The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2023

Volume 33, Pages 96-103

IConSE 2023: International Conference on Science and Education

A Systematic Literature Review: Utilization of Geographic Information Systems (GIS) in Geography Education in the 21st Century

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Abstract: Nowadays, the development of information and communication technology is running very rapidly. Geography education has a prominent role in ecosystem sustainability and cultural development, which is influenced by geographic data. Learning in the 21st Century with technological developments has increased. Geographic Information Systems (GIS) have become essential in changing how geography is understood and supported in the 21st century. Therefore, this research was conducted to investigate the role of Geographic Information Systems (GIS) in improving the quality of geography education. This research uses the PRISMA 2020 systematic literature review method using Scopus and Google Scholar as the database. A total of 101 articles were collected, but only 12 articles met the criteria for qualitative-thematic analysis. Research findings based on a systematic literature review state that there are two subject areas for using GIS in geography education: secondary schools and higher education. GIS in secondary school-level geography teaching, focuses on the output of increasing students' understanding and knowledge of spatial thinking. The aim of implementing GIS in higher education places greater emphasis on practical benefits in future geographic education development.

Keywords: Geography education, Systematic literature review, Geographic information system.

Introduction

The development of the 21st Century is marked by the use of information and communication technology (ICT) in all aspects of life. The rapid development of ICT impacts various sectors (Sakarneh et al., 2022) including in the field of education. The impact of ICT developments has brought a shift in learning paradigms worldwide towards modern learning. The use of technology as a learning medium is commonly used as an effort to anticipate the challenges of the Industrial Revolution 4.0. The learning process in the 21st Century must meet the demands of 4C skills (critical thinking, creativity, collaboration, and communication) (Ye & Xu, 2023). Various learning adjustment actions were taken to support this.

The issue of geography learning, which seems dry to students, has been developing for a long time. Some students think that geography lessons only consist of memorization. Geography teachers are often fixated on using classical methods in teaching through lectures and questions and answers, resulting in little use of learning media. One of the significant opportunities to revive geography learning is through the Geographic Information System (GIS). GIS is a relevant tool in supporting geographic learning to observe the natural world around us (Rød et al., 2010). For geography teachers, proficiency in using geographic information system (GIS)-based technology is essential to support educational programs. As a medium for teaching geography, GIS can improve students' understanding of geographic concepts (West, 2007). Not only that, GIS can help students

develop critical thinking skills in understanding space so they can find solutions to the problems they see (Baker et al., 2015; Liu et al., 2010; Tomaszewski et al., 2015). Much potential can be developed through the use of GIS in education. Often, the main obstacle geography teachers face in teaching GIS material is their need for mastery of GIS material, which becomes an obstacle in understanding and delivering the teaching material. Strategies are needed to support teachers' needs in developing GIS skills and experience in schools. Collaboration between schools and universities in the GIS industry is the scope of application (Healy & Walshe, 2019; Manson et al., 2013). This is a challenge for geography teachers to be able to utilize technology optimally to facilitate innovative learning.

The best effort to answer GIS implementation problems is through integration into geography education. Seeing this problem, the author is interested in conducting systematic literature review (SLR) research on using GIS in Geography education in the 21st Century. SLR is used to find information related to the use of GIS as a learning support at a level of geography education. Many studies focus on using GIS but still need a comprehensive, in-depth, and detailed analysis of the results. This research provides something new regarding the scope and framework for integrating GIS in geography education. It is hoped that this work can provide a scientific contribution not only limited to cognitively improving the quality of education. The main aim of the research is to answer two questions: 1) What is the scope of the subject and material for using GIS in geography education? 2) How can the objectives of using GIS in geography education be achieved?

Method

This research is a thematic-qualitative type of research—systematic literature review method. The purpose of this method is to identify, evaluate, and interpret the results of previous research that are relevant to a particular topic so that they are interesting to study (Calderón & Ruiz, 2015). Regarding the context of this study, the topics studied are related to GIS, which is part of geography education learning. To ensure that this study was conducted systematically, this study consulted the PRISMA 2020 guidelines (Page et al., 2021). The data search was performed on September 10, 2023, using Scopus and Google Scholar database sources. Specifically, for the Google Scholar database, searches were performed using Harzing's Publish or Perish application. Researchers search for journals that match the research topic by using keywords to make searching more accessible, such as "GIS," "education," and "geography." The search strings used in two databases, namely Google Scholar and Scopus, are shown in Table 1.

