

INTEGRATING GIS TECHNOLOGIES INTO GEOGRAPHY EDUCATION: MODERN TEACHING APPROACHES

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Summary. The increasing use of geospatial technologies has created new opportunities for improving the teaching and learning of geography. This study examines the integration of Geographic Information Systems (GIS) into geography education, with particular attention to teaching approaches that promote spatial thinking, inquiry, and active student participation. The study analyzes the educational potential of GIS in relation to inquiry-based learning, problem-based learning, project-based learning, fieldwork, and digital mapping activities. Particular attention is given to the transition from the traditional presentation of geographical information to learning environments in which students collect, visualize, interpret, and compare spatial data and use the results to investigate geographical problems. The analysis indicates that effective GIS integration depends not only on access to geospatial technologies but also on appropriate teaching methods, teacher competence, curriculum design, and the selection of learning activities suitable for students' abilities. Based on these considerations, the study proposes a practical framework that connects geographical problems, spatial data, GIS-based analysis, interpretation, and student decision-making within a unified learning process. The proposed approach can support the development of geographical knowledge, spatial reasoning, digital skills, and independent problem-solving in contemporary geography education.

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1. Introduction

Geography education is closely connected with the ability to understand spatial relationships, interpret patterns, and explain interactions between natural and human processes. The increasing availability of digital geospatial data has expanded the ways in which these skills can be developed in the classroom. Geographic Information Systems (GIS), in particular, allow students to work with location-based information through mapping, visualization, comparison, and spatial analysis rather than relying only on static maps and descriptive materials. Consequently, GIS has become an increasingly important component of contemporary geography education (Bondarenko, 2025).

The educational value of GIS extends beyond the acquisition of technical mapping skills. When incorporated into appropriate learning activities, GIS can support spatial thinking, geographical inquiry, problem-solving, and the interpretation of relationships between different geographical phenomena. Web-based GIS platforms and increasingly accessible geospatial datasets have also created opportunities for students to investigate real geographical problems using interactive maps and spatial information (Fargher, 2018). Such an approach changes the role of the learner from a passive recipient of geographical information to an active participant in its collection, analysis, and interpretation.

The effectiveness of GIS-supported learning, however, depends strongly on how the technology is integrated into the teaching process. Simply providing GIS software or digital maps does not necessarily improve learning outcomes. Research has identified teacher preparedness, technical resources, curriculum requirements, and the design of appropriate learning activities among the major factors influencing successful GIS

implementation in education (Kerski et al., 2022). Recent empirical evidence also indicates that combining GIS with inquiry-based learning can improve students' academic achievement, attitudes toward geography, and some dimensions of geographical literacy (Hursen & Beyoğlu, 2025).

Despite the growing use of geospatial technologies, a gap remains between the technical possibilities offered by GIS and their systematic pedagogical integration into geography lessons. GIS is still frequently approached primarily as a technological tool rather than as part of a broader learning process connecting geographical questions, spatial data, analysis, interpretation, and decision-making. Therefore, greater attention is needed to teaching approaches that integrate GIS with inquiry-based, problem-based, project-based, and field-oriented learning.

The aim of this study is to examine the educational role of GIS in modern geography teaching and to identify effective approaches for its integration into the learning process. The study also proposes a practical framework linking geographical problems, spatial data, GIS-based analysis, interpretation, and student decision-making.

2. Materials and methods

This study employs a qualitative analytical approach to examine the integration of Geographic Information Systems (GIS) into contemporary geography education. Relevant academic literature on GIS-supported teaching, spatial thinking, geographical inquiry, problem-based learning, project-based learning, and digital mapping was reviewed and comparatively analyzed. Particular attention was given to studies addressing the educational use of desktop GIS, Web GIS, interactive mapping, and other geospatial learning environments.

The analysis focused on four interconnected dimensions: (1) the educational functions of GIS, (2) teaching approaches used with GIS, (3) learning outcomes associated with geospatial activities, and (4) barriers affecting effective classroom implementation. Previous systematic research demonstrates that GIS-related educational studies commonly address curriculum integration, teacher preparation, student learning, pedagogical strategies, implementation barriers, and technological development (Bondarenko, 2025).

Based on the comparative analysis of these dimensions, the study develops a conceptual teaching framework in which GIS is treated not simply as a mapping technology but as part of a structured learning sequence. As illustrated in Figure 1, the proposed framework organizes GIS-supported geography learning as a sequential process beginning with the identification of a geographical problem and progressing through spatial data analysis and interpretation to discussion and evidence-based decision-making.

