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Improving Geographical Skills Through Geospatial Technology Based Tools Among High School Students

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Abstract: This study aims to analyze improvements in students' geographic skills, determine the effect of using geospatial technology-based tools on geographic skills, and describe "learning to learn" skills in geography instruction. The study employed a quantitative approach with a quasi-experimental nonequivalent control group design. The study sample consisted of 48 10th-grade students at SMAN 3 Siak, comprising 25 students in the experimental class and 23 students in the control class. Data were collected through pretest–posttest tests, observations, and documentation, then analyzed using descriptive statistics, the N-Gain test, normality tests, homogeneity tests, and simple linear regression with the aid of IBM SPSS 26. The results showed that the average score of the experimental class increased from 59.72 to 77.00, while that of the control class increased from 48.52 to 67.22. The N-Gain value for the experimental class (0.41) was higher than that of the control class (0.38). Regression analysis showed that the use of geographical tools had a positive and significant effect on geographical skills ($F = 27.667$; $p < 0.001$) with a coefficient of determination (R^2) of 0.376. This approach also helped develop students' "learning to learn" skills. Thus, geospatial technology-based tools are effective in improving geographic skills and supporting contextual, independent, and 21st-century competency-oriented geography learning.

Keywords: Geographical skills; Geographical tools; Geography education; Geospatial technology; Learning to learn

Introduction

Advances in science, technology, and information in the 21st century have brought about fundamental changes in the way humans understand, analyze, and solve various global problems. Issues such as climate change, environmental degradation, natural disasters, urbanization, food security, and natural resource management require critical thinking, problem-solving, evidence-based decision-making, and lifelong learning (Gersmehl & Gersmehl, 2011; Sugandhi & Rakuasa, 2023). Therefore, education is no longer viewed merely as a process of knowledge transfer but as a means to build 21st-century competencies that enable students to adapt to social, economic, and environmental changes in a sustainable manner. In this context, every academic discipline is expected to develop learning experiences that integrate conceptual mastery, higher-order thinking skills, and the ability to apply knowledge to solve real-world problems (Rivaldi et al., 2024; Sambonu et al., 2023).

As one of the disciplines that examines the reciprocal relationship between humans, space, and the environment, geography plays a strategic role in developing students' spatial thinking and geographical skills. Geographical skills are a set of competencies that include the ability to ask geographical questions, acquire geographical information, organize geographical data, analyze spatial relationships, and formulate answers or solutions to various geographical phenomena (Gersmehl & Gersmehl, 2011). Mastery of these skills forms the foundation of geography education because it enables students to comprehensively understand geosphere phenomena, interpret spatial data, and make decisions based on accurate geospatial information (National Research Council, 2006). Along with the

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development of digital technology, geography education has also undergone a transformation through the use of geographical tools, such as Geographic Information Systems (GIS), the Global Positioning System (GPS), remote sensing, satellite imagery, and Web-GIS. These technologies enable students to explore geographic phenomena in a more contextual manner through the visualization, analysis, and interpretation of spatial data, thereby making learning more meaningful, participatory, and inquiry-based (Manakane et al., 2023).

Nevertheless, the implementation of geography instruction in schools still faces various challenges in developing students' geographical skills. The learning process is still dominated by a teacher-centered, expository approach, so students primarily receive information rather than constructing knowledge through the process of geographical inquiry. Consequently, students' abilities to identify geographical problems, acquire and organize spatial information, analyze relationships between phenomena, and draw conclusions based on empirical evidence have not developed optimally. This situation is reinforced by the findings of Silaban et al. (2026), which indicate that geography instruction in schools has not yet fully facilitated the development of spatial thinking skills and geographic skills in line with the demands of 21st-century competencies. In fact, various studies show that the use of geospatial technology can improve the quality of learning through the presentation of authentic spatial data, enhance learning activities, and develop students' spatial analysis skills (Maulidiah et al., 2023). However, the implementation of this technology in schools is still suboptimal, so its potential for developing geographic skills has not been fully utilized.