Table 1. Swarch strategy

Google Scholar	Scopus
TITLE (“GIS” and “geography education”)	TITLE-ABS-KEY (“GIS” AND “geography education”)

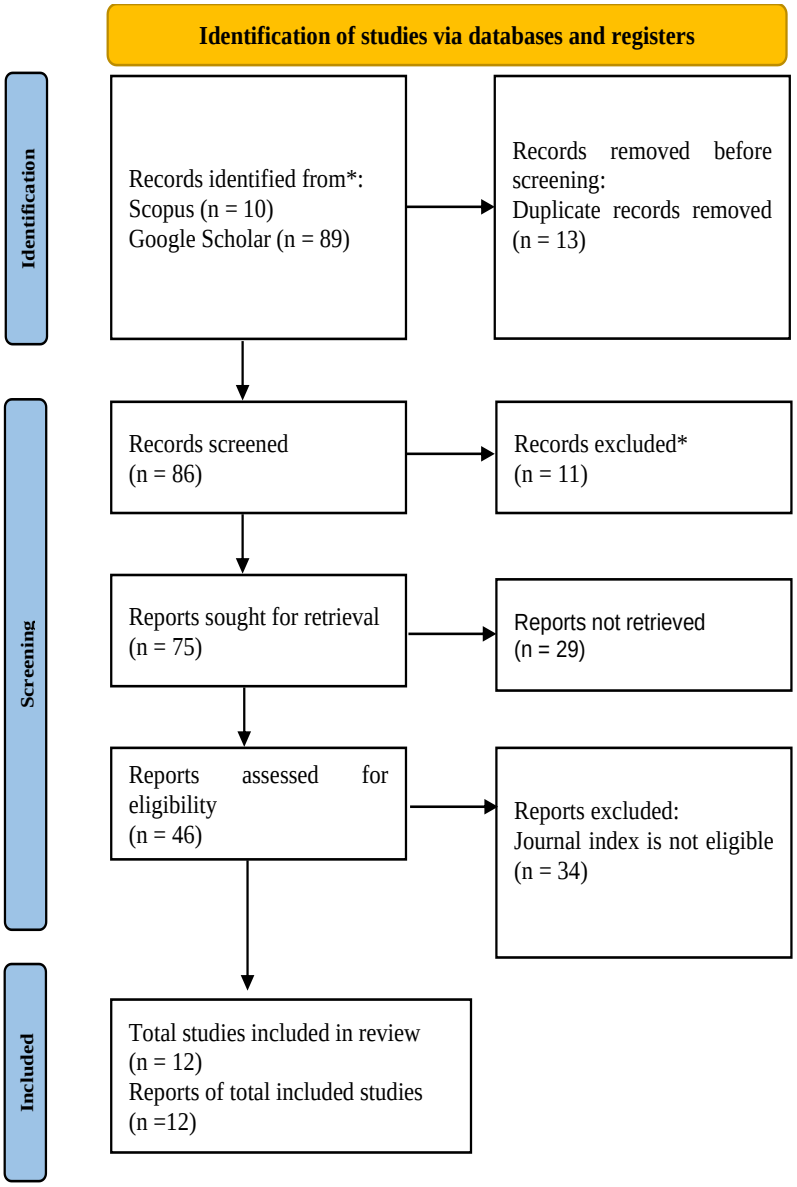
The data obtained was 101 articles (89 Google Scholar and 12 Scopus articles) based on these keywords. Next, the data is filtered and evaluated to obtain relevant articles. The criteria used can be seen in table 2.

