Usage of Satellite Navigation Technologies in Schools Around the World

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Abstract: The study of satellite navigation technologies in educational courses became common at the end of the 20th and the beginning of the 21st century. The practical use of satellite navigation for educational purposes was developed in 2000 and is actively used in the educational process in many countries. This problem has become especially relevant in technological progress when global positioning systems accompany people daily. In school life, satellite navigators are a powerful technical tool that opens new opportunities for learning and teaching. Satellite navigation provides an opportunity to familiarise students with the concept of coordinates and teaches them to orient themselves in the area both with the help of a map and compass and a navigator's help. In addition, the navigation device is a powerful tool for teaching geography, biology, history, and mathematics. It studies wild nature, compiles relief maps, and conducts local history research. Satellite navigation for game purposes has become widely used in school geographical education in Europe and the USA. Such educational and entertaining games include geocaching, geotating, and geographic crowdsourcing. At the same time, unfortunately, satellite navigation is not used correctly in the Ukrainian school geographic educational system.

1 INTRODUCTION

The study of satellite navigation technology within the context of educational courses in schools began in the late 20th to early 21st centuries. Geoinformation systems and remote sensing data of the Earth have already found widespread use in school instruction as crucial aspects of geoinformatics. The implementation of satellite navigation was delayed because of its primary military application. Access to civilian navigation receivers was restricted during this time (civilian use of GPS on USSR territory was outlawed until 1991). Before the year 2000, the US military used a method to determine coordinates that were not accurate and could result in errors of up to 100 meters.

On May 1, 2000, US President Bill Clinton announced the termination of the "Selective availability" mode. The United States government recognised GPS as a widely used technology in various industries, ranging from urban emergency services to mineral exploration. With the removal of restrictions, GPS users have significantly more accuracy in determining their geographic locations. That marked the practical development of satellite navigation's educational applications. Given that global positioning systems have become an essential aspect of professional activity in various scientific and economic disciplines, students must learn this type of geoinformation technology. As a technical teaching tool, the satellite navigator provides educators with an altogether new level of training and learning. It allows students to develop spatial thinking, which is critical for real-world perception (Kholoshyn, 2017).

2 METHODS

There are various examples of using satellite navigation in school classes in the literature today (Kholoshyn, 2014; Baker and White, 2003; Cooke, 2005; Demirci, 2009; Fang et al., 2007; Gomez, 2013; Lambrinos and Asiklari, 2014; Zarske et al., 2003). The authors propose several techniques and strategies

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for incorporating satellite navigation technology into the educational process. Effective use of this technology in school instruction requires understanding its historical development, advanced pedagogical experience, and careful consideration of the challenges during its implementation.

Therefore, in our opinion, it is necessary to study and analyse the existing experience to promote and widely implement satellite navigation technologies in the educational process of modern schools.

Research object: Analyse the existing worldwide and domestic experience of using satellite navigation in educational institutions and consider the possibilities of its implementation in the practice of modern schools.

3 RESULTS AND DISCUSSION

Satellite navigation was only taught theoretically in schools worldwide until the beginning of the 21st century. The United States of America was at the forefront of this field for an extended period. The study of place is one of the five essential themes with priority in the K-12 geography curriculum of the United States education system, according to the "Guidelines for Geographic Education" adopted by the Joint Committee on Geographic Education in the United States in 1984 (Brooks, 2006). Hill (1989), an American scientist and head of the Center for Geographic Education at the University of Colorado, discovered that location may be determined at two levels: absolute and relative. Absolute location involves determining geographic coordinates (latitude and longitude), while relative location involves determining an object's position relative to other larger or prominent objects. In this aspect, GPS technologies were initially studied in schools in the USA.

A complete lesson for teaching satellite navigation in high school, produced by researchers at the University of Colorado's Navigation Institute (USA), is an example of such an approach. The program included ten standard lessons for students of different ages and levels of preparation (Zarske et al., 2003). The lessons were designed for middle school teachers during regular and extracurricular activities. While analysing the content of the lessons (table 1), it should be noted that the program has a general theoretical orientation, with more than half of the lessons (6 out of 10) dedicated to the fundamentals of cartography. In contrast, others cover satellite navigation operations and application principles. Most courses are theoretically linked but can also be taught individually – students can select topics based on their interests.

The program's key feature is its ability to be easily integrated into the existing curriculum of middle school education in the United States. While most planned courses are directed towards 7th-grade students, they are equally appropriate for use in younger and older schools.

