ISSN 2354-9114 (online), ISSN 0024-9521 (print)
Indonesian Journal of Geography Vol 57, No.3 (2025): 606-616
DOI: 10.22146/ijg.104914 website: https://jurnal.ugm.ac.id/ijg

INDONESIAN JOURNAL OF GEOGRAPHY

RESEARCH ARTICLE

Geospatial Education as a Means of Improving the Skills of Geography Teachers

Sakhislam Laiskhanov[1-2], Erzhan Abikbaev[2*], Erkegul Seminar[2*], Zhanbolat Nurmagambetuly[2], Nurdana Assen[3], Omirzhan Taukebayev [3], Amandyk Kopbossyn[3]

[1]Department of Science and Innovation, International Educational Corporation, st. Ryskulbekova, 28 Almaty 050043, Kazakhstan
[2]Faculty of Natural Sciences and Geography, Abai Kazakh National Pedagogical University, st. Kazybek bi, 30 Almaty 050010, Kazakhstan.
[3]Faculty of Geography and Environmental Sciences, Al-Farabi Kazakh National University, 71 Al-Farabi Ave., Almaty 050040, Kazakhstan.

Received: 2025-02-20
Revised: 2025-08-04
Accepted: 2025-12-03
Published: 2025-12-31

Key words: geospatial education; geospatial technologies (GST); spatial skills of geography teachers; advanced training course; curriculum

Correspondent email :
erzhan_8787_kz@mail.ru

Abstract In the context of digitalization, there are many obstacles to the successful introduction of geospatial technologies (GST) into school geography and their integration with geographical education. The main one is the low geospatial education of teachers. The purpose of this study is to develop a curriculum for advanced training courses and an experimental study of its effectiveness by analyzing the content of the school's geography educational programs and studying the demands of geography teachers for geospatial knowledge. During the study, such general scientific methods as review, analysis, synthesis of scientific papers, study, comparison of regulatory documents on education were used. Based on the analysis of the role of GST in the curricula of Kazakhstan's secondary education and a survey study of the professional needs of geography teachers in geospatial education, 2-level (basic, advanced) training programs of advanced training courses for geography teachers, an additional manual for it, have been developed. The effectiveness of the basic level curriculum has been proven by an experimental study. The results of "pretest" and "posttest" from 24 teachers participating in the experiment showed that after the refresher course, the spatial skills of the course participants increase from "insufficient" and "average" to "high" and "very high". The research carried out supports the introduction of GST in school geography and contributes to speeding up this process.

1. Introduction

The XXI century is the age of information. The value and availability of information are decisive factors in the development of modern society. In this regard, in the world, there is a trend towards the use of geospatial (Geoinformation) technologies in all sectors of the economy, providing full and operational access to spatio-time data and their storage, processing, analysis, transportation and modeling (Laiskhanov et al., 2023; Ozgen, 2009). Geospatial technologies (GST) have become one of the main tools of geographical education, including in the field of education in developed countries of the world (Berezhnyi et al., 2013; Kholoshyn I. V., 2016; Somantri & Hamidah, 2023). «Just as the role of vehicles in the era of the "great geographical discoveries" is the place of Geoinformation systems in modern geography." From this we can already understand the importance of GST in geographical education.

Unfortunately, GST is not fully integrated into the secondary education programs of many countries of the world (DeMers et al., 2021; Kholoshyn I. V., 2016) or is not used at the proper level even if embedded (Ocak et al., 2023; Walshe, 2017). Especially this is typical for developing countries (Laiskhanov et al., 2023; Somantri & Hamidah, 2023). In the early stages of the introduction of these technologies, the harmony between teaching logistics and standards-based curricula, teacher motivation and geospatial education was broken (Demirci, 2009; Sinton, 2023). Since the early 2010s, many of these barriers have been reduced or even eliminated thanks to the development of web mapping (Fargher, 2018). This made it possible to replace paper cards and present new details (Kapustin, 2009). Even now, teachers can create apps in WebGIS and use them in the classroom (Ivan & Glonți, 2019). However, despite the ease of access to cartographic platforms andthe current requirements of education, the practical application of GST in secondary education is not at the proper level (Ocak et al., 2023; Shakhislam et al., 2024; Sinton, 2023; Walshe, 2017). For example, in accordance with the updated content of education in Kazakhstan, the content of school geography textbooks reflects the problem of teaching GST and Geoinformation methods (Laiskhanov et al., 2023). However, a survey study conducted in Kazakhstan found that 70% of geography teachers are limited to using mobile GIS applications (Shakhislam et al., 2024). Walshe (2017) this is due to the fact that it is not possible to improve the skills of teachers in the use of GST. It is known that these problems are solved primarily by training professional geography specialists with geospatial education, and then professional development of geography teachers and providing them with methodological support (Demirci, 2009; Jo & Hong, 2018; Knecht & Spurná, 2022; Mitchell et al., 2022). Moreover, many scientists (Fairman et al., 2023; Kolnik, 2010; Leat et al., 2005) argues that the basic education of teachers cannot provide them with the knowledge and skills necessary for their professional activities. Because teachers have to constantly update their knowledge and skills in their professional careers due to the introduction of new curricula and changes in teaching technologies and changes in the tastes of students due to the exchange of knowledge (Avalos, 2011; Fairman et al., 2023; Kolnik, 2010).

