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Teaching geography using Web-GIS to improve students' spatial thinking ability

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ABSTRACT

Web-GIS was a mapping technology that could be used to support the learning process. Although in practice, the use of Web-GIS in learning is still low. Therefore, this study aimed to analyze (1) types of Web-GIS platforms in geography learning, (2) geography topics in Web-GIS-based learning, (3) methods of using Web-GIS in learning, and (4) the impact of Web-GIS on students' spatial thinking ability. The method used was a literature study with content analysis. There were 12 selected articles analyzed from Google Scholar. As a result, (1) the types of Web-GIS platforms that could be used in learning were Arc-GIS online, National Geography MapMaker, Digital Atlas, and Web-GIS INARISK. (2) Geography topics that could be used in Web-GIS-based learning were physical geography, human geography, regional geography, cartography, environment, and disaster. (3) Methods that could be used to use Web-GIS in learning were map investigation, project based learning, blended learning, inquiry, and demonstation. (4) The impact of using Web-GIS was very effective to improve students' spatial thinking ability. From research. Hopefully, in the future there will be more development research on Web-GIS-based media and teaching materials that could be used in geography learning.

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INTRODUCTION

Geographic Information System (GIS) is a computer-based geospatial technology used for mapping (Wijaya et al., 2022). GIS is highly essential for geography teachers and students to enhance the geography learning process in a more engaging and contextual manner. Teachers can utilize GIS to assist students in comprehending, interpreting, analyzing, and addressing geographic issues related to the environment, disasters, social, economic, and political aspects at local, national, and global

scales (Metoyer et al., 2015). There are numerous advantages to harnessing GIS in geography education. The most prominent benefit of using GIS in education is its ability to enhance students' spatial thinking skills (Lay et al., 2013).

Spatial thinking ability refer to an individual's ability to understand, analyze, and map space or location (Metoyer et al., 2015). These skills are highly valuable for students when dealing with issues related to space or place (Setiawan, 2016). The indicators of spatial thinking ability encompass six aspects, namely the ability to recognize patterns, understand orientation and direction, navigate using maps, comprehend spatial relationships, grasp the integration of geographic features, and understand spatial shapes and patterns (Bednarz & Lee, 2019). To improve spatial thinking ability, the integration of GIS technology into geography education can be employed.

The use of GIS technology in geography education to enhance spatial intelligence has been seriously pursued by various developed countries worldwide. In Taiwan, GIS is utilized as one of the ways to improve spatial intelligence with the aim of enhancing students' national awareness and nationalism (Chen, 2012). They employ GIS technology as a tool for geography education, often referred to as "Teaching with GIS" (Lay et al., 2013). Geography teachers in developed countries use GIS for creating teaching materials, instructional media, presentation tools, and as a facility for map-making practice.

In Indonesia, the utilization of GIS technology in geography education is still very limited. The presence of GIS in geography education in Indonesia is limited to theoretical knowledge, often known as "Teaching about GIS." Students primarily learn about GIS theory, components, functions, and types of GIS applications. However, practical usage of GIS as a learning tool is rarely conducted by students and geography teachers. Yet, "Teaching with GIS" has a far more positive impact on geography education compared to "Teaching about GIS" (Lay et al., 2013). The primary constraint for geography teachers in utilizing GIS in geography education is the inadequate computer lab facilities and the difficulty in operating GIS software (Ridha & Kamil, 2021).

Web-GIS or web-based GIS can be a solution to address the limitations of computer facilities and teachers' knowledge of GIS. Web-GIS can be operated without requiring high-spec software and hardware, is easier to use, more flexible, easier to update, and can even be accessed using internet-connected smartphones. Thus, the challenges in utilizing GIS in geography education can be overcome. Web-GIS users can interact with digital maps by zooming in, panning, identifying features, measuring, filtering, symbolizing, and performing spatial analysis functions directly on data while connected to the internet (Kerski & Baker, 2019). Furthermore, through Web-GIS, students can use others' maps, create their own maps easily, and easily share their work (Kerski, 2017).