Table 2. Eligibility criteria

Inclusion Criteria	Exclusion Criteria
Article published within the time frame of 21 Century (2001 to 2023)	Article or proceeding not indexed by Scopus or Google Scholar
The Written content was either in English language	No empirical research on GIS in geography education
The article is research result a peer review journal or proceedings	Subjec unrelate to high school and higher education
Article were available full text acces	

In selecting and evaluating relevant and structured articles, the researchers used the Microsoft Excel application for the coding, sorting, and data analysis processes. After going through a selection process that refers to the criteria, 12 out of 101 articles met the criteria. The more detailed process of selecting articles can be seen in Figure 1. The selected papers were then analyzed using the method described (Miles & Huberman, 2014) and followed the steps suggested, namely: (1) data classification, which was performed using Microsoft Excel software to facilitate selection and focus on essential points relevant to the study; (2) Data presentation in the form of tables, legends, and graphs showing interrelationships among categories. (3) conclude to answer previously formulated research questions. By performing these steps, it was hoped that a comprehensive

summary of the results would be obtained for thematic discussion, leading to the desired contribution to the body of knowledge.



* Not relevant with inclusion criteria

Figure 1. Selection process (Page et al., 2021)

Results and Discussion

The research results obtained 12 articles that met the inclusion and exclusion criteria. Table 3 shows 12 articles related to the use of GIS in geographic education.

Subject and Material Scope of Utilization of GIS in Geography Education

The integration of GIS into geographic education is integral to the concept of technology-based 21st century learning. This learning emphasizes the use of programming systems designed to support geography learning. Course design and instructor characteristics are the most important factors that determine students' actual use of an online learning system (Almaiah, 2019). Referring to Table 3, the scope of the use of GIS that can be identified is presented in Figure 2 below:

Table 3. Application of GIS in geography education

Study	Code	Autthor and Year	Result
(DeMers, 2019)	1	Michele De Mars, 2019	The use of a retrospective learning approach in teaching GIS allows students to understand and strengthen understanding of the concept that there are many problems with GIS tools and they are not static.
(Lukinbeal & Monk, 2015)	2	Chris Lukinbeal, 2015	Build a professional educational perspective and the skills geography students need to find employment
(Yağbasan & Yılmaz, 2021)	3	Ozlem Yabasan, 2021	Increase level of perception of spatial variation skills
(Yuk Yong, 2014)	4	Yukyong, 2014	Government support in the integration of information systems and geographic aspects of GIS has a major impact on geographic education in the future.
(Wang & Chen, 2013)	5	Yao Hui Wang, 2013	Promotion of GIS education It also proposes strategies for further extending GIS education to other levels.
(Kakhramon, 2023)	6	Sabirov, 2023	GIS functions that contribute to the development of spatial geographic thinking
(Knobelsdorf et al., 2017)	7	M Knobels, 2017	Connecting CS Education to the field of Geography reaching out to students that usually are not exposed to CS Education.
(Liu et al., 2010)	8	Yan Liu, 2014	GIS technology can be used as an effective pedagogical tool to develop students' higher-order learning skills.
(Incekara, 2010)	9	S Incekara, 2010	Effective integration of technology in geography learning and increasing students' understanding of geographic concepts through GIS applications
(Tas & Finchum, 2005)	10	Hi Tas, 2005	Improving the quality, accessibility and distribution of GIS education in various academic institutions by considering institutional capacity and geographical areas.
(Vir Singh & Asst Professor, 2017)	11	PV Singh, 2016	Innovative smart classrooms in India have adequate ICT facilities and trained human resources for GIS implementation
(Scheepers, 2009)	12	D Scheepers, 2006	Universities play an important role in creating educators and prospective educators who are more competent in GIS so that teachers do not just impart knowledge.