Currently, the professional development of a geography teacher is primarily related to geospatial education. Geospatial knowledge here is a practice-based knowledge that consists of searching, collecting, storing, processing, analyzing spatial data using GST, obtaining and transporting the final product (Berezhnyi et al., 2013). Geospatial education for geography teachers builds their skills in applying GST (Kapustin, 2009), digital literacy (Kholoshyn et al., 2019), spatial and geospatial literacy (Jo & Solari, 2015) and spatial intelligence (Somantri & Hamidah, 2023). And the teacher's ability to use GST in the classroom at the proper level helps students develop geospatial thinking and problem-based thinking skills (Bearman et al., 2016; de Miguel González, 2017; Donert et al., 2016; Metoyer & Bednarz, 2017; Robertson et al., 2019), cartographic skills (Robertson et al., 2019), high-level thinking skills (Chen & Wang, 2015) intellectual skills (Kapustin, 2009). According to Cichoń & Piotrowska (2018), for effective education, it may not be enough for the teacher to use ICT with traditional methods. The modern "generation Z" needs a teacher who is publicly available, able to work using modern devices, software and internet resources. The basis of these lies in geospatial education for geography teachers. Therefore, improving the qualifications of teachers in the application of GST and considering various ways to integrate it into the geography of the school is a very urgent problem (Millsaps & Harrington, 2017). This and other data discussed above, whichshow how relevant the problem is and whether it is important to solve it on an international and national scale.

Although there is some research on advanced training for geography teachers (Boehm et al., 2012; Brysch, 2020; Kolnik, 2010; Leat et al., 2005; Mitchell et al., 2022; Solem et al., 2006; Thenga et al., 2020), there is very little research around the problem of professional development through geospatial education and determining its effectiveness (Somantri & Hamidah, 2023; Walshe, 2017). Comprehensive research, which consists in studying the requests and opportunities of geography teachers, analyzing the content of curricula and developing a program for advanced training courses, is also not enough. In terms of conducting research on this issue and the applied significance of the research results, we asked ourselves the following questions: What is the role of GST in school geography curricula? To what extent do geography teachers need geospatial education? What should be the content of the advanced training course on teaching GST? How to determine its effectiveness? These research questions allowed us to determine the specific purpose of the study.

The purpose of this study is to design and experimentally evaluate a professional development course on geospatial technologies based on the needs of geography teachers and the content of school geography curricula.

Based on these research questions and the purpose of the study, the following hypothesis was formulated: "If geography teachers complete a professional development course on the applied foundations of geospatial technologies (GST), then their spatial skills and ability to integrate GST into school geography teaching will significantly improve."

This hypothesis was tested through a pretest-posttest experimental design involving geography teachers who participated in the in-service training course.

2. Methods

During the study, general scientific theoretical methods such as review, analysis, synthesis of scientific works on the topic, study of normative documents on education, comparison were widely used. To demonstrate the level of thematic research, search systems for scientific materials were used, and a retrospective analysis was performed through a literature review.

A survey was conducted to study the demand for geospatial education among geography teachers. The questionnaire was distributed to rural and urban schools in all regions of the country and secondary educational institutions of the cities of republican significance: Astana, Almaty and Shymkent, and a total of 119 geography teachers responded. Among them, 62 were female and 38 were male, with ages ranging from 25 to 56 years old. The majority of the participants were mid-career teachers with several years of teaching experience. This demographic distribution provides insight into the professional profile of respondents and supports the relevance of the survey findings. The questionnaire was distributed via social networks (Facebook and WhatsApp) and e-mail, and respondents were randomly selected. In the survey, respondents answered 8 questions, providing information about themselves. The survey results were evaluated using frequency and percentage analysis. This allowed the researchers to determine how often certain answers are found, what is the proportion of teachers with knowledge and skills in GST, and the demand for geospatial education among teachers.

In order to determine the role of GST in school geography, an analysis was made of the learning objectives and long-term plans outlined in the normative documents issued by the Ministry of Education of the Republic of Kazakhstan, specifically the standard geography curricula for senior grades (9–10 and 10–11). These documents, which serve as official guidelines for curriculum implementation, were used to identify where and how geospatial technologies are integrated into the educational content and learning outcomes..

The curriculum and supporting materials for the in-service training course for geography teachers were developed based on teaching methods that help integrate GST into the pedagogical process, Bloom's categories of educational objectives, recommendations of scientists for the development of the curriculum, the content of geography textbooks for schools, as well as the results of the survey and the analysis of the typical curriculum.

The effectiveness of the developed in-service training course was determined through an experimental study. Geography teachers who attended the in-service training course on the use of GST voluntarily participated in the experiment. They consisted of 24 teachers from urban and rural schools in Kyzylorda, Almaty, Zhetysu, Mangistau, Turkestan and Zhambyl regions of Kazakhstan.

The experiment used a "pretest-posttest control group design". The research procedures were based on the methodology of Devecioglu-Kaymakci (2016).