There are numerous free Web-GIS platforms available for geography teachers. Some of these platforms include ArcGIS Online, National Geography Map Maker, Digital Atlas, and others. However, geography teachers still require proper references to effectively utilize Web-GIS in geography education. Therefore, this research addresses the topic of "Teaching Geography Using Web-GIS To Improve Students' Spatial Thinking Ability." This study has several objectives: (1) analyzing the types of Web-GIS platforms commonly used in geography education, (2) examining geography topics suitable for Web-GIS-based education, (3) analyzing the methods of Web-GIS utilization in education, and (4) assessing the impact of Web-GIS on students' spatial thinking abilities.

RESEARCH METHODOLOGY

Research Design

The study in this research employs a literature review methodology, systematically analyzing the content of scholarly articles gathered. I collected several articles on the utilization of Web-GIS to enhance students' spatial thinking abilities from Google Scholar. Google Scholar is the most popular journal indexing platform used to access research conducted by scholars worldwide, and it is freely accessible.

I used English keywords, specifically "Effect Web-GIS on Spatial Thinking," and retrieved 4,030 articles. However, after analyzing the suitability of titles and abstracts, I identified 17 relevant articles. In the final screening phase, considering the suitability of the articles and the research objectives, it was found that only 12 articles met the criteria for this study. The criteria used to filter these articles included the use of a PRISMA flowchart, consisting of identification, screening, and eligibility stages (Mašterová, 2023).

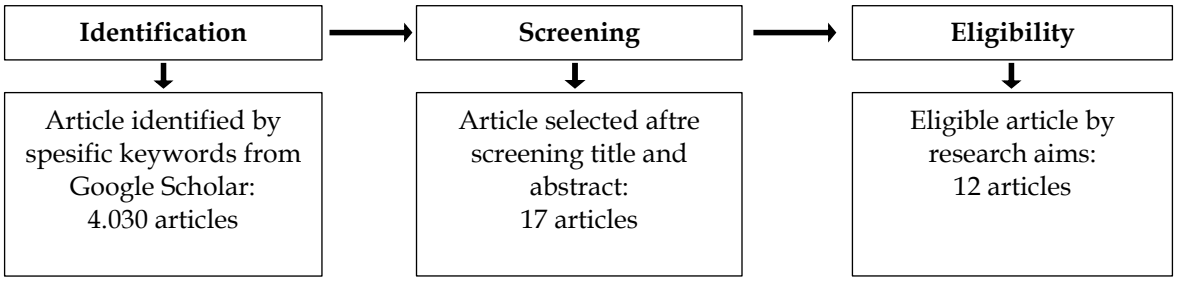

Figure 1. Article Flowchart Processing (Adapted from (Mašterová, 2023))

Research Instrument

The research instrument that I use is adapted from the model used by (Susetyarini & Fauzi, 2020) which can be seen in table 1. There are as many as six main aspects that are reviewed to analyze the content of the selected article. These aspects include (1) the type of Web-GIS platform used, (2) the topics presented, (3) research samples, (4) research methods, (5) how to apply them, and (6) their influence on spatial thinking ability.

Table 1.
The Aspects and Categories used for Content Analysis in the Study

No	Aspects	Category
1	Web-GIS Platform	Depends on article
2	Topics	Physical Geography, Human Geography, Regional Geography, Environmental Geography, Cartography, and Disaster
3	Sample	High school students, teacher, and undergraduate students
4	Research Method	Quantitaive,qualitative, mixed, and action research
5	Implementation	Depends on article
6	Impact on spatial thinking	Efective and inefective

Source: Adapted from (Susetyarini & Fauzi, 2020)

RESULTS AND DISCUSSIONS

I have analyzed 12 empirical research articles (see Table 2) and here is an overview of the findings. Overall, the articles were published between 2012 and 2023. The platforms used for Web-GIS varied, but ArcGIS dominated. The topics or subjects of instruction also varied, with a majority focusing on physical and regional geography topics. The research samples included high school students, undergraduate students, and teachers. Quantitative research methods dominated the studies. Most of the use of Web-GIS in schools was done through the map investigation method. The impact of Web-GIS on spatial thinking abilities was found to be mostly very effective. Here is a comprehensive summary of the research findings:

Table 2.
Research Result Overview

No	Author and Year	Web-GIS Platform	Topics	Sample	Research Method	Implement ation	Impact on spatial thinking
1	(Cirruci et al., 2012)	ArcGIS Online	Physical Geography	High school students	Quantitative	Map investigati on	Efective
2	(Alec M. Bodzin et al., 2014)	ArcGIS Online	Physical Geography	High school students	Quantitative	Map investigati on	Efective
3	(Jo et al., 2016)	ArcGIS Online	Regional Geography	Undergra duate Students	Quantitative	Map investigati on	Efective
4	(Bodzin et al., 2016)	ArcGIS Online	Physical Geography	Undergra duate students	Qualitative	Problem Based Learning	Efective
5	(Xiang & Liu, 2018)	National Geographic Map Maker	Environme nt	Undergra duate students	Mixed	Blrended learning	Efective
6	(Perugini & Bodzin, 2020)	ArcGIS Online	Disaster	High school students	Quantitative	Inquiry learning	No Efective
7	(De Miguel González & De Lázaro Torres, 2020)	Digital Atlas	Regional Geography	High school students and undergra duated students	Quantitative	Map investigati on	Efective
8	(Sofias & Pierrakeas, 2021)	ArcGIS Online	Cartograp hy	High school student	Quantitative	Project Based Learning	Efective
9	(Febrianto et al., 2021)	Web-GIS INNARISK	Disaster	High school student	Quantitative	Map investigati on	Efective
10	(Cao et al., 2023)	ArcGIS Online	Human Geography	High school students	Qualitative	Project Based Learning	Efective
11	(Somantri & Hamidah, 2023)	ArcGIS Online	Regional Geography	Teacher	Quantitative	Demostrati on	Efective
12	(Puertas-Aguilar et al., 2023)	ArcGIS Online	Human Geography	High school students	Action Research	Blended learning	Efective

Source: Research result, 2023

Web-GIS Platforms and Used in Research

Commonly used Web-GIS platforms are ArcGIS, Digital Atlas, National Geography Map Maker, and several other platforms. If you look at figure 2, it is very clear that the most widely used Web-GIS platform is ArcGIS Online and followed by several other platforms. All Web-GIS platforms used have their own advantages and disadvantages. In addition, its use is also adjusted to the purpose and material to be delivered. But ArcGIS Online is the easiest Web-GIS platform to use and has the most complete features.

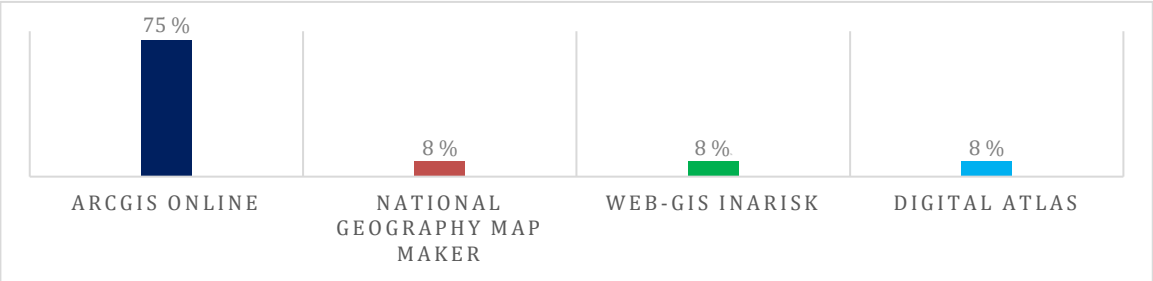

Figure 2. Web-GIS Platform Used in Research (Source: Research result, 2023)

ArcGIS Online is a platform developed by Esri. This platform is very popularly used in the field survey and mapping. Even today, ArcGIS Online is already widely used in education (Kerski &; Baker, 2019). The advantages of ArcGIS Online are (1) it does not need to be installed on a computer but must be accessed using a fast internet network, (2) various types of maps are available, (3) it has special features for learning such as story map features and geoinquiries that can be used as learning resources, (4) can be used as a practice tool for making maps, and (5) it is easy to operate (Kholoshyn et al., 2019). While the drawback of ArcGIS online lies in some exclusive paid features, so schools need additional funds to subscribe to ArcGIS Online. This is the address of the ArcGIS Online website: https://www.arcgis.com/index.html.