Satellite navigation further evolved into a practical component. Many K-12 standard middle school teachers in the US educational system have increasingly started using GPS receivers during their lessons. However, initially, the application of navigators was dominated by a limited technological approach, where teachers focused solely on teaching students how to operate these devices during the sessions.

Table 2 show an example of this approach using GPS navigators in geography classes by Ninno and Kuhl (2002). The lesson plan analysis indicates that the lesson's primary focus is teaching students how to determine geographical coordinates using the navigator and finding points based on known coordinates.

Later, Tim Cresswell's research improved the subject of establishing location by satellite navigation in school geography. Cresswell (2013) illustrated the importance of broadening educational options for determining the position of various geographical objects. Determining geographical coordinates should not be considered as an aim in itself. Moreover, the prospect of doing extensive research on territories with precise coordinates should be acknowledged. These can include physical landscapes, natural resources, cultural qualities of individuals, and so on (Brooks, 2006).

The statements of Hill (1989) also support the significance of this approach: "Geography is not just about places and names – capitals, countries, and rivers, but rather an entire science about the significance of location." Only in this way can we transition from memorising the names of countries, capitals, and other dry figures and dates to analysing the relationship between humans and the surrounding environment.

This detailed territory analysis converts theoretical knowledge into practical applications. According to Morgan (2003), a renowned British geographer, enhancing spatial literacy contributes to students' active life perspectives, develops their practical problem-solving skills, and opens their eyes to the real world.

The importance of this approach is confirmed by the conclusions drawn independently by Favier and van der Schee (2014), Mitchell et al. (2018), Nielsen et al. (2011), and Osborne et al. (2020). In their works, the authors provide examples of how pupils and students using GIS technologies develop skills

Table 1: Lessons of the comprehensive program for studying satellite navigation in middle school (Zarske et al., 2003).

Lesson title	Lesson description
Where are we?	It contains essential navigation information, such as relative and absolute location, latitude, longitude, cardinal directions, and working with a map and compass.
Becoming a Great Navigator	Discusses the history of the development of navigation methods.
Navigation by Numbers	Demonstrates the role of mathematics in navigation.
Doing it Right!	Discusses faults that limit location accuracy and the function of computers in navigation.
Topographic Map Mania	Provides information on how to read topographic maps and navigate using them in the terrain.
Reaching the Point	The teacher demonstrates how to determine a location using triangulation and practically shows how to locate objects on a map, in the classroom, and in the field.
On Land, Sea, and Air	Shows how navigational techniques expand the possibilities for world travelers and introduces students to various navigation methods.
Satellite-Speed Navigation	Explores the fundamentals of the Global Positioning System (GPS), including trilateration and the use of the speed of light to determine distances to satellites.
GPS in Motion	Discusses the use of GPS receivers for determining location coordinates.
Not Lost in Space	Describes the movements of planets and spacecraft in Earth's orbits, which are used in navigation.

and abilities in solving problem-based tasks related to situations that may arise in real life. Learning based on these technologies encourages independent problem-solving or self-inquiry, which is considered a challenge in geography education (Piotrowska et al., 2019).

As Cooke (2005) rightly pointed out, "Instead of trying to fit GPS and GIS into the curriculum, simply present them as technologies that need to be learned alongside text processing, spreadsheets, the internet, digital photography, or video editing". Gomez (2013) shares a similar viewpoint, emphasising that educators should not teach students 21st-century skills but rather use 21st-century skills in the teaching process. In other words, teachers should focus on something other than teaching students how to use a navigator but actively employ its functional capabilities in the educational process.

For example, Broda and Baxter's research demonstrated how GPS devices can be employed in the classroom to create an atmosphere where students actively investigate their surroundings (Broda and Baxter, 2003).

Navigation devices, utilising the motivational possibilities provided by this technology, disrupt the monotony of everyday classroom learning, promote the use of critical thinking skills in students, and enhance their understanding of geographical concepts (Bednarz et al., 2006).

As a result, despite the navigator's association with geographical tools, many teachers in related subjects have actively begun to use it in their classes. Historians, biologists, physicists, and mathematicians are among those included.

For instance, Baker (2001) shows how a navigation receiver may become a valuable ally for geography, biology, mathematics, and history professors undertaking scientific studies in various areas. The author demonstrates how Minnesota students use satellite navigation to investigate wildlife, research Civil War history, record student movements on the school-home route, and much more.