The criteria proposed by Astawa et al. (2019), were used to assess the spatial skills of the participants in the experiment:

1. 0–44 points - very insufficient level;
2. 45–54 points - insufficient level;
3. 55–69 points - average level;
4. 70–84 points - high level;
5. 85–100 points - very high level.

The pretest and posttest results obtained before and after the professional development course were evaluated using a quantitative method and a descriptive analysis was performed on them.

3. Result and Discussion

Historical development and periodization of GIS in geographical Education

The professional development of teachers is carried out in different ways at different stages and is discussed in many scientific literature.

The issue of geospatial education has been raised since the emergence of geographic information system (GIS) technologies. However, their use in secondary schools began only in the early 1990s. (Kerski et al., 2013). Through a retrospective analysis of the scientific literature, the introduction of GST into secondary education around the world (Kholoshyn et al., 2021) and, consequently, the history of geospatial education for teachers can be divided into 4 periods:

1. *The first period* of introducing GIS technology into the process of geographical education in schools is associated with the emergence of geospatial education programs in the USA and Canada in the late 1970s and early 1990s. The National Geographic Society of America (NGSA) was one of the first to begin work on introducing GIS into the school education process, and in 1986 it created a system of seminars to teach teachers the applied basics of GIS. (Kholoshyn et al., 2021). Since 1993, ESRI has been involved in teacher training in the United States, publishing the ArcSchool Reader newsletter. Educational materials for schools have been developed and GIS training has been systematically implemented (Cadoux-Hudson & Heywood, 1992).
2. *The second period* of the introduction of GIS in geographical education in schools dates back to the mid-1990s and the beginning of the 21st century. This period is characterized by the spread of GIS curricula in schools in the more developed countries of Europe and Australia. Under the leadership of Peter O. Connor, a multi-level program for the use of GIS in schools was developed within the framework of the Geographical Community Project (Kholoshyn et al., 2021). The GISAS project for schools has been implemented in a number of European countries (Johansson & Pellikka, 2006). During this period, the development of GIS functions helped to teach students in schools tasks such as analyzing and processing geodata. (Kholoshyn et al., 2021). Its increasing role as a learning tool is directly related to its accessibility and availability as free software (DeMers et al., 2021).
3. *The third period* of the introduction of GIS technology into school geographical education is associated with the beginning of the teaching of geospatial knowledge in schools in Eastern Europe, Asia, Africa and Latin America in 2005-2012. (Akinyemi, 2016). During this period, in addition to the development of online courses, the use of geospatial technologies in education was considered an active direction. (Solem et al., 2006). The emergence of the ArcGIS Online platform and Schoolnet Future classroom Lab, NetCad programs, ESRI and Intergraph products have contributed to the development of geographic teaching in secondary education institutions in Turkey, India and China, Russia, etc. (Berezhnyi et al., 2013; Demirci, 2009; Kapustin, 2009). According to Demirci (2009), despite obstacles such as lack of equipment and software during this period, teachers' positive attitude towards GIS was an important determinant of the successful implementation of these technologies in geography lessons.
4. *The fourth period* of the introduction of GST in school geography covers developing countries in Eastern Europe and Asia and other regions (from 2012 to the present). This stage is characterized by the development of web-browser-based versions of GST in addition to GIS software, as well as work on various methods for their effective introduction into schools. (Fargher, 2018; Gadeng et al., 2022; Hong & Stonier, 2015; Ivan & Glonți, 2019; Mitchell et al., 2022; Walshe, 2017). In Eastern Europe and other countries, open source applications such as ArcGIS Online (Ivan & Glonți, 2019; Walshe, 2017) and platforms such as GeoCapabilities for developing geography teacher professional skills are gaining popularity (Fargher, 2018; Mitchell et al., 2022).

In the last 20 years, the development of the skills of geography teachers has been carried out in the areas of climate change (Mukminan, 2018; Thenga et al., 2020), thinking skills strategies (Leat et al., 2005), the use of video materials (Boehm et al., 2012), distance learning (Nurbol et al., 2022; Solem et al., 2006), continuing education (Kolnik, 2010), alternative professional development (Brysch, 2020), the use of a comprehensive model of teaching using geospatial technologies (Jo & Solari, 2015), curriculum managemen (Mitchell et al., 2022) and many others. Studies on improving the skills of geography teachers through geospatial education have been conducted by Walshe (2017), Jo & Solari (2015), Somantri & Hamidah (2023), Hong & Stonier (2015), Millsaps & Harrington (2017), DeMers et al. (2021). However, despite the expanding scope of GST and its increasing role in geographical education, the use of this innovative technology in the training and professional development of geographers has not yet become common practice (Millsaps & Harrington, 2017).

The role of GST in school geography curricula

Currently, in the secondary education programs of many countries, GST is integrated into geographical education (de Miguel González, 2017; Fairman et al., 2023; Kapustin, 2009; Shakhislam et al., 2024; Walshe, 2017). They are included in educational programs as a mandatory section, additional module or elective course (Chen & Wang, 2015). It is shown that with the help of this technology, students acquire geographic information, perform spatial analysis and interpretation and processing of it.