In addition to ArcGIS Online, there is also the National Geography Map Maker platform. The platform can be accessed for free. There are 112 interactive maps that can be directly used with themes ranging from regional, physical, social, environmental, to disasters that occur around the world. In addition, we are also given the facility to make our own maps according to the theme you want to display. If you want to access it, here is the link to the National Geography Map Maker that can be visited: https://www.nationalgeographic.org/mapmaker-interactive/.

There is also Digital Atlas as a Web-GIS platform that is ready to be used in learning for free. There are 11 themes available, namely climate change, plate tectonics, disasters, weather and climate, geopolitics, map of Canada, demography, regional development, globalization, resources, and urbanization. Each theme still consists of dozens of specific maps. The structure on the Digital Atlas can theoretically be used to teach material physical and environmental geography, population and settlement, human and economic geography, spatial imbalances and regional planning and to simplify the interface of student interaction with maps (De Miguel González &; De Lázaro Torres, 2020). If you want to visit Digital Atlas, you can click this link: https://www.digitalatlasproject.net/.

There is also a Web-GIS platform that has a special topic regarding disaster data in Indonesia. Our platform is Web-GIS INARISK issued by the Indonesian National Disaster Agency. In the platform, dozens of disaster data in Indonesia are available, ranging from natural disasters to social disasters. Here is INARISK Web-GIS access: https://inarisk.bnpb.go.id/.

Geography Topic on Web-GIS Based Learning

Topics or materials in geography learning are very broad and diverse. However, geography topics can be divided into several large groups, namely physical geography, human geography, regional geography, and some additional topics such as disaster, cartography, and the environment (De Miguel González &; De Lázaro Torres, 2020). In principle, all material in geography can be mapped and can be integrated with Web-GIS technology (Kerski &; Baker, 2019). Based on the results of the research in figure 3, it can be seen that Web-GIS can be integrated with various learning topics in geography. However, the most frequently used topics are regional geography and physical geography. After that, followed by the topic of disaster and human geography. The least used topics are cartography and the environment.

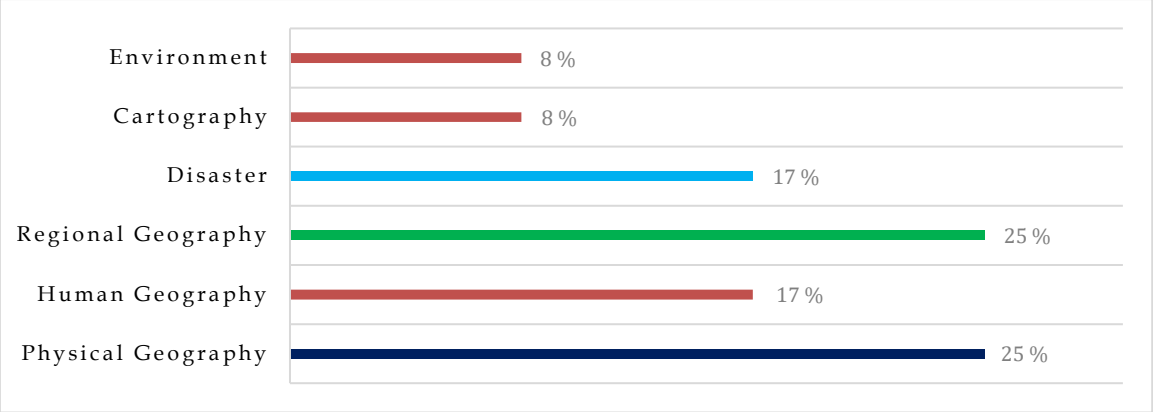

Figure 3. Distribution of Geography Topic on Web-GIS Based Learning

Research Sample Studying Web-GIS Based Learning

There are several groups that can be used as subjects or samples in Web-GIS research for learning. Of course, they are high school students, undergraduate students, and teachers. In the results of the study in figure 4, it is known that most of the Web-GIS research sample is dominated by high school students. In developed countries, the use of GIS technology in secondary school learning has indeed been very often done in the last decade (Bednarz &; Lee, 2019). While the least or least party is the teacher. Uniquely, only geography teachers in Indonesia are the subject of research with the aim of honing teachers' ability to apply Web-GIS and teach it in the classroom (Somantri &; Hamidah, 2023). This is in line with research which states that only 6% of geography teachers in Indonesia have ever used geospatial technology, which means that the use of Web-GIS and other geospatial technologies is very low in Indonesia (Ridha &; Kamil, 2021).