Overall, the geographical component of using satellite navigation is actively employed by modern educators. For example, Lambrinos and Asiklari (2014) from the Center for Advanced Digital Earth Experience utilised GPS technologies in extracurricular geographical research projects with students from grades 4 to 6. The tasks assigned to the students included determining the coordinates of historical objects using a navigator and plotting them on a paper map at a scale of 1:20000. This allowed students to become familiar with the concept of coordinates, learn how to orient themselves in the terrain using both a map and a compass, as well as understand the principles of global positioning systems. The project resulted in a paper map of the region constructed by the students and a GIS project of positioning historical objects in the ArcGIS environment (Lambrinos and Asiklari, 2014). The use of satellite navigation technologies allows students to be involved in solving real-world problems in an integrative and excit-

Table 2: Lesson plan: GPS navigation and map reading (Hill, 1989; Ninno and Kuhl, 2002).

Lesson content	**Student actions**	**Teacher actions**	**Materials for the lesson**
Introduction by the teacher	Listen to the teacher	Explains the purpose and content of the lesson	Presentation slides in MS PowerPoint
What is GPS and its role in GIS	Listen to the teacher	Explains the basics of GPS and GIS, their relationship, and applications	Presentation slides in MS PowerPoint
Critical functions of GPS Waypoints	Listen to the teacher	Describes the main operations with the Garmin navigator	Presentation slides in MS PowerPoint. Garmin navigator
Navigation actions Waypoint Creation Function. Determination of the Waypoint Name. Navigation to the Waypoint using the "Goto" Function.	Navigation to the Waypoint is using the "Goto" Function. 1. Students follow individual directions. 2. They determine a waypoint and give it a name. 3. Using the "Goto" function, they navigate to the waypoint. 4. After reaching the waypoint, they return to the base.	1. Provides instructions for the navigation task decision. 2. Teacher 1 stays at the base. 3. Other teachers accompany students and ensure compliance with safety rules. 4. Monitors the recording of waypoints.	Garmin navigator. Information cards
Putting GPS points on the map	1. Listen to the teacher. 2. Put the waypoints on the map.	1. Check the correctness of the waypoint. 2. In case of incorrect execution of the task, achieve its repetition.	Printed maps
Navigation actions 2 Create a waypoint with coordinates from the map. Navigate to a waypoint using the "Goto" function.	1. Determine and write out the coordinates of an object from the map. 2. Enter the waypoint in the navigator. 3. Using the "Goto" function, go to the specified waypoint 4. Define the waypoint in the navigator. 5. Zoom in and estimate the difference between the positions of the specified points.	1. Check the correctness of the coordinates. 2. Teacher 1 is at the base. 3. Other teachers accompany students and monitor compliance with safety rules. 4. Explains possible reasons for the discrepancy between the waypoints.	Garmin navigator. Information cards. Printed maps
Quizzes	Listen to and discuss the results of the lesson with the teacher	Discusses the results of the practical part	Part of the presentation in MS PowerPoint

ing manner. For example, elementary school students in Rochester, New York, USA, gather and geographically evaluate water quality data (temperature, pH level, dissolved oxygen and phosphate levels, and other indicators) from rivers flowing into Lake Ontario using global positioning systems. As a result of their efforts, they identified and outlined many contamination zones (Harshman, 2008).

High school students in Syracuse, New York, USA, actively employ navigators in area geological research. Other intriguing initiatives include charting the position of trees on school grounds and providing specific information such as species, size, and projected age. Socioeconomic studies, which include finding vacant or abandoned dwellings and monitoring road sections with poor pavement conditions, can benefit local governments.

Kerski (2003) explained how geography students might use navigators to calculate the circumference of the Earth. The activity is simple and informative, based on calculating the length of one second of latitude.

Harshman's way of building a local terrain profile with a navigator is also intriguing. It entails students using GPS receivers to follow predetermined routes and determine the absolute elevation of checkpoints every 5 meters. It is possible to generate a map of the terrain relief by organising the routes radially from a central point (Harshman, 2008).

Most educators agree that many programs produced within the scope of national educational standards in various nations must effectively teach satellite navigation in traditional classroom formats. As a result, it is advised to actively participate in extracurricular activities such as optional courses and clubs.