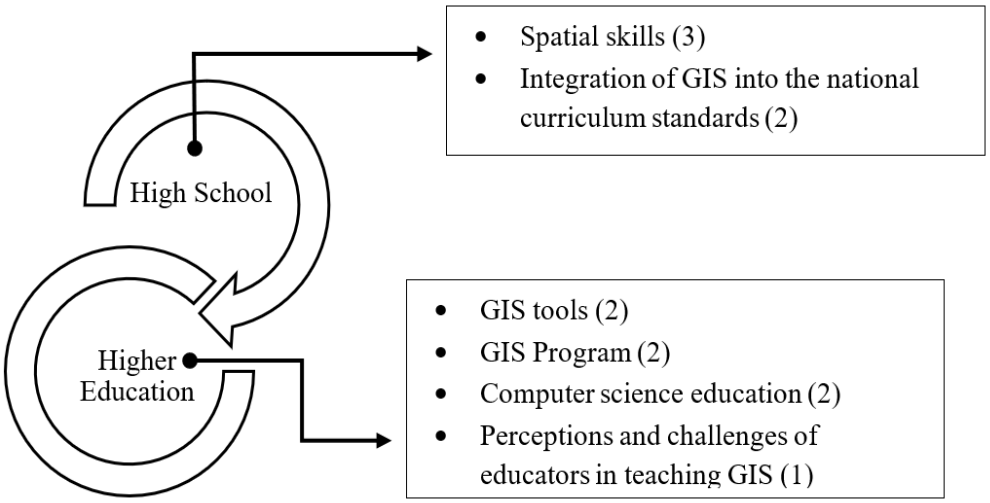


Figure 2. Subject and material scope utilization of GIS tion process (Page et al., 2021)

Based on Figure 2, it can be explained that the use of GIS in geography education is not only applied within the scope of higher education but is also widely used in learning in secondary schools. Differences in GIS implementation material can be seen at the level of education. The GIS material implemented at the secondary school level emphasizes aspects of knowledge, abilities, and integration of GIS into the school education curriculum. Geospatial technology learning design is one of the crucial aspects required in the geography learning curriculum (Kerski, 2003; Ridha & Kamil, 2021). GIS aspects in learning in secondary schools can expand students' spatial abilities and can even improve students' spatial thinking (McLaughlin & Bailey, 2022). Therefore, using GIS that can be carried out in the scope of schools or higher education can optimize the geography education process.

In contrast to the scope of GIS implementation in higher education, the use of GIS places more emphasis on applicable aspects such as programming and GIS in looking at future employment opportunities. Work carried out using GIS makes the work done more efficiently and effectively (Kholoshyn et al., 2019). Implementing GIS in higher education is also intended to produce teachers who are competent in learning geography. GIS teacher professional development and actually seeing long-term classroom implementation (Collins & Mitchell, 2019). In other words, integrating GIS into the geography education process is crucial to produce individuals who are ready to face global challenges, including in the 21st-century era. The use of GIS in the geography education process tends to be flexible according to the needs and potential of resources in the study country so that it can contribute to producing a resource with spatial competencies as the foundation for responding to the challenges of technological change.

Classification of Results from GIS Implementation in Geography Educationnd Material Scope of Utilization of GIS in Geography Education

Researchers carry out classifications based on the impact of the results of GIS implementation in geographic education. Classification of 12 research articles, there are two articles with the impact of implementation on innovation in the use of GIS, two articles with the results that GIS has a significant impact on geographic education in the future to find employment, two articles with the impact of creating more competent teaching staff in the field of GIS, 1 article has an impact on understanding of GIS tool problems, 1 article on expanding GIS education to other levels, and four articles have an impact on increasing students' understanding of spatial thinking geographic—figure 3 classification based on the results of the measured impact of GIS implementation.