By analyzing the learning objectives and long-term plans of the standard geography curricula for grades 9 and 10-11 (Minister of Education and Science of the Republic of Kazakhstan, 2017), developed by order of the Ministry of Education of the Republic of Kazakhstan, we found that the learning objectives become more complicated from grade 9 to grade 11, and most of the learning objectives here are achieved or can be achieved using GST. For example, in the 9th grade, the section "Cartography and Geographical Databases" aims to explain the importance and features of remote sensing methods and describe the importance of using GST in the economy and science, while in the 10th grade, the section "Cartography and Geoinformatics" aims to create cartograms and cartograms based on the results of statistical data analysis and to create thematic map schemes in a graphic editor of information and communication technologies. In the 11th grade, the learning objectives are to explain remote sensing methods, geoinformation methods and features of GIS technologies, and to create a geographic database on the topic and to create thematic map schemes.

The content of geography textbooks for high school includes sections entitled "Cartography and Geoinformatics" (Kaimuldinova, Abdimanapov, & Abilmazhinova, 2019; Kaimuldinova, Abdimanapov, Abilmazhinova, et al., 2019; Kaimuldinova, Abilmazhinova, et al., 2019; Kaimuldinova & Abilmazhinova, 2019) and "Cartography and Geographic Databases" (Karatabanov R. A., 2019). These sections should teach GST and its methods used in cartography and geoinformatics. However, until now, no methodology for their use, or even instructions showing how to use them, has been developed. In most cases, GST is taught in schools only in theory. Although the authors of geography textbooks for schools touched on GST geoinformatics methods, they did not show how to use them. They left the work performed with the help of GST and resources to the teacher. However, the inability of many teachers to use GST in practice, due to their low digital literacy or lack of skills in using geospatial resources in education, negatively affects the full acquisition of new knowledge in accordance with the educational program (Shakhislam et al., 2024).

It was determined that GST is one of the main tools specified in the considered typical curricula and the content of geography textbooks for schools. Their effective use directly affects the quality of geographical education (Millsaps & Harrington, 2017).

Through an analysis of scientific works and practices, we have come to the conclusion that there are 3 main reasons for the relevance of geospatial education aimed at teaching school teachers to use GST (Figure 1).

Geospatial education helps teachers to create new formats for their curricula, to exchange experiences and to create professional development networks among teachers (DeMers et al., 2021). The use of GCE allows teachers to update their teaching methods by using modern geographic tools (Millsaps & Harrington, 2017). These works increase the long-term impact of geospatial education. GCE allows geography to connect with other disciplines such as ecology, economics and social sciences. This opens up opportunities for teachers to consider a wide range of issues in a comprehensive way (DeMers et al., 2021).

Study of professional requests of Geography teachers

Research on the professional needs of geography teachers helps to make decisions on improving the quality of education, develop methodological teaching materials, support teachers' professional development and create professional development programs (Somantri & Hamidah, 2023; Walshe, 2017). This research helps to identify the specific needs, difficulties and solutions of teachers, and thereby contributes to increasing the effectiveness of the education system (Fairman et al., 2023). The tools used in teacher professional development depend on the goals and needs of both teachers and their students (Avalos, 2011).

Figure 1. Reasons for the relevance of geospatial education (DeMers et al., 2021; Millsaps & Harrington, 2017; Minister of Education and Science of the Republic of Kazakhstan, 2017; Shakhislam et al., 2024).

We conducted a survey among 119 geography teachers working in different regions of Kazakhstan to study the issues of using GST in geographical education and the demands of teachers on this issue. The survey was conducted in November 2022. The survey was conducted on a voluntary basis using a Google form. Respondents who participated in the survey answered 8 questions, filling in information about themselves and their workplace (Table 1).

One of the key findings of the study is the generally low level of knowledge and skills related to geospatial technologies among geography teachers in Kazakhstan. Several factors may contribute to this situation. First, most teachers did not receive adequate training in GST during their initial teacher education, as geospatial technologies were not yet widely integrated into university geography programs at the time. Second, in-service professional development opportunities focused on GST have been limited, fragmented, or optional rather than mandatory. Third, there is a lack of accessible, Kazakh-language methodological resources and teaching tools that would allow teachers to confidently apply GST in their classrooms. Additionally, the rapid pace of curriculum reform often outpaces the ability of teachers to adapt, especially in rural or under-resourced schools. Finally, digital literacy levels vary significantly, particularly among older teachers who may be less comfortable with new technologies.