Table 3 provides a brief overview of the recommended tasks for learning GPS navigation in the geographical elective course in secondary school, according to American educators (Baker and White, 2003). The following key points, embedded by the authors in the elective program, deserve attention:

- The successful integration of tasks aims to equip students with theoretical and practical skills in using GPS receivers at various application levels.
- The field component of the training includes working with the navigator, learning terrain orientation techniques, and conducting an in-depth investigation of the surrounding area.
- The GPS data is processed using the ArcGIS GIS program.

We should point out that satellite navigation is already being used in schools in Africa and Asia with a low level of economic development despite a need for more critical technical resources. For example, Nigerian researchers (Mba et al., 2017) highlighted the potential of GPS navigation in teaching mathematics and natural sciences, including:

- Creating a map of the school and its surroundings.
- Geocaching.
- Locating various institutions (e.g., examination centres).
- Determining the elevation of different points in the area, and more.

Social media and dedicated websites play a vital role in promoting satellite navigation as an essential technology in education. Because of the popularity of these platforms among young people, new enthusiasts might be engaged in modern technology knowledge. Amos Gikunda's Grind GIS website is a beautiful example of educational work since the author offers numerous facets of geographic knowledge gained by geographic information systems (Grind GIS, 2023) quickly and unobtrusively. He highlights the benefits of adopting this technology in teaching by describing the theoretical and practical features of global positioning systems, including:

1. Increased study accuracy and reliability, particularly during field learning.
2. Visual representation of the acquired results.
3. Inclusion of cutting-edge technologies in the classroom.
4. Facilitating the learning process's mobility.
5. Improving students‘ everyday safety.
6. Gamification in the classroom.
7. Making inter-disciplinary links.
8. Improving computer literacy, among other things.

Overall, the analysis of methodological studies (Albion, 2015; Anunti et al., 2020; Osborne et al., 2020) shows that preliminary training of teachers is necessary for the effective use of satellite navigation technologies in the educational process. Thanks to this, the teacher can develop methods and forms of implementing geospatial technologies in the learning process. As an example, we can cite the recommendations given by Mašterová (2023):

- deal with local problems related to the area around the school and home as a start that can lead to observing other areas later;
- involve fieldwork;
- deal with problems relevant to the learner;
- involve group learning;
- involve prior teacher training (e.g., through workshops), which is essential;
- acknowledge this teaching is time-consuming;
- involve long-term and frequent inclusion of GSTs in teaching, which has benefits; and
- involve a choice of web-based tools, as these are advisable.

The widespread use of gamification technologies is one of the most defining elements of school geography in European countries, particularly in the United States. Satellite navigation has not gone unnoticed

Table 3: A brief overview of the recommended tasks for learning GPS navigation in the geographical elective course in secondary school (Baker and White, 2003).

Name of the task	Purpose of the task	Content of the work
Working with a world map	Updating knowledge about latitude and longitude, teaching teamwork skills	Working in groups of 3 - 4 students: They are playing a game to find the most important objects (cities) using geographic coordinates on the world map.
Introduction to GPS technology, map reading, observation, and data collection	Acquiring practical skills in using a GPS device	Determining geographic coordinates on the school premises, locating places specified by the teacher using the GPS device.
GPS surveying of the area	Learning to conduct surveys of the territory using a GPS device, observing the environmental conditions	Based on the geographic coordinates and data obtained with the GPS device, learning to orient oneself in the area (in the park zone), conducting ecological observations (photography, counting, etc.)
Creating a comprehensive map of the area	Learning to create a map of the locality based on data obtained with the GPS device and eco-geographical observations using GIS	Analysing data collected in groups during the GPS survey of the area, constructing an all-encompassing map of the park's territory utilising ArcGIS, and assessing the knowledge gained by students.

by researchers and educators. The emphasis on gamification surely helps the Global Positioning System (GPS)'s appeal among students.

One of the most common educational games is geocaching. Implementing this technology broadens the educational area beyond the typical classroom. American scientists and educators have contributed to creating educational geocaching, including Christie (2007) and Spencer (2015).

The global development of geocaching has resulted in the emergence of "educational geocaching," an innovative method of teaching, playing, and competing. It includes locations of rare plant species (populations), geological landmarks, natural and cultural monuments, historical sites, and other educational geocache points. Our knowledge of educational geocaching helps us to define its organisational characteristics.

Educators initially hide small caches in convenient locations such as parks, squares, and school premises in this game. Students are divided into teams using a smartphone with a GPS module and a route sheet containing 10-20 waypoint coordinates. Although the coordinates and route sheets are identical for all teams, they start from different locations, determining their route and the order of finding the waypoints.

