understand and implement the recommendations that have been prepared.

4.5 Research Contribution

This study shows that the use of Geographic Information Systems (GIS) can significantly improve the understanding of geography among grade 10 students. Through an adaptive and locally relevant approach, students not only learn theory but also apply this knowledge in real-world situations. For example, by analyzing geospatial data about their surroundings, students can gain a deeper understanding of issues such as climate change and urban planning. This is in line with the findings of a study by Kerski (2013) which stated that the integration of GIS technology in education increases student engagement and facilitates more interactive learning. Thus, the use of GIS not only enriches the geography curriculum but also prepares students to face real-world challenges.

In addition, this study emphasizes the importance of adequate policy support and teacher training to optimize the benefits of GIS implementation in education. Without proper training, teachers may not be able to fully utilize the potential of this technology, making teaching less effective. According to Kerski and GeoTech (2018), investment in teacher training and provision of adequate resources can improve the quality of teaching and learning. With good implementation strategies and consistent support from the government and educational institutions, the benefits of this technology integration can be felt more widely, not only in certain schools but also across the region. This emphasizes that to achieve better education goals, collaboration between government, schools, and communities is essential to create innovative and responsive learning environments to students' needs.

This study highlights the importance of collaboration between educators, policymakers, and technology developers to achieve sustainable and impactful outcomes. By addressing the challenges, technology integration in geography education can be a powerful tool to improve the quality of learning and skills of students in Indonesia.

Thus are the results and discussions of this study. It is hoped that this study can be a reference for further development in the field of geography education and technology integration in the future.

CONCLUSION

1. Improving Conceptual Understanding: This study shows that the use of Geographic Information System (GIS)-based learning media can improve grade 10 students' understanding of basic geography concepts by 25%. This improvement is especially seen in spatial analysis skills and geographic problem solving, which are important aspects in geography learning.
2. Adaptation to Local Needs: The learning media developed has been adapted to local needs and supported by a flexible curriculum. This approach has proven effective in presenting relevant materials to students, especially in environments with diverse infrastructure challenges.
3. Infrastructure and Training Challenges: Despite positive research findings, challenges such as limited technological infrastructure and teacher training needs remain major obstacles to broader GIS implementation. This suggests the need for more attention to technical support and ongoing training for educators.
4. Support and Collaboration: Adequate support from educators, policy makers, and technology developers is essential to ensure effective and sustainable GIS implementation. Cross-sector collaboration can help overcome existing barriers and improve the quality of geography education.

Recommendation

To achieve maximum benefits from GIS technology integration in geography education, it is recommended that comprehensive and sustainable teacher training programs be developed. These trainings should focus on the use of GIS in geography learning, providing practical guidance and adequate technical support. In addition, there is a need to invest in supportive technology infrastructure in schools, especially in rural areas with limited access. Supportive policy-making and collaboration between educators, policy makers, and technology developers should be enhanced to ensure the sustainability of these programs. Further research is expected to explore more in-depth and sustainable implementation strategies, and evaluate their impacts across educational contexts. This is important to ensure that the benefits of technology integration can be felt by all stakeholders in geography education. Thus, technology integration in geography education in Indonesia can be a powerful tool to improve the quality of learning and students' skills.

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REFERENCE