The above survey showed that GST is rarely used in practice in secondary education institutions and there is a need to develop teaching aids and materials aimed at teaching GST and organize training courses to develop teachers' spatial skills by teaching the applied basics of GST. According to Jo and Hong (2018), it is also essential to study effective ways of integrating spatial thinking into the training of geography

Table 1. Questions considered in the survey and their results

Question	*Results and Discussion*
1. Do you know the application basics of GIS technologies?	Only 17.6% of respondents indicated that they "know" the applied basics, while 82.4% indicated that they "do not know".
2. "Do you use GST in teaching geography?"	Only 32.8% of respondents answered "yes", while the rest (67.2%) indicated that they "don't know how to use it" or "use it partially."
3. "If you can, what types do you use?"	Of the 36 respondents who answered the question, 27 were able to indicate specific types. Most of those who can use GST use Google earth, google maps,2 GIS in geography lessons. The most frequently incorrectly written answers are:Exel, Word, PowerPoint, Zoom. Analyzing the respondents' answers, the results of the answers given to question 2 change. In fact, only 22.7% of respondents indicated that they use GST(s) in geography lessons
4. "Do you think that using geoinformation resources and technologies is necessary as an auxiliary methodological tool to explain knowledge from geography textbooks to students and to perform practical tasks?"	93.3% of respondents answered "yes", 6.7% answered "no". In general, this question indicated that geography teachers need pedagogical and methodological developments. Teachers who do not need them (6.7%) either have mastered the GST at the required level or, as Sinton (2023) points out, their answers may be related to the teacher's personal motivation and internal resistance. Thus, our prediction was confirmed by the answers given in text form to the following questions (questions No. 6 and No. 8).
5. "Would you like to participate in a course aimed at teaching the applied foundations of GST in teaching school geography with updated content?"	96.6% of geography teachers stated that they would like to participate in advanced training courses that teach the applied foundations of GST. While 3.4% indicated that they would not like to participate. In general, it was found that there is a high demand for advanced training courses.
6. Which section or issue of the "Geography Textbook" do you think should be taught using geoinformation technologies and resources (indicate the grade)?	The majority of responses (87 out of 103, or 85%) indicated upper grades and the subjects taught in them. Of the remaining 17 respondents, 12 indicated lower grades, 2 respondents could not answer, and 3 respondents wrote that the use of GST is impossible due to the lack of specialists and the material and technical condition of the school.
7. What is the level of provision of thematic maps used in geographical education at the educational institution where you work?	22.7% of respondents indicated "bad", 57.1% - "average", and 20.2% - "good".
8. What other problems do you think exist in teaching geography? What are your suggestions for solving them (if any)?	88 respondents answered this question. 10 respondents (11%) wrote that everything is correct and they have no suggestions. 24 respondents (27%) suggested that the material and technical base of the school should be improved, 28 respondents (32%) suggested that the content and quality of school textbooks should be improved (among them, there were many suggestions for re-introducing old textbooks), 8 respondents (9%) suggested developing auxiliary methodological resources, especially Kazakh learning materials. In addition, there were suggestions such as allocating more hours to geography, raising salaries, improving the qualifications of teachers, etc.

Source : secondary data processing

teachers. This will also solve the problem of providing schools with thematic maps. Because GST can provide interactive maps on various topics and issues.

Preparation of 2-level programs of advanced training courses.

Based on the results of the analysis of the content of school geography education programs and the study of geography teachers' needs for geospatial knowledge, we developed a curriculum for the advanced training course for geography teachers. In addition, Kyriacou's (2018) recommendations for the development of an advanced training course were used in its development.

The advanced training courses "Applied Fundamentals of Geospatial Information Systems in Teaching School Geography with Updated Content" were developed, consisting of 2 levels (basic level, advanced level). The purpose of the curricula is to teach methods and techniques for using Geospatial Information Systems and resources in teaching school geography.

The programs were approved by the decision of the Academic Council of the Institute of Natural Sciences and Geography of the Abai Kazakh National University (Minutes No. 8 dated May 4, 2023). They are basic and advanced advanced training courses of 80 academic hours. The program of the advanced training course on the topic "Applied Fundamentals of GST in Teaching School Geography" at the basic level was included in the list of educational programs for advanced training courses agreed with the Ministry of Education of the Republic of Kazakhstan in 2024 (Ministry of Education of the Republic of Kazakhstan, 2024). At the end of the course, in accordance with the provisions established in legislative documents (Minister of Education and Science of the Republic of Kazakhstan, 2016), teachers are issued a certificate of completion of the 80-hour course.

The program of professional development courses offered to teachers consisted of four modules:

1. Normative and legal,
2. Content and procedural,
3. Technological,
4. Variable application.

The basic level advanced training course (80 hours) is designed to teach theoretical knowledge of the types of GST and their application, the use of cartographic services and geoportals in geographical education (Google Earth, Ya Kartograf, Gorus maps, ArcGIS Earth mobile application, World Data Atlas, 3D Earth map, Google Maps, Yandex map, etc.), portals and services for remote sensing and use of their materials (Satellite Tracker - Sputnik, SAS Planet, Kosmosnimki, Sentinel Hub EO browser and Sentinel Playground, US Geological Survey platform, USGS FEWS NET), working with statistical data sites for obtaining geodata, and creating databases in ILWIS and ArcGIS GIS programs.

The advanced level professional development course (80 hours) begins with theoretical knowledge about GIS technology and its capabilities and is aimed at developing practical skills in creating and managing vector models and geodatabases in ArcGIS and Ilwis GIS programs, decoding satellite images, transforming geodata, spatial analysis, visualizing geoinformation, mapping and creating final products.

The professional development course programs are taught in offline and online formats at the Abai Kazakh National Pedagogical University, Institute of Natural Sciences and Geography.