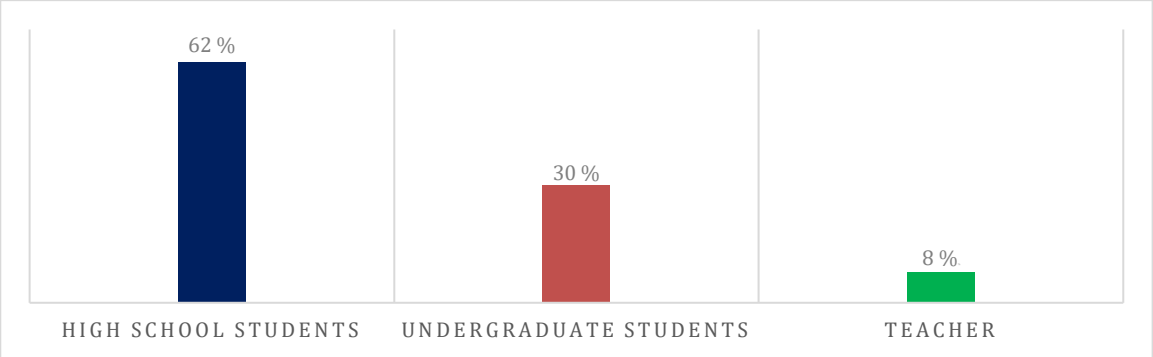

Figure 4. Research Sample Studying Web-GIS Based Learning

Web-GIS Implementation Methods

Web-GIS acts as a medium and teaching material in a learning (Santoso et al., 2021). Therefore, the method of implementing Web-GIS in the classroom can vary according to the goals to be achieved. Based on the review of research results listed in figure 4, some methods that are often used when using Web-GIS are map investigation, project based learning, inquiry learning, demonstration, and problem based learning. Of the six methods, the map investigation method is the most popular.

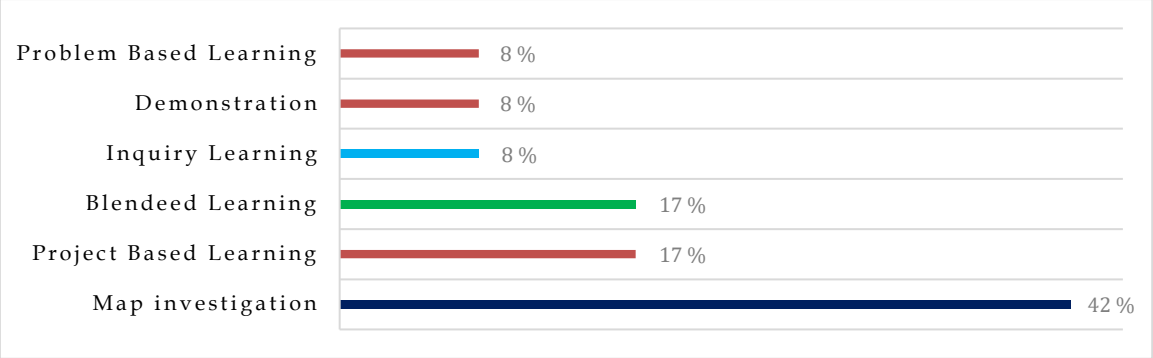

Figure 4. Web-GIS Implementation Methods

Map investigation is a term that can be used to refer to a method used to investigate or understand information contained in a map or in the context of mapping (Cirruci et al., 2012). The use of maps contained in Web-GIS makes it easier for users to investigate maps because in Web-GIS we can zoom in, zoom out, measure, shift, identify, filter, symbolize, and perform spatial analysis functions directly on data when connected to the internet (Kerski &; Baker, 2019). So this method is very appropriate to use.