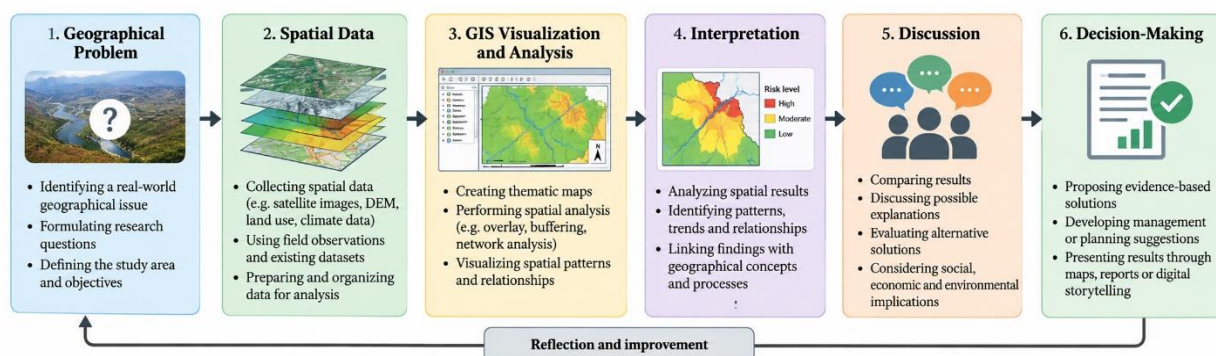


Fig. 1. Conceptual framework for integrating GIS into the geography teaching and learning process

Source: Developed by the authors

This framework is used to evaluate how inquiry-based, problem-based, project-based, and field-oriented teaching approaches can be combined with GIS to develop students' geographical knowledge, spatial thinking, digital competence, and problem-solving skills.

3. Results and discussion

The analysis shows that the educational value of GIS is determined not simply by the availability of digital maps or software, but by the way geospatial technologies are incorporated into the learning process. In geography lessons, GIS can connect theoretical concepts with real spatial problems by allowing students to work directly with geographical data. Instead of only observing a completed map, students can select data, create thematic layers, compare locations, identify spatial patterns, and interpret the causes and consequences of ge-

ographical processes. This makes GIS particularly suitable for teaching topics such as land-use change, population distribution, climate variability, natural hazards, water resources, urban development, and environmental management.

A major advantage of GIS-supported teaching is its contribution to spatial thinking. Students are required to consider location, distance, distribution, scale, spatial association, and change while interpreting geographical information. These operations are central to geographical reasoning and allow learners to move beyond the memorization of place names and definitions. Previous research has similarly emphasized that GIS-supported learning can contribute to the development of spatial thinking when geospatial tools are integrated with clearly defined educational objectives.

3.1. Inquiry-based learning with GIS

Inquiry-based learning is particularly compatible with GIS because both approaches begin with questions rather than predetermined descriptions. A lesson may start with a geographical problem such as: *Why are flood-risk areas concentrated in particular parts of a river basin?* Students can then examine elevation, slope, drainage, precipitation, land-use, and settlement layers to identify possible relationships.

In this process, GIS becomes an analytical environment rather than simply a map-production tool. Students formulate questions, select relevant spatial data, compare layers, identify patterns, and use geographical evidence to develop explanations. Recent research has shown that GIS-supported inquiry-based instruction can positively influence students' academic achievement and attitudes toward geography, although the effectiveness of the approach depends on the design of the learning activities and the level of guidance provided by the teacher.

3.2. Problem - and project-based learning

GIS can also be effectively integrated into problem-based and project-based learning. These approaches are especially useful when students investigate issues connected with their own region or community. For example, students may examine changes in urban land use, identify areas exposed to environmental risk, evaluate accessibility to public services, analyze local water resources, or investigate changes in vegetation cover.

A GIS-based project can follow a sequence from defining the problem and collecting spatial information to creating maps, interpreting results, and proposing solutions. In this way, students are not limited to learning how GIS functions technically; they learn how geospatial information can be used to support geographical arguments and decisions. The final product may include a thematic map, a short analytical report, a digital presentation, or an interactive story map.

3.3. Integrating GIS with fieldwork

The combination of GIS and field-based geography education provides another important teaching opportunity. Field observations can be georeferenced and subsequently incorporated into a GIS environment together with satellite images, topographic information, land-use data, or other spatial datasets. Students can therefore compare what they observe directly in the field with broader spatial patterns visible through digital data.

This approach establishes a connection between observation, location, mapping, analysis, and interpretation. For instance, students investigating a river can record sampling or observation points, photograph environmental conditions, identify potential pollution sources, and map the collected information. Such activities help students understand that geographical data are not abstract values but representations of real places and processes.