Additionally, an instructional manual has been developed, providing methodological guidelines for performing various tasks and focusing on the application of GST and related resources to enhance teachers' geospatial competence. The textbook consists of 4 sections and has the following 5 advantages:

1. Through the textbook, geography teachers will receive information about more than 60 GSTs and resources, including GIS applications, mobile GISs, geoportals, cartographic services, get acquainted with the features and capabilities of their use, and learn to obtain and work with geographic data from international and domestic sources;
2. The textbook simplifies and makes it more interesting to teach the sections "Cartography and Geographic Databases" and "Fundamentals of Cartography and Geoinformatics" in the geography textbook for senior grades;
3. The textbook provides methodological instructions for completing many complex tasks given in geography textbooks for senior grades.
4. For the convenience of readers, links to GSTs and resources are provided in the textbook via hyperlinks and QR codes.
5. The textbook offers electronic alternatives to paper maps used in the classroom, i.e. interactive and electronic maps.

The curriculum and teaching materials for the advanced training course for geography teachers are available through the website http://giseducation.kz

Experimental study of the effectiveness of the advanced training course

The advanced training course "Applied Fundamentals of Geospatial Information Systems in Teaching School Geography with Updated Content" (basic level) was held at the Faculty of Natural Sciences and Geography of the Abai Kazakh National Pedagogical University from November 4 to 16, 2024. The course was attended by 24 geography teachers from the regions of Kazakhstan.

The pedagogical experiment was conducted in the format of a "single-group pretest-posttest design" and all 24 teachers who participated in the advanced training course voluntarily participated in it. In order to assess their level of geospatial knowledge, tasks corresponding to Bloom's Taxonomy of Educational Objectives (Bloom, 1956) were compiled (Table 2).

The tasks were taken from geography textbooks for grades 9, 10, and 11 of secondary educational institutions (schools). Thus, it was determined how correctly and completely the geography teachers themselves could complete the tasks in the textbook.

The tasks were given before and after the start of the advanced training course and were completed in the classroom by filling in paper forms.

The answers of the experiment participants to each task were evaluated individually on a 100-point scale, and the average score for all options was calculated (Figure 2).

Table 2 - Tasks for assessing the level of geospatial knowledge of teachers

Tasks	Categories on Bloom's taxonomy
What types of remote sensing do you know? What methods are they used for?	knowing
Are the above-mentioned tasks solved in your region using GIS services? Give specific examples.	
Describe how information is presented using a digital map of your place of residence or any other place; 2) How and in what conditions can digital maps be stored?; 3) How do you think it is most effective to work with a digital map on a display?	understanding
Is it possible to get acquainted with the environmental problems of Kazakhstan on the basis of geoinformation technologies and suggest ways to solve them? How?	
Using a GPS-navigator, a smartphone, review digital images taken by satellites moving over the territory of Kazakhstan and show how to use it.	applying
How can you track the geographical location and movement of a certain object using GPS-navigators of the GIS service?	
How can you identify factors affecting the pollution of the World Ocean using geoinformation technologies?	analysis
Analyze attribute data on one thematic map based on the GIS service database. Do these characteristics meet the above requirements?	
Review electronic maps of Kazakhstan and describe what information can be obtained from such maps.	collection
Prepare information about the Kokaral dam (using geoinformation technologies).	
Using a GIS application, determine the length of a river, the area of a lake, and the average volume of a sea, and evaluate the advantages of a modern interactive digital map.	evaluating
What do you think is Kazakhstan's share in the global ecological footprint? What ecological footprint does the economy of your region leave? (Can these be displayed on the basis of cartographic services?)	