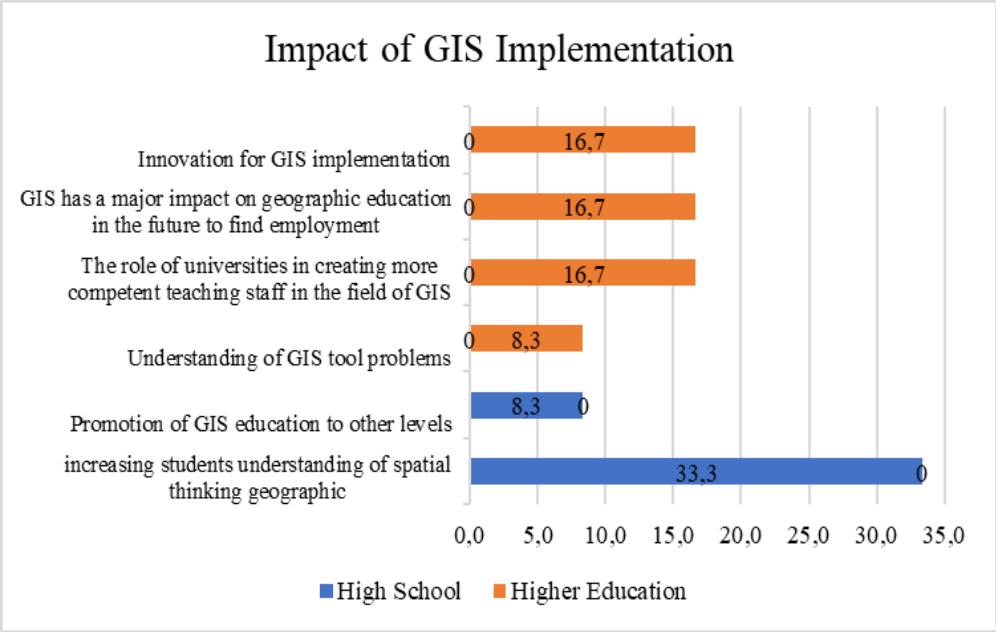


Figure 3. Result GIS implementation in geography education

The classification of results from the application of GIS in geography education in terms of achieving objectives overall states that the application of GIS in learning at the secondary school level can improve students' understanding of spatial thinking. Studying geography using GIS as a teaching and learning medium is very effective. This condition allows students to observe geographic problems in actual visuals to transfer knowledge

and understanding based on what they see. Students use a manual map or atlas to apply learning treatment before using GIS, so, the involvement and experience that students get needs to be improved. So, with GIS in geography learning, learning becomes more effective (Lee & Bednarz, 2009; Schlemper et al., 2019; Schulze et al., 2012). The classification of the results of the application of GIS in higher education places more emphasis on the realm of concrete implementation, such as increasing the competence of prospective educators and experts in the field of GIS and developing innovations from GIS programs for learning in higher education.

A problem often arises in introducing GIS into teaching is a lack of teacher training (Mínguez, 2022). Technological developments are gradually making GIS more user-friendly, so teachers' technological skills need to be improved. Improving GIS practices that focus on developing skills, competencies, and critical spatial thinking abilities can produce competent graduates (Bearman et al., 2016). The significant impact of GIS in education has resulted in many countries aggressively implementing GIS into the educational curriculum in schools and higher education.

Conclusion

During the last 21 years, namely 2002-2023, there were 12 relevant articles from Google Scholar and Scopus reviewing the use of GIS in geography education both in secondary schools and higher education. GIS-based geography education teaches the efficient use of technological developments in education. This will not only increase the potential for success in geography education but also contribute to making geography education more contextual through visual images that are close to students' lives, more varied because it can be implemented through various forms of application, and more comprehensive because it can not only be done within the scope of schools but also higher education to produce prospective educators who are competent in teaching.

The application of GIS in Geography education in secondary schools mainly discusses using varied learning models to improve students' geographical spatial thinking to obtain maximum learning outcomes. The application of GIS in Geography education in higher education emphasizes practical applications such as creating new programming for GIS development, preparing competent teaching candidates through training, and preparing experts to support geography education in the future. Many obstacles are found in implementing GIS in geography education, from the availability of supporting facilities to the government budget. However, in this case, several countries are making maximum efforts to apply GIS in the educational curriculum.

Recommendations

It is important to have a comprehensive approach to learning geography by involving GIS experts, educators, and education experts. Innovative learning models that utilize GIS, with an emphasis on evaluating the use of GIS can determine the extent of students' understanding and achievement in geography lessons. It should be noted that there are obstacles to implementing GIS in the curriculum. Research on the implementation of GIS in learning makes an important contribution to the development of geographic education based on GIS technology in the future.

Scientific Ethics Declaration

Eka Wulan Safriani., Iwan Setiawan., and Nanin Trianawati declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Acknowledgements or Notes

* This article was presented as an oral presentation at the International Conference on Science and Education (www.iconse.net) held in Antalya/Turkey on November 16-19, 2023.

*The authors would like to thank Lembaga Pengelolaan Dana Pendidikan (LPDP/ Indonesia Endowment Fund for Education) and the Ministry of Education, Culture, Research, and Technology in Indonesia for supporting the publication.

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To cite this article:

Safriani, E.W., Setiawan, I. & Trianawati, N. (2023). A systematic literature review: Utilization of geographic information systems (GIS) in geography education in the 21 st century. *The Eurasia Proceedings of Educational & Social Sciences (EPESS), 33,* 96-103.