Various previous studies have demonstrated that the use of geospatial technology has a positive impact on improving learning outcomes, spatial thinking skills, and student engagement in geography instruction (Simarmata & Citra, 2020). However, most studies still focus on learning outcomes or spatial thinking skills in general. Studies that comprehensively analyze geographic skills as a holistic construct—comprising asking, acquiring, organizing, analyzing, and answering geographic questions—remain relatively limited. Furthermore, the relationship between the use of geographic tools and the development of "learning to learn" skills in geography instruction has not been extensively studied, particularly at the high school level in Indonesia. Based on these gaps, this study offers a novel approach through the integration of geospatial technology-based geographical tools to simultaneously analyze: (1) the improvement of students' geographical skills based on five indicators of geographical skills, (2) the effect of using geographical tools on students' geographical skills, and (3) the development of students' "learning to learn" skills in understanding geographical issues independently and sustainably (Wulandari & Maryani, 2020). This study aims to generate empirical evidence regarding the effectiveness of using geographical tools in geography education so that it can serve as a basis for developing geography instruction that is more innovative, contextual, and relevant to the demands of 21st-century competencies (Sugandhi & Rakuasa, 2023; Cahyanti et al., 2023; Baidowi et al., 2015).

Method

Time and Location of the Study

This study was conducted during the even semester of the 2025/2026 academic year at SMAN 3 Siak, Siak Regency, Riau Province. The selection of the location for this study was based on the results of a preliminary study, which indicated that geography instruction at the school was still dominated by expository methods and had not yet optimized the use of geospatial technology-based tools as teaching aids. The research was carried out during the learning process on geographic technology material through a series of learning activities that had been adapted to the sequence of learning objectives and the teaching modules used at the school.

Research Design

This study employed a quantitative approach with a quasi-experimental design using a nonequivalent control group design. This design was chosen because the researcher utilized naturally formed classes (intact groups) without randomly assigning individuals to either the experimental or control groups, making it suitable for research in an educational context (Gersmehl & Gersmehl, 2011). The study population consisted of all 10th-grade students at SMAN 3 Siak for the 2025/2026 academic year. The research sample consisted of 48 students, comprising 25 students in the experimental class and 23 students in the control class. The sample was determined using purposive sampling, which involved selecting classes based on considerations of equivalence in academic characteristics, class size, and recommendations from the geography teacher to ensure the intervention could be delivered optimally. The independent variable in this study was the use of geospatial technology-based geographical tools, while the dependent variable was students' geographic skills. Research data were collected through geographic skills tests in the form of pretests and posttests, as well as documentation of the learning process. The test instruments were developed based on five indicators of geographic skills: asking geographic questions, acquiring geographic information, organizing geographic information, analyzing geographic

information, and answering geographic questions. The tools and materials used in the study included computers/laptops, an LCD projector, an internet connection, the Google Earth application, digital maps, satellite imagery, Web-GIS, student worksheets (LKPD), teaching modules, test instruments, and observation sheets.

Research Procedures

The study was conducted in four stages: preparation, implementation, data collection, and evaluation. During the preparation stage, the researchers conducted a preliminary study, developed instructional materials and research instruments, and had the instruments validated by experts. The implementation stage began with administering a pretest to the experimental and control classes to assess the students' initial geographic skills. Next, the experimental class received instruction using geospatial technology-based tools—such as Google Earth, digital maps, satellite imagery, and Web-GIS—designed according to the geographic inquiry approach, while the control class followed conventional teaching methods in line with standard school practices. Throughout the learning process, observations were made of the students' "learning to learn" skills. After all interventions were completed, both classes took a posttest to measure improvements in their geographic skills. All test and observation data were then compiled to serve as the basis for the research analysis.

Data Analysis

The research data were analyzed using IBM SPSS Statistics version 26. The analysis began with descriptive statistics to describe the mean, standard deviation, minimum, and maximum scores of the pretest and posttest results for both groups. Next, prerequisite tests for the analysis were conducted, including a normality test using the Shapiro–Wilk test and a homogeneity test using ANOVA. Improvements in geographic skills were analyzed by comparing pretest and posttest scores as well as gain scores for each group. To determine the effect of using geographical tools on geographical skills, simple linear regression analysis was used to test the regression coefficient, coefficient of determination (R^2), and model significance. Meanwhile, "learning to learn" skills were analyzed using descriptive statistics to describe students' ability to manage the learning process independently, reflectively, and continuously.

Result and Discussion

Result

The research results are presented based on three research objectives, namely: (1) to analyze the improvement in students' geographic skills using geographic tools, (2) to analyze the effect of using geographic tools on students' geographic skills, and (3) to analyze students' "learning to learn" skills in understanding geographic issues contextually (Farah et al., 2024; Lahay & Mohamad, 2020).

Descriptive statistical analysis shows that the average pretest score in the experimental class was 59.72, increasing to 77.00 on the posttest, while the average score in the control class increased from 48.52 to 67.22. Although both classes experienced an improvement in learning outcomes, the improvement in the experimental class was greater than that in the control class. The gain score calculations also showed that the experimental class achieved an increase of 0.41, while the control class achieved only 0.38, indicating that learning using geospatial technology-based geographical tools resulted in a greater improvement in geographical skills compared to conventional learning.