The game aims to find the maximum number of waypoints and answer the questions hidden at these points in the shortest possible time. Each found waypoint earns the team 1 point. Additionally, a team can earn two bonus points by correctly answering one of the questions. Each waypoint has a "thematic" question, and teams send their answers to the teacher via SMS, who then determines their correctness.

The educational geocaching questions posed to participants are divided into four categories:

1. *Questions about attention and search activity*. Answers to these questions demand attentiveness and observation. For example, if an old photograph is attached to the question, determining the answer to "What in this photo does not correspond to reality" will necessitate the discovery of objects that appeared or disappeared in that region.
2. *Questions on geography that will test student's knowledge*. The teacher verifies students' basic geographical knowledge in an easy-to-understand manner. For example, "Identify the type of soil in the area of the waypoint."
3. *Questions about knowledge of the local area*. Teams search for the answer to "What was here before?" that assumes that the participants either know the history of these places themselves or find out from residents, for example, "Why is this place called 'Smychka'? Why is the street called?" and so on.
4. *Local measurement questions*. The GPS receiver's capabilities can be used to get the answers

to these queries. For instance, the "Area Calculation" feature on the GPS calculates the square's area.

Several variables affect how educational geocaching is conducted, but the following stand out:

1. *Age of students, team composition, and their level of preparation*. The instructor must consider the participants' varying ages when selecting the sites of the caches and creating the questions. The student's technical proficiency, physical prowess, and subject understanding should also be considered when forming teams. Students with leadership experience, skill, and authority should be chosen to lead teams.
2. *Number of participants*. Suppose more than 3–4 teams per educator; control over the game's development may be lost.
3. *Type and quantity of available GPS receivers*. The number of participating teams is based on the number of navigators. Each group should preferably have equivalent equipment to provide equitable conditions.
4. *Availability of computers and Internet access*. Participants must have unrestricted access to computers and the Internet to appropriately prepare and process game results.
5. *Venue selection*. The teacher should carefully select the area where the game will be played. The students should be as safe as possible, and at the same time, it should make it possible to position the caches effectively. The teacher should pay particular attention to the students' safety during the exercises. That includes enforcing rigorous geocaching time limits (which include rest breaks), hiding caches in secure locations, being in regular mobile contact with groups, setting geographic boundaries for the game, etc.
6. *Season and weather conditions*. Since it is an outdoor activity, the weather dramatically impacts how it goes. Before conducting geocaching, the teacher should consider the climatic and meteorological circumstances.

Indeed, the use of gamification technologies in the educational process with the application of satellite navigators is not limited to geocaching. For example, various games are hosted on the GPSgame website, such as Geodashing Golf, GeoVexilla, GeoDashing, GeoPoker, and others. Despite their diversity, all these games share a common foundation – the use of satellite navigation. For instance, Geodashing Golf is a game where players use GPS receivers to navigate to 18 randomly located waypoints. The result depends on how accurately and closely the participant approached each "hole." The winner is the one who, like in golf, visited all 18 virtual holes at the closest distance to them.

Geotagging is another method of using GPS navigators in education that is strongly tied to social media platforms. It is based on using the GPS coordinates of a location as keywords to identify where a picture was shot. Each digital snapshot is given a spatial value and a time value. For instance, the web service Geobloggers (https://www.flickr.com/groups/16736639@N00/) combines the digital map features of maps.google.com with the capabilities of the Flickr.com photo service.

Geographic crowdsourcing is a relatively recent approach to using navigation in education. It entails using students' collective intelligence to produce knowledge that has enormous practical value. An experiment that Google ran in numerous Indian cities exemplifies this. Free GPS navigators were distributed to the populace, and they were tasked with noting the whereabouts of every notable landmark they came across in the city. The object was added to the map if data from numerous sources was available. In a short time, comprehensive city maps were made, showing landmarks, restaurants, government offices, and other structures.

GPS drawing is possible by fusing artistic ability, spatial awareness, and navigational understanding. Its core involves students following a predetermined path while using GPS, and their track points create a precise pattern on the device's screen. Individual words, complete sentences, silhouettes of people, animals, other objects, and more can all be included in the drawing, which is decided upon by the participants themselves. Any activity (including walking, running, skiing, cycling, and driving) can be used to create a drawing.