3.4. Web GIS and digital storytelling

The development of Web GIS has made geospatial technologies more accessible for geography education. Unlike traditional desktop GIS, web-based platforms can often be used directly through a browser and allow students to explore spatial data without extensive technical preparation. Interactive maps can be used to compare regions, examine environmental change, visualize demographic patterns, and investigate relationships between natural and socioeconomic processes.

Digital storytelling further extends these possibilities by combining maps with text, photographs, graphs, and other multimedia materials. In geography education, this approach is useful because students can present not only *where* a phenomenon occurs but also *why* it occurs and *how* it affects people and places. Student-created story maps can therefore serve both as a learning activity and as a form of assessment. They require students to select relevant information, organize spatial evidence, and communicate geographical findings in a clear and logically structured form.

3.5. Challenges of GIS Integration

Despite its educational potential, the effective integration of GIS into geography teaching remains associated with several practical and pedagogical challenges. Limited access to appropriate hardware and software,

differences in students' digital skills, insufficient teacher preparation, restricted classroom time, and difficulties in selecting suitable spatial datasets may reduce the effectiveness of GIS-supported activities. These challenges are particularly important when GIS tasks require considerable technical preparation but have only a weak connection with the intended geographical learning outcomes.

For this reason, GIS should not be introduced merely to increase the use of technology in the classroom. The selected GIS activity should correspond to the topic, students' level of preparation, available resources, and clearly defined learning objectives. Simple mapping and visualization may be sufficient at introductory levels, whereas more advanced students can perform overlay analysis, examine spatial relationships, and evaluate alternative solutions to geographical problems. A gradual progression from map interpretation to independent spatial analysis can therefore provide a more practical model for GIS integration in geography education.

Table 1

GIS-supported teaching approaches and their educational applications

Teaching approach	GIS-based activity	Expected learning outcome
Inquiry-based learning	Exploring spatial questions and comparing thematic layers	Spatial thinking and geographical inquiry
Problem-based learning	Analyzing real geographical or environmental problems	Problem-solving and evidence-based reasoning
Project-based learning	Creating thematic maps and regional projects	Independent research and digital competence
Field-oriented learning	Mapping field observations and georeferenced data	Connection between field evidence and spatial patterns
Web GIS	Exploring and comparing interactive spatial datasets	Data interpretation and digital map literacy
Digital storytelling	Combining maps, text, images, and analytical findings	Geographical communication and synthesis

Source: Developed by the authors

3.6. Pedagogical implications of GIS integration

The findings suggest that effective GIS integration requires a shift from technology-centered instruction to learning-centered application. Teaching students how to operate GIS software is useful, but technical competence alone does not constitute geographical learning. The educational value of GIS becomes more evident when students use spatial data to investigate questions, recognize geographical relationships, interpret patterns, and justify conclusions.

As summarized in Table 1, different teaching approaches emphasize different stages of this process. Inquiry-based activities are particularly suitable for developing geographical questioning and spatial reasoning, whereas problem-based and project-based activities encourage students to apply geographical knowledge to real situations. Field-oriented learning connects spatial datasets with direct observation, while Web GIS and digital storytelling provide accessible environments for visualization, interpretation, and communication.

The framework proposed in Figure 1 therefore places the geographical problem, rather than the GIS software, at the beginning of the learning process. GIS functions as a means of moving from spatial information to interpretation and, ultimately, evidence-based decision-making. This distinction is important because the same technology may produce very different educational outcomes depending on the task assigned to students and the degree of analytical thinking required.

For practical implementation, GIS activities should be introduced progressively. Students may initially work with existing digital maps and basic visualization before moving to data comparison, thematic mapping, field-data integration, and independent spatial analysis. Such progression can reduce technical difficulties while allowing GIS skills to develop alongside geographical knowledge and spatial reasoning.

4. Conclusion

The integration of GIS technologies into geography education provides opportunities to move beyond the traditional presentation of geographical information toward a more analytical and student-centered learning process. GIS enables students to visualize spatial relationships, work with geographical data, investigate real-world problems, and develop evidence-based explanations. Its educational value, however, depends less on the technology itself than on the teaching approach through which it is applied.

The analysis demonstrates that GIS can be effectively combined with inquiry-based, problem-based, project-based, and field-oriented learning, as well as Web GIS and digital storytelling. The conceptual framework proposed in this study emphasizes a progression from identifying a geographical problem to working with spatial data, conducting GIS-based analysis, interpreting results, and making evidence-based decisions. This approach places geographical reasoning at the center of GIS-supported learning rather than treating GIS primarily as a technical mapping tool.

Effective implementation also requires appropriate teacher preparation, access to suitable geospatial resources, and GIS activities adapted to students' knowledge and digital skills. A gradual transition from basic map interpretation and visualization to independent spatial analysis may facilitate the integration of GIS into geography curricula. Future empirical studies should test the proposed framework in different educational settings and examine its effects on students' spatial thinking, geographical knowledge, digital competence, and problem-solving skills.