Before hypothesis testing was conducted, the data first met the assumptions of parametric statistics. The results of the normality test using the Shapiro–Wilk test showed that the data in the experimental class (Sig. = 0.258) were normally distributed. Furthermore, the results of the homogeneity test using ANOVA yielded a significance value of 0.21, indicating that the variances of the two groups were homogeneous. With both assumptions met, the analysis proceeded using simple linear regression.

To determine the extent of the effect of using geographical tools on students' geographic skills, a simple linear regression analysis was conducted. The results of the analysis showed that the regression model revealed a positive and significant relationship between the use of geographical tools and students' geographic skills ($F = 27.667$) with a significance value of < 0.001, which is less than the significance level of 0.05. The coefficient of determination (R^2) indicates that the use of geographical tools contributes significantly to the improvement of students' geographical skills, while the remainder is influenced by other factors outside the research model.

In addition to improvements in geographic skills, this study also analyzed students' "learning to learn" skills during the learning process. The results of the descriptive analysis show that students in the experimental class demonstrated strong abilities in planning their learning process, managing information, monitoring their learning progress, reflecting on their learning outcomes, and independently utilizing various learning resources. These achievements indicate that learning using geographical tools not only enhances geographical skills but also fosters the development of independent learning skills (learning to learn) that support sustainable geography learning.

Overall, the research results show that the use of geospatial technology-based geographical tools is effective in enhancing students' geographical skills, has a positive impact on the mastery of geographical skills, and supports the development of "learning to learn" skills in geography education.

Discussion

The results of the study show that the use of geospatial technology-based geographical tools significantly improves students' geographical skills. The greater improvement observed in the experimental class compared to the control class indicates that technology-integrated learning not only affects learning outcomes but also the quality of students' thinking processes. This indicates that geographic skills are not sufficiently developed through conventional approaches but rather require learning experiences based on data exploration and spatial context (Asep et al., 2023; Muliyadi et al., 2026).

More specifically, the use of geographic tools drives a shift in the learning paradigm from teacher-centered to student-centered learning. In the learning process, students do not merely receive information but actively ask questions, access data, and analyze geographic phenomena. This process strengthens students' cognitive engagement, particularly in spatial and analytical thinking skills. These findings align with research showing that the integration of geospatial technology can enhance conceptual understanding through more interactive and data-driven learning experiences (Lee & Tan, 2022; Manakane et al., 2023). Furthermore, the effectiveness of geographical tools in improving geographical skills can be explained by the characteristics of geospatial technology that enable the concrete visualization of phenomena. Geographical concepts that were previously difficult to grasp become easier to analyze through digital maps, satellite imagery, and geographic information systems. Thus, students not only understand concepts theoretically but are also able to connect them to real-world conditions in the field. This is supported by findings that the use of GIS significantly enhances students' spatial analysis skills through data-driven exploratory activities (Rosali & Singkawijaya, 2020; Hubaib & Hadi, 2025).

When viewed from the perspective of geographic skill indicators, the improvements observed in the experimental class demonstrate that learning based on geographic tools is capable of developing all stages of geographic skills in an integrated manner. Students are not only able to identify geographic problems but can also systematically organize and analyze data to arrive at logical conclusions. This indicates that the use of geospatial technology not only improves learning outcomes but also optimizes higher-order thinking processes. This finding is consistent with studies indicating that the use of GIS contributes to the development of analytical skills and decision-making based on spatial data (Silaban et al., 2026).

Beyond cognitive aspects, this study also shows that the use of geospatial tools contributes to the development of students' "learning to learn" skills. Students become more independent in seeking information, more active in discussions, and more confident in presenting their analysis results. These conditions indicate that geospatial technology-based learning can foster the development of self-regulated learning. In other words, students not only learn to understand the material but also learn how to learn. This aligns with research stating that the integration of technology into learning can enhance students' independence and self-regulation in the learning process (Syofniati, 2019; Shakhislam, 2025).

However, the successful implementation of geospatial tools depends on supporting factors, such as teacher readiness and the availability of facilities. In the context of school practice, challenges remain in the utilization of geospatial technology, particularly regarding teachers' digital competencies and access to learning devices. Therefore, systematic efforts in the form of training and professional development for teachers are needed so that they can effectively integrate geospatial technology into geography instruction (Manakane et al., 2023).