In addition, Web-GIS is also very suitable to be applied with project methods. If you want to use Web-GIS as a medium to assign a project to students then we can use the project based learning method. Tasks can be in the form of field surveys such as collecting field data with GPS and smartphones, then the data is inputted in Web-GIS platforms such as ArcGIS Online (Sofias &; Pierrakeas, 2021).

Impact Web-GIS on Spatial Thinking Ability

The ability to think spatially can be interpreted as the ability to understand the location and space around it. Spatial thinking indicators include the ability to recognize patterns, understand orientation and direction, navigate using maps, understand spatial relationships, understand the integration of geographical features, and understand spatial shapes and patterns (Bednarz &; Lee, 2019). In this review research, it can be seen in figure 5 that Web-GIS can be very effective in improving students' spatial thinking ability with an effectiveness level of up to 92%. Only 8% of studies have shown ineffective results in the use of Web-GIS on students' spatial thinking ability.

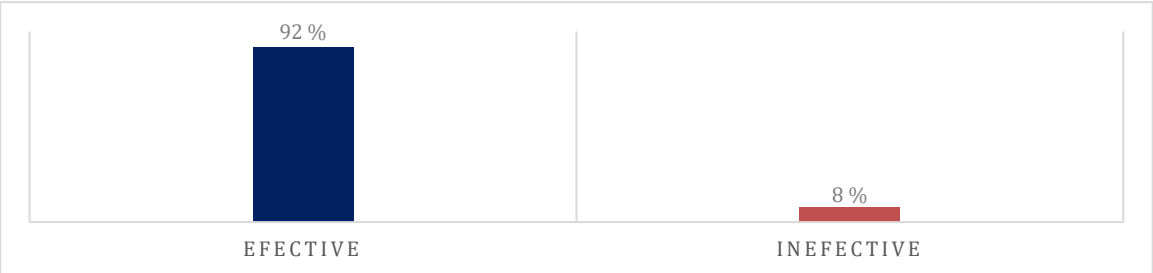

Figure 5. Impact Web-GIS on Spatial Thinking Ability

These results are not surprising, as one of the most effective ways to improve spatial thinking ability is to study maps (Jo et al., 2016). Through investigation on a map, students will be stimulated to recognize patterns, shapes, and distributions of places that exist in the world (Cao et al., 2023). These activities can be done easily in a Web-GIS platform. For example, a study conducted by (Bodzin et al., 2016) by developing Web-GIS to map the distribution of tectonic plates in the world and their impacts. Students are invited to recognize the shapes of tectonic plates and their

distribution and movement patterns (transform, convergent, divergent). This activity certainly stimulates students to think spatially.

In addition, the key to spatial thinking consists of three elements, namely the nature of space, tools or methods to represent spatial information, and the process of reasoning (Setiawan, 2016). All three keys can be found in the Web-GIS platform simultaneously. So it is natural that Web-GIS as a tool and method to display spatial data has a very effective impact on improving students' spatial thinking ability.

CONCLUSION

Based on the results of research that has been conducted by reviewing 12 scientific articles, the following points can be implicated. First, Web-GIS platforms that can be used in geography learning include ArcGIS Online, Digital Atlas, National Geography Map Maker, and Web-GIS INARISK. But the most popular and easy-to-use platform is ArcGIS Online. Secondly, all geography topics such as physical geography, human geography, regional geography, cartography, disaster, and environment can be integrated using Web-GIS. But the easiest topics to integrate are physical geography and regional geography. Third, the method of using Web-GIS in geography learning can vary including map investigation, project-based learning, problem-based learning, inquiry, demonstration, and blended learning. However, the map investigation method is the most widely used and easiest to implement. Fourth, the influence of Web-GIS on spatial thinking ability is very effective. Most studies have found that the use of Web-GIS in learning can improve spatial thinking ability. This study only reviews existing research articles. Thus, this research requires further research so that the impact of Web-GIS in improving students' spatial thinking ability can be achieved in the field. The recommendation for further research is that this research can be used as a reference to conduct experimental research, classroom action research, and development research related to the use of Web-GIS in geography learning to improve students' spatial thinking ability. In particular, future research should focus on utilizing or creating Web-GIS-based learning media. So that the practical impact can be felt directly by geography teachers and students.

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