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ИНТЕГРАЦИЯ ГЕОИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ В ПРЕПОДАВАНИЕ ГЕОГРАФИИ: СОВРЕМЕННЫЕ МЕТОДИЧЕСКИЕ ПОДХОДЫ

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Резюме. Расширяющееся использование геопространственных технологий создаёт новые возможности для совершенствования преподавания и изучения географии. В исследовании рассматривается интеграция географических информационных систем (ГИС) в географическое образование с особым вниманием к педагогическим подходам, способствующим развитию пространственного мышления, исследовательской деятельности и активного участия учащихся. В работе анализируется образовательный потенциал ГИС в контексте исследовательского обучения, проблемно-ориентированного обучения, проектного обучения, полевых исследований и деятельности по цифровому картографированию. Особое внимание уделяется переходу от традиционного представления географической информации к образовательной среде, в которой учащиеся собирают,

визуализируют, интерпретируют и сопоставляют пространственные данные, а также используют полученные результаты для исследования географических проблем. Анализ показывает, что эффективная интеграция ГИС зависит не только от доступности геопространственных технологий, но и от соответствующих методов преподавания, профессиональной компетентности учителей, разработки учебных программ и выбора учебных видов деятельности, соответствующих способностям учащихся. На основе указанных положений в исследовании предлагается практическая модель, объединяющая географические проблемы, пространственные данные, анализ на основе ГИС, интерпретацию результатов и принятие решений учащимися в рамках единого образовательного процесса. Предлагаемый подход может способствовать развитию географических знаний, пространственного мышления, цифровых навыков и способности к самостоятельному решению проблем в современном географическом образовании.

Ключевые слова: географические информационные системы (ГИС), географическое образование, пространственное мышление, исследовательское обучение, проектное обучение, геопространственные технологии, цифровое обучение

CİS TEKNOLOGİYALARININ COĞRAFIYA TƏHSİLİNƏ İNTEQRASIYASI: MÜASİR TƏDRİS YANAŞMALARI

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Xülasə. Geoməkan texnologiyalarından istifadənin getdikcə genişlənməsi coğrafiyanın tədrisi və öyrənilməsinin təkmilləşdirilməsi üçün yeni imkanlar yaratmışdır. Tədqiqatda Coğrafi İnformasiya Sistemlərinin (CİS) coğrafiya təhsilinə inteqrasiyası araşdırılır və məkan təfəkkürünü, tədqiqata əsaslanan öyrənməni və şagirdlərin fəal iştirakını təşviq edən tədris yanaşmalarına xüsusi diqqət yetirilir. Tədqiqatda CİS-in təhsil potensialı tədqiqata əsaslanan öyrənmə, problem əsaslı öyrənmə, layihə əsaslı öyrənmə, çöl tədqiqatları və rəqəmsal xəritələşdirmə fəaliyyətləri kontekstində təhlil edilir. Coğrafi informasiyanın ənənəvi təqdimatından şagirdlərin məkan məlumatlarını topladığı, vizuallaşdırdığı, şərh etdiyi və müqayisə etdiyi, həmçinin əldə olunan nəticələrdən coğrafi problemlərin araşdırılmasında istifadə etdiyi təlim mühitinə keçidə xüsusi diqqət yetirilir. Təhlil göstərir ki, CİS-in səmərəli inteqrasiyası yalnız geoməkan texnologiyalarına çıxış imkanlarından deyil, həm də müvafiq tədris metodlarından, müəllimlərin peşəkar səriştəliliyindən, tədris proqramlarının hazırlanmasından və şagirdlərin qabiliyyətlərinə uyğun təlim fəaliyyətlərinin seçilməsindən asılıdır. Bu mülahizələr əsasında tədqiqatda coğrafi problemləri, məkan məlumatlarını, CİS əsaslı təhlili, nəticələrin şərhini və şagirdlərin qərar qəbul etmə prosesini vahid təlim prosesi çərçivəsində əlaqələndirən praktik model təklif olunur. Təklif edilən yanaşma müasir coğrafiya təhsilində coğrafi biliklərin, məkan təfəkkürünün, rəqəmsal bacarıqların və problemləri müstəqil həll etmək qabiliyyətinin inkişafını dəstəkləyə bilər.

Açar sözlər: coğrafi informasiya sistemləri (CİS), coğrafiya təhsili, məkan təfəkkürü, tədqiqata əsaslanan təlim, layihə əsaslı təlim, geoməkan texnologiyaları, rəqəmsal təlim