When describing the use of satellite navigation in Ukraine's educational system, it should be noted that the lengthy ban on open access to the navigation system and the high price of receivers severely limited the application of this cutting-edge technology in domestic and international scientific, technical, and educational spheres. Since 2007, there has been a noticeable increase in interest in satellite navigation, partly due to the introduction of smartphones with GPS capabilities. Therefore, Satellite receivers are increasingly used in schools' teaching and learning processes.

Involving students, teachers, and working scientists in the international science and education program GLOBE (Global et al. to Benefit the Environment), which gained popularity in the early

2000s, was the first time GPS navigators were used in Ukrainian classrooms. Participants in the program received GPS receivers, the cost of which frequently exceeded the monthly budget of a tiny rural school. These receivers were used to identify the coordinates of locations for undertaking ecological measures and climate observations. The Astronavigation Consortium of Universities (UNAVCO) provided technical support and navigator rental services. Participants of this program learned how to use satellite navigators, which ultimately stimulated interest in satellite global positioning technologies among teachers and students.

Summarising our own experience of using satellite navigation technologies in the practice of modern schools, we can draw the following conclusions.

The introduction of satellite navigation systems into the educational process of a modern school can be achieved by the following steps:

1. Inclusion of satellite navigation technologies in the curriculum of school geography courses.
2. Development and use of educational situations and tasks with the use of satellite navigation both in the classroom and in extracurricular activities (scientific picnics, travel lessons, game lessons).
3. Preparation of research projects using navigation systems.
4. Conducting optional classes and geoinformation clubs.

The theoretical and practical component of satellite navigation is an integral part of geography courses: General Geography, Grade 6, Section II Earth on the Plan and Map; Ukraine in the World: Nature, Population, Section I Geographic Map and Work with it; Geographic Space of the Earth, Section I Cartography and Topography. However, this technology should not be limited to these courses only; it should be used as a "cross-cutting" technology throughout the entire geography course through research tasks and game technologies using navigation systems.

During classes and practical work in the field and extracurricular activities, students acquire knowledge about the history of satellite navigation; the structure of the main types of navigation receivers; acquire the ability to determine geographical coordinates using a navigator; solve various applied spatial problems (finding objects by coordinates, laying routes, saving and analysing tracks, etc.)

The tasks for students can be of the following nature:

1. Measuring the Earth's circumference using a GPS navigator;
2. Finding objects by geographical coordinates using a navigator.

To perform the relevant tasks, you can use smartphones with navigation applications (*My Location – GPS Coordinates, GPS Coordinates, My GPS Location*, etc.).

As part of the optional course "Cartography with the Basics of Topography," students learn to work with a digital compass. The digital compass, tied to a satellite signal, determines which way the navigator is turned and displays the data on the receiver screen. In addition to its high accuracy, unlike the magnetic compass, the compass in a satellite navigator has a very important practical function – demonstrating a bearing or course to determine the direction of movement. The compass arrow is a bearing or course indicator of the destination. This function is very useful in solving various spatial orientation tasks.

When performing a polar survey, the navigator is used to accurately determine the locations of points (stations) from which azimuth measurements are made and their relationship to each other. Having recorded the coordinates of the stations and stored them in the receiver's memory in klm format, students in the classroom can easily visualise them using the *Google Earth* geo-service on a computer screen. Then, using a printer, they print the base of the plan, on which all the stations are marked in compliance with all cartographic requirements. Later on, all the results of angular and linear measurements are plotted on this base.

Satellite navigation is actively used in various thematic and scientific studies that require determining the exact location of research points. To improve the quality of student research, navigators should be used in regional hydrological and geological studies and socio-economic studies, such as mapping dilapidated buildings, fixing road sections with poor pavement conditions, etc. Also, navigators and navigation maps are essential attributes of various local history and tourist educational excursions.

Thus, satellite navigation technologies have significant didactic potential in the study of geography and the development of key competencies of primary and secondary schools and contribute to the development of intellectual abilities, spatial thinking, and a holistic view of the world around us.

4 CONCLUSIONS

The conducted research allows us to draw the following conclusions:

1. Satellite navigation is quite actively used in the educational process in many countries of the world, and domestic education system has significant didactic potential but requires a systematic and well-founded methodological approach to this process.
2. Introducing satellite navigation technologies in world education is based on a research approach. Hence, using existing experience in introducing satellite navigation into school education is the key to obtaining the best pedagogical result.
3. Satellite navigation is most successful in countries with a comprehensive GIS education approach.
4. We see further development of scientific research in developing an educational and methodological complex for introducing satellite navigation technology into the school educational process based on the analysis of world and domestic experience.

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