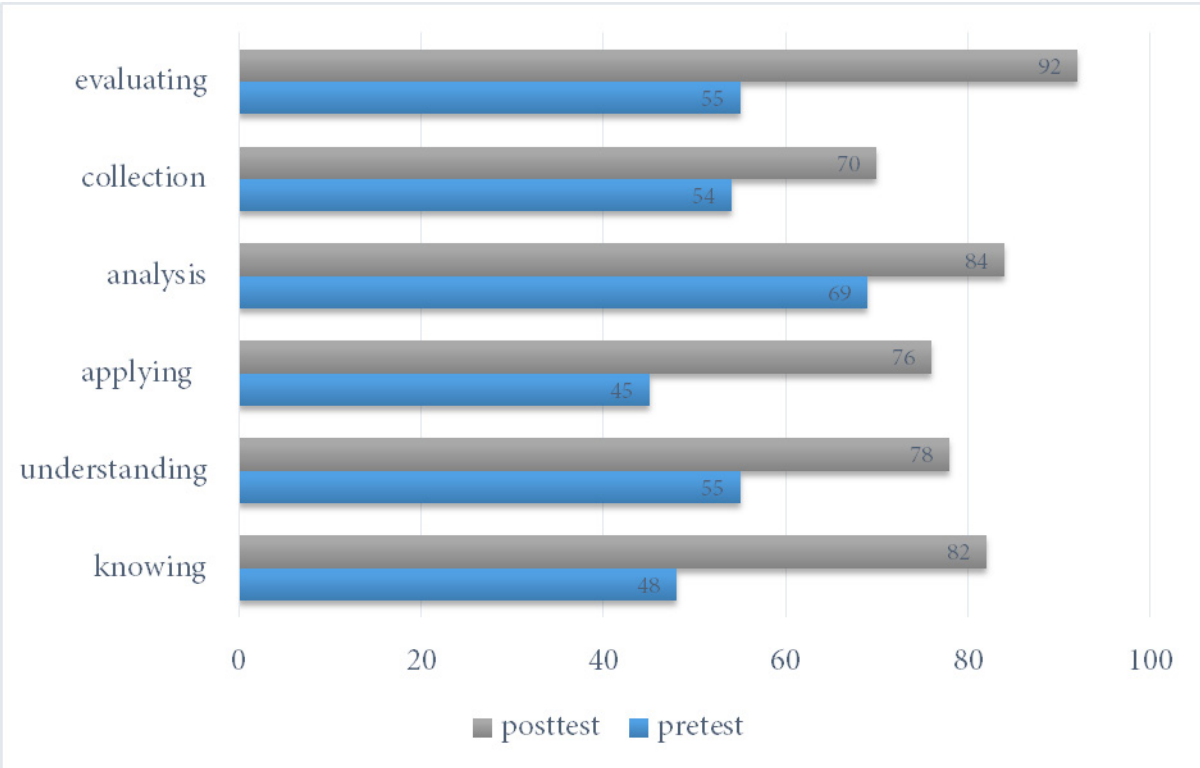

Figure 2. Pretest and posttest results for the advanced training course

The figure shows that the posttest results of the participants increased in all categories compared to the pretest results obtained before the advanced training course. In particular, the answers to the tasks in the "knowing", "understanding", "applying" and "evaluating" categories improved significantly. The posttest results showed that the average score of the participants on the tasks in the "knowing" category during the pretest was 48, while after the advanced training course it increased by 70.8% (34 points). This showed the maximum level of growth when comparing the results of the two periods. And the average score assigned to the answers to the tasks in the "applying" category was 45 points during the pretest, while in the posttest it was found that it increased by 68.8% (31 points). This increase was 67.2%, or 37 points, for

Table 3. Changes in the spatial skills of participants during the experiment

Bloom's Categories	*Level by Pretest*	*Level by Posttest*	*Change*
Know	insufficient level (48 points)	high level (82 points)	Level 2+
Understand	average level (55 points)	high level (78 points)	Level 1+
Apply	insufficient level (45 points)	high level (76 points)	Level 2+
Analyze	average level (69 points)	high level (84 points)	Level 1+
Collect	insufficient level (54 points)	high level (70 points)	Level 2+
Evaluate	average level (55 points)	very high level (92 points)	Level 2+
Across all categories	insufficient level (54 points)	high level (80 points)	Mostly Level 2+

the tasks in the "evaluating" category. The deepening of the geospatial knowledge of the course participants also improved in other categories. For tasks in the "understanding" category, it increased by 41.8% (23 points), for tasks in the "analysis" category by 21.7% (15 points), and for tasks in the "collection" category by 29.6% (16 points).

The results of the experiment conducted on the basis of the "single-group pretest-posttest design" allowed us to determine the changes in the spatial skills of geography teachers who participated in the advanced training course (Table 3).

According to the criteria for assessing spatial skills (Astawa et al., 2019), before the in-service training, the spatial skills of the participants were found to be at the "insufficient" and "average" level, while after the in-service training, they were assessed as "high" and "very high". An increase in the level of spatial skills of the participants was observed in all Bloom's categories. In particular, it was proven that spatial skills in the categories of "knowing", "applying", "collecting" and "evaluating" increased by 2 levels. These results showed that the in-service training has a significant impact not only on the geospatial knowledge of teachers, but also on the level of spatial skills.

After the in-service training, participants in the in-service training provided feedback on their impressions and experiences from the course via social networks. This helps to evaluate and improve the content of the professional development program.

The results of the study show that, as in many countries, GST is currently integrated into the curriculum of geography in the secondary education system of Kazakhstan, and therefore into the content of geography textbooks for senior grades. However, a survey revealed that 1/3 of geography teachers do not use GST at all or only partially in their lessons. The curriculum of geography is constantly being updated (Kolnik, 2010), and this process can be faster than the process of improving the qualifications of teachers. In fact, in some countries, the poor quality of geography education provided in schools is explained by the teaching of unprofessional teachers (Knecht & Spurná, 2022). This undoubtedly further complicates the practical application of GST. If 10 years ago there were conflicting opinions among teachers about the effectiveness of GST (Akinyemi, 2016), now this has become an unquestionable issue. Because they are considered an indispensable tool for any "good and modern geography lesson" (Jo & Solari, 2015). Some teachers confuse GST with GPS and digital maps, ignoring its spatial analysis capabilities. This can also hinder its practical integration into the teaching process (Kerski et al., 2013). However, it is important to consider different ways to integrate it into geography education (Millsaps & Harrington, 2017).