Overall, the findings of this study confirm that the use of geospatial technology-based tools not only significantly improves students' geographic skills but also develops their spatial and analytical thinking abilities as well as their independence in learning. Thus, the integration of geospatial technology into geography instruction is a relevant strategy for addressing the demands of 21st-century learning, which emphasizes the mastery of higher-order thinking skills and technological literacy.

Conclusion

The results of the study show that the use of geospatial technology-based tools significantly improves students' geographic skills compared to conventional learning. This improvement is demonstrated by a larger average difference in pretest and posttest scores in the experimental class compared to the control class, and is supported by the results of a simple linear regression test, which indicate a significant difference between the two groups ($p < 0.05$). These findings indicate that learning that integrates geospatial technology provides a more meaningful learning experience because students do not merely receive information passively but are actively engaged in the

process of observing, exploring, interpreting, and analyzing geographic phenomena through authentic spatial data. Theoretically, this improvement can be explained through the concept of constructivist learning, which positions students as active agents in constructing knowledge based on their learning experiences. The use of geospatial tools enables students to connect geographic concepts with real-world conditions through the visualization of digital maps, satellite imagery, and location-based information. This process helps students develop five indicators of geographic skills: asking geographic questions, acquiring geographic information, organizing geographic information, analyzing geographic information, and answering geographic questions. When students have the opportunity to explore geographic phenomena directly through spatial data, their geographic thinking develops more systematically, thereby enhancing their conceptual understanding and spatial analysis skills. These findings align with the National Research Council (2006), which asserts that the use of geospatial technology can strengthen spatial thinking skills through visual representations and the analysis of spatial relationships. The results of this study are also consistent with the research by Manakane et al. (2023), which shows that the integration of geospatial technology into geography instruction enhances students' spatial analysis skills and active participation.

A simple linear regression analysis indicates that the use of geospatial tools has a positive and significant effect on students' geographic skills. This suggests that improvements in geographic skills are not solely due to the learning intervention but are also influenced by the intensity of geospatial technology use during the learning process (Nurlaela, 2016). The coefficient of determination (R^2) indicates that the use of geospatial tools contributes significantly to the variation in students' geographic skills, although other factors also play a role, such as prior knowledge, learning motivation, technological readiness, and the learning environment. These findings reinforce the view that geospatial technology functions not only as a learning medium but also as a pedagogical tool capable of facilitating the process of geographic inquiry. Through spatial data exploration activities, students learn to identify problems, gather information, interpret data, and make decisions based on empirical evidence. The results of this study support the findings of Hubaib et al. (2025) that the use of geospatial technology has a significant impact on improving spatial thinking skills compared to conventional learning. An interesting finding in this study was the development of students' "learning to learn" skills while participating in lessons using geographical tools. Observation results showed that students were able to plan learning strategies, independently search for various sources of information, monitor their learning progress, reflect on the results obtained, and refine their learning strategies for the next session. These findings indicate that the use of geographical tools not only develops academic abilities but also fosters independent learning skills, which are among the key competencies in 21st-century education. When students are presented with contextual geography problems, they are encouraged to explore various data sources, compare information, and construct arguments based on available spatial evidence. These activities indirectly foster metacognitive skills, self-regulation, and responsibility for the learning process. These findings align with the OECD (2023), which emphasizes that "learning to learn" is an essential competency in fostering lifelong learning, and are supported by Shakhislam's (2025) research, which demonstrates that the use of digital technology in learning can enhance students' self-regulated learning and learning autonomy. Overall, the results of this study demonstrate that the integration of geospatial technology-based tools makes a comprehensive contribution to geography education. The use of technology not only enhances geographical skills and spatial thinking abilities but also fosters "learning to learn" skills that support students in understanding geographical phenomena independently, reflectively, and sustainably. These findings reinforce the urgency of transforming geography education toward geospatial technology-based learning oriented toward the development of 21st-century competencies. Therefore, the implementation of geographic tools must be supported by enhancing teachers' competencies in utilizing geospatial technology, developing learning materials based on geographic inquiry, and providing adequate digital facilities and infrastructure so that geography education can produce graduates with geographic skills and lifelong learning abilities in line with the demands of scientific and technological advancements (Lestari et al., 2024).

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Author Contributions

The author's contributions to this study include research design, the development of test instruments and observation sheets, the creation of learning materials based on geographical tools and geospatial technology, the conduct of the study at Siak State Senior High School 3, the collection of pretest, posttest, and observational data, data analysis and interpretation, and the writing and revision of the article as a

whole. The author has read and approved the final published version of the manuscript.

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Conflicts of Interest
This study has no conflicts of interest.

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