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PERSPECTIVES OF THE IMPLEMENTATION OF WEB GIS TECHNOLOGIES IN PUBLIC SCHOOLS OF ARMENIA

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The 21st century is marked by the rapid development of science and technology, clearly demonstrated by the unprecedented growth of artificial intelligence and machine learning in recent years. Within the framework of geographical science, geographic information systems (GIS) occupy a particularly important place, as they represent a synthesis of geography and modern information technologies. By offering extensive opportunities for the collection, analysis, and visualization of spatial data, GIS significantly expand the methodological toolkit of geography and support data-driven spatial thinking. At the same time, these technologies create favorable conditions for the integration of information technologies into public schools' education, enabling geography to be taught and perceived from a fundamentally new perspective. Based on the results of international research and contemporary educational practices, this article examines the current state of GIS education in public schools in the Republic of Armenia. Attention is given to identifying the main challenges related to the implementation of GIS in the school curriculum, including teachers' preparedness, technical and infrastructural limitations, and the content-related characteristics of existing educational materials. The study emphasizes the need for a systematic approach to GIS integration in secondary education and highlights the potential role of web-based GIS solutions in overcoming existing barriers.

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Introduction. The idea of introducing geographic information systems (GIS) in public schools arose two decades ago. T. Becker in his work [1] notes that, despite the development of desktop applications (DA) in those years, their use in public schools was extremely limited. One of the main reasons for this, according to the author, is the complex design of DA for students, the difficulties associated with their installation and licensing on individual computers. It is noteworthy, however, that in those years when the Internet was not yet as widespread as it is now, T. Becker points out the development and use of WebGIS as a way to solve this

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problem, which will make learning and using GIS relatively easier for the student. In another study [2], conducted in those years, A. Milson, speaking about the difficulties of teaching GIS in public schools, notes that very often this is due to which of these issues corresponds to GIS education: "learning about GIS" or "learning through GIS". If in a public school, GIS education is determined by the first of the questions, then this can be more fitting to Geographic Information Sciences and inherently more like computer engineering, while the second formulation of the question allows the student to develop GIS thinking, and to use GIS as a tool for geographic research to achieve the goal.

Despite the fact that about two decades have passed between the above-mentioned works and our days, nevertheless, this problem continues to be relevant even now. This is evidenced by numerous studies conducted in this area in recent years [1, 3–10]. In particular, as noted by V. Ribeiro et al. [11], despite the development of GIS technologies, these technologies are used in learning process with strict restrictions. And, as the authors themselves note, "At the same time, the poor experience of using these technologies by many teachers creates unfavorable conditions for the introduction of geographic information technologies, while students show more desire to study technologies". With this one sentence, we can say that the authors identify one of the main obstacles to the introduction of GIS in public schools – the low level of teacher training, and, on the other hand, emphasize the most important trend of our days, namely the desire of the younger generation to study technology, which in itself characterizes the problem, which our work is devoted to discussing.

According to [12], an important prerequisite for teaching GIS in public educational institutions is the link between universities and public schools. The main way to ensure this connection is to send students who have studied GIS technologies at universities and own them to public schools in the form of various internships. During this time, the student must draw up a manual containing instructions on how to use GIS technologies, what he shares with the teacher and students who are attached to him. As a result, thanks to the annual iterative work, on the one hand, the number of such manuals is increasing, and on the other hand, the introduction of GIS in secondary schools.

It is important to emphasize that in the main part of the existing research and, in particular in [13–16], WebGIS technologies are offered as the best option for studying GIS technologies in a public school.

Materials and Methods. The literature analysis we conducted in the previous section boils down to the basic idea that at the current stage of technology development, it is necessary to give preference to WebGIS technologies rather than traditional desktop GIS. To have a clearer understanding of this, it is necessary, first of all, to understand what are the main advantages of modern WebGIS technologies, and, conversely, what are the limitations typical of traditional desktop GIS systems.

One of the first and most important advantages is that dependence on computer resources is reduced. WebGIS applications deployed in a cloud environment (AWS, Azure, GCloud), depending on the degree of workload, can expand their resource capabilities both vertically and horizontally, and all this in an automated manner. What does this mean in terms of education? First of all, the important precondition

that exists for the use of desktop GIS is eliminated, according to which, running a program on a PC depends only on the resource capabilities of that PC. This means that the availability of powerful computer resources is no longer a prerequisite for the implementation of GIS programs in educational institutions. Having a high-quality Internet connection is quite enough to use the WebGIS applications.

The use of a WebGIS also makes it possible to solve the problem of spatial data storage. The fact is that in the case of desktop GIS programs, the main spatial data storage environment is the PC's local file system, which is a limited resource. In the case of WebGIS, since they run in a cloud environment, as we have already mentioned, such resource constraints may not be a significant obstacle. At the same time, the WebGIS applications are flexible enough to integrate with various high-tech solutions. In particular, they can be easily integrated with various relational as well as non-relational databases such as PostgreSQL/PostGIS, MySQL, Cassandra, AWS S3, AWS RDS, AWS Aurora, AWS DynamoDB, MongoDB, etc., allowing incoming data to be stored in the most optimized and classified way. From the education perspectives, this means, that storing spatial data, which is growing every day, will no longer be a problem, and the user, in this case a student, can upload the spatial data he has at hand directly to the WebGIS platform without worrying about the secure storage of this data. Cloud environments provide high data storage security and accessibility from anywhere in the world.

Integration capabilities with various online services enable the use of web-based GIS platforms for real-time or real-time spatial data analysis. In particular, special tools for spatial visualization of earthquakes occurring in different parts of the world can be integrated into the WebGIS platform. From an educational point of view, it will be crucial for the student to, for example, in addition to a theoretical understanding of earthquakes, it will also be possible to work with relevant data and perform relevant cartographic work.

WebGIS applications, as modern information tools, have ample opportunities to include special tools working with artificial intelligence (AI), which is becoming more popular every day. By implementing the appropriate tools, a student who does not yet have the necessary skills to work with GIS technologies will have the opportunity to implement the simplest visualizations simply by interacting with AI on the WebGIS platform.

After all, WebGIS applications, unlike desktop GIS programs, provide the opportunity for group work, for which the main purpose of research between groups of spatial data is the effective exchange of information. From an educational point of view, this makes perhaps the most important sense when students from a group will be able to implement joint projects, study and visualize, its individual components, then put it all together as a final result. Doing group research can be a serious incentive to increase a student's interest in GIS technologies.

Results and Discussion. The main obstacles to the introduction of the GIS in public schools in our Republic can be divided into two different groups:

1. Insufficient theoretical and applied skills of teachers in the field of GIS technologies.
2. Technical limitations related to access to spatial data, their quality, as well as the complexity of programs, etc., and their licensing restrictions.

In the public schools of the Republic of Armenia, the teaching of GIS is related to the subject “Geography”. To date, the GIS topic is taught only in the textbook “Geography 10” for the 10th grade [3]. The topic is presented on only 2 pages. Naturally, from the very first approach, it can be stated that this volume is extremely insufficient if we set ourselves the goal of increasing the role of GIS in public schools. And this, of course, is a very urgent problem., which almost all developed countries of the world are striving to solve. Returning to the presentation of the topic of GIS in the textbook for the 10th grade “Geography 10”, if we try to summarize the content of the topic, it will lead to the following main points:

1. The topic emphasizes that modern geography is not only about creating maps, but also spatial analysis, modeling, and forecasting. GIS is an important tool in the study of natural and socio-economic processes (for example, population, economy, environment, resources, etc.).

2. The main components and technologies of GIS are briefly mentioned, in particular databases, data entry and digitization systems for maps, database management systems, global positioning system, geographic analysis system, image processing system and cartographic visualization system.

If we try to consider the content of the topic about GIS in textbook “Geography “ from the point of view of the questions given in the introductory section of this work: “learning about GIS” or “learning through GIS”, then this topic from the textbook is more focused on the first question in its content. Therefore, the topic of GIS in the textbook “Geography 10” for the 10th grade needs to be adjusted meaningfully and should at least be focused on the question “learning through GIS”.

The vast majority of teachers teaching in RA public schools are not familiar with any GIS technology and do not have the skills to work with this technology. In fact, this is a very large gap that exists today, despite the fact that in the universities of the Republic of Armenia with a pedagogical bias, GIS is one of the main subjects of study in the bachelor’s degree program.

Regardless of the fact that there are relevant courses in university educational programs, both for bachelor’s and master’s degrees, nevertheless, teaching in public schools faces challenges. The reason is the inefficiency of communication between universities and public schools. This is reflected in the fact that a student, who studied GIS at a university, cannot introduce his knowledge of the same subject at school during his teaching practice. This problem, in turn, is caused, on the one hand, by the specifications of the content of educational practices, and, on the other, by the technical limitations existing in schools.

If the first problem can be regulated by the university from the outside, such as in a school of pedagogical practice in GIS, knowledge sharing is a prerequisite, an appropriate class or classes, conducting guidelines for drafting by, etc., then the second problem is inherently a problem for the republic level. The fact is that there are still no WebGIS platforms in Armenia that would make it possible to reduce dependence on computer resources available in schools, in particular, on their capacity. The availability of WebGIS platforms and Internet connections, in many ways, will make it easier to implement GIS study in public schools. A teacher or student will not have to think about installing GIS desktop programs on computers, ensuring their smooth operation, licensing, or working with complex tools. Instead,

they can access the WebGIS platform for educational purposes, use a spatial data database designed for a special school curriculum, and implement data visualization and digital mapping. The availability of the WebGIS platform on the other hand, will facilitate the teacher retraining process. Instead of working with complex desktop GIS programs, the teacher can gain a knowledge on WebGIS platform usage from online courses and obtain spatial data from open source databases.

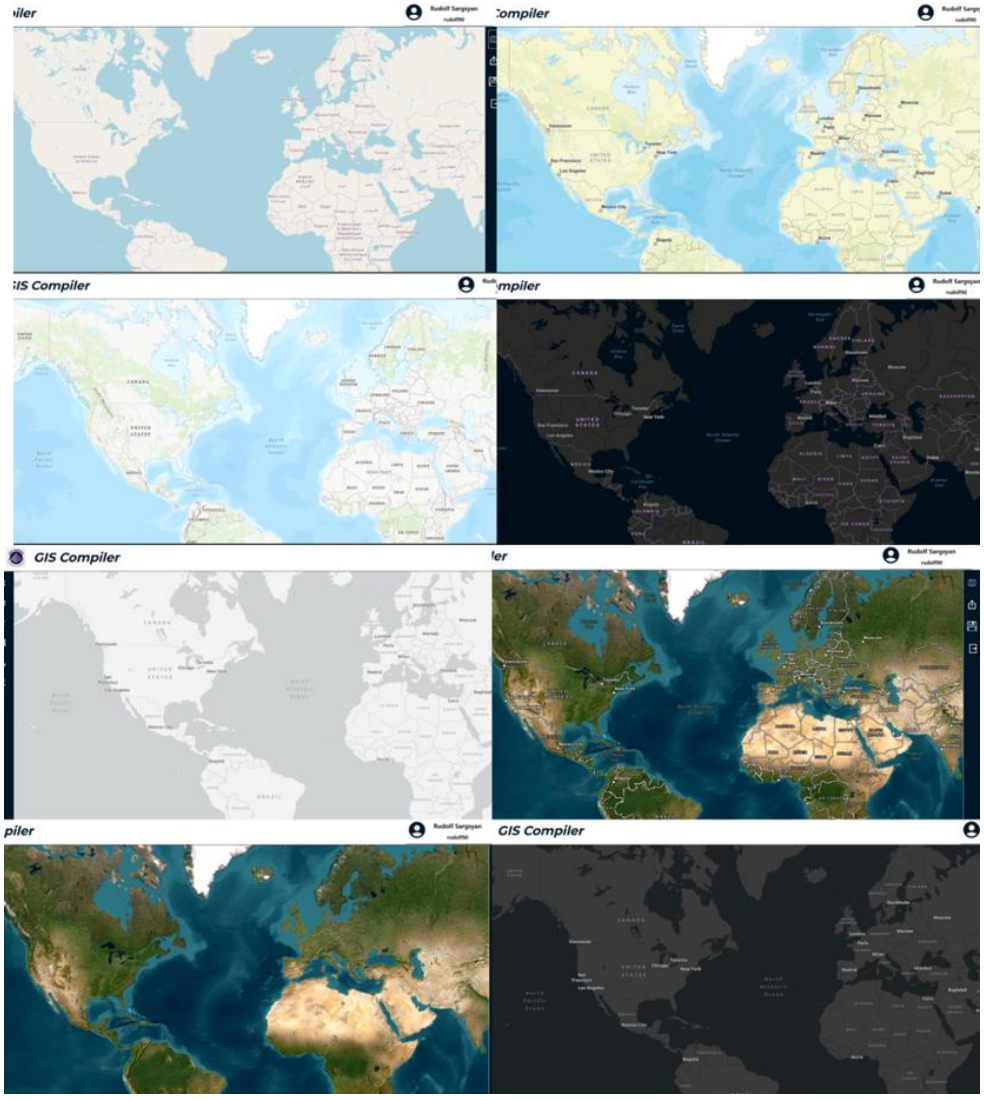


Fig. 1. Basemap layers available in GISCompiler WebGIS platform.

This highlights the urgency of creating a unified WebGIS platform and a corresponding open database of spatial data in our country. We have already taken appropriate steps towards the creation of a unified WebGIS platform (GISCompiler), which will possess all the features presented by us in the previous section of the work. Nevertheless, the creation of the WebGIS platform will only be the first important

step towards solving the problem of implementing GIS in the public schools of the Republic of Armenia. The complete and comprehensive solution to the problem requires a systemic approach, including teacher training, revision of educational program content, and the creation of WebGIS infrastructure.

GISCompiler will be a fully cloud-native Web GIS platform. It will consist of several important software components, the main one of which will be the so-called frontend layer. At this level, users enter the system, visualize spatial data, and create web maps. The main component of the interface is the desktop, which shows the cartographic basis, with all thematic layers that are selected or added by the user (Fig. 1).

In addition to the desktop, the main toolbar is available on the platform. The subsections "Projects", "Layers", "Editor", "Data Management", "User Management", "AI Assistant", "Earthquake Data" are available here. The "Projects" subsection stores a list of projects supported by the user. For each project, in the "Layers" section, the user will see the main layers that have been added to the basemap. It is worth emphasizing that the platform will allow you to work with both vector (Fig. 2) and raster (Fig. 3) spatial data models.