According to Demirci (2009), the study of teachers' knowledge and skills about GIS provides an insight into how they use GIS in schools and how successfully they implement it in their lessons. Therefore, in accordance with the purpose of this study, we found through a survey that only 17.6% of teachers know the basic principles of GIS, and 82.4% do not. They need to improve their skills. The lack of use of geospatial technologies in geography lessons affects the quality of education. Students bear the brunt of this gap (Fairman et al., 2023). According to many scholars (Coulter, 2014; Demirci, 2009; Ocak et al., 2023; Shakhislam et al., 2024), mastering GIS programs and applications can be difficult for teachers. Therefore, they avoid using them (Walshe, 2017). Teachers need to use more accessible and lightweight versions of GIS through a web browser (Ocak et al., 2023; Shakhislam et al., 2024) and mobile GIS applications more often (Issakov et al., 2022; Shakhislam et al., 2024). The technological capabilities of the GST are focused on the evolution of the web platform. It can be configured on any device, edit online maps, analyze and share geospatial information (Somantri & Hamidah, 2023; Walshe, 2017).

A 2-level (80-hour) in-service training curriculum was developed by analyzing the content of the geography curriculum and studying the level and needs of teachers in geospatial knowledge. In addition, a teaching tool was developed to provide methodological support to teachers. The in-service training curriculum first introduced the concepts of GIS and GST, and then demonstrated methods for their practical application. According to Chen & Wang (2015), providing an understanding of GIS in geography is the first step in integrating GST. Avalos (2011) found that long-term programs are more effective than short-term ones, and that a combination of learning tools and reflective practices yields better results. Textbooks, teaching materials, and empirical data developed on the basis of assessment and geocompetence research have proven that not only teachers but also students develop knowledge and skills in geography (de Miguel González, 2017; Kapustin, 2009).

Any training course gives positive results. In our case, this was proven by experimental research. The spatial skills of the participants in the training course increased from the "insufficient" level to the "very high" level. A similar study was conducted by Filipino scientists Somantri & Hamidah (2023). They found that WebGIS had a positive effect on the level of spatial intelligence of geography teachers and that after the training course, the level of spatial intelligence of teachers increased by 28.24%. Millsaps & Harrington (2017) also proved that long-term training is also effective in improving the geospatial knowledge of teachers. According to Hattie (2008), the effectiveness of a training course depends primarily on the quality of teaching. According to his research, 30% of the variation in student performance depends on the quality of teaching. The trainers in the training course we conducted were the best teachers of higher education institutions - geographers, GIS specialists, and the author of a geography textbook for high school students. We believe that their knowledge and experience have greatly influenced teachers' mastery of the GST. According to Brysch (2020), organizing professional development courses in a hybrid format can positively affect its quality and number of participants. However, according to Avalos (2011), not all types of professional development, even those with proven positive effects, may be relevant for all teachers. Therefore, it is important to constantly research, experiment and discuss the educational needs of their students, teachers' working conditions and opportunities for their development.

According to Chen & Wang (2015), GST can be integrated into various subjects such as geography, history, economics, and mathematics. However, geography is the subject most directly related to GST. GST allows students to visualize geodata in the classroom to understand phenomena and processes, patterns, and trends on the ground, to process geographic information (de Miguel González, 2017), to create a collaborative learning environment, to develop project management skills (Mitchell et al., 2022), to develop geospatial thinking and analysis skills (Bearman et al., 2016; de Miguel González, 2017; Donert et al., 2016; Metoyer & Bednarz, 2017), to develop cartographic skills (Robertson et al., 2019), to develop geospatial skills (Jo & Solari, 2015), and to conduct geographical and geoecological research (Jo & Solari, 2015; Kapustin, 2009; Robertson et al., 2019). This develops students' spatial intelligence (Somantri & Hamidah, 2023). Therefore, we believe that in the era of information science and globalization, geographical education is impossible without its use.

4. Conclusion

This study aimed to analyze the geography curriculum and the professional needs of teachers in the context of geospatial education, and to develop and evaluate an in-service training course on geospatial technologies (GST). The analysis of curriculum documents revealed that GST is formally embedded in the learning objectives for grades 9–11, yet practical guidance for implementation is lacking. The survey conducted among 119 geography teachers showed a significant gap in their knowledge and use of GST, with over 80% reporting insufficient understanding and limited classroom application.

In response, a two-level (basic and advanced) in-service training curriculum was developed, along with a methodological manual. The effectiveness of the basic-level course was confirmed through a pretest-posttest experiment involving 24 teachers. After the course, participants' spatial skills improved from "insufficient" or "average" to "high" or "very high" levels across all cognitive categories. These results demonstrate the importance and impact of targeted professional development in enhancing teachers' geospatial competencies.

Future research should focus on evaluating the advanced-level training program, scaling the model to a larger teacher population, and exploring long-term impacts on teaching practices and student outcomes

Funding

This study was funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP13067931 Development of methodological foundations for the use of digital geoinformation technologies in teaching geography of updated content (higher secondary education).

Acknowledgement

We express our gratitude to Kulyash Kaimuldinova, Dean of the Faculty of Natural Sciences and Geography of the Abai Kazakh National Pedagogical University, and Duman Aliaskarov, Head of the Department of Geography and Ecology, for their support in conducting advanced training courses for geography teachers and conducting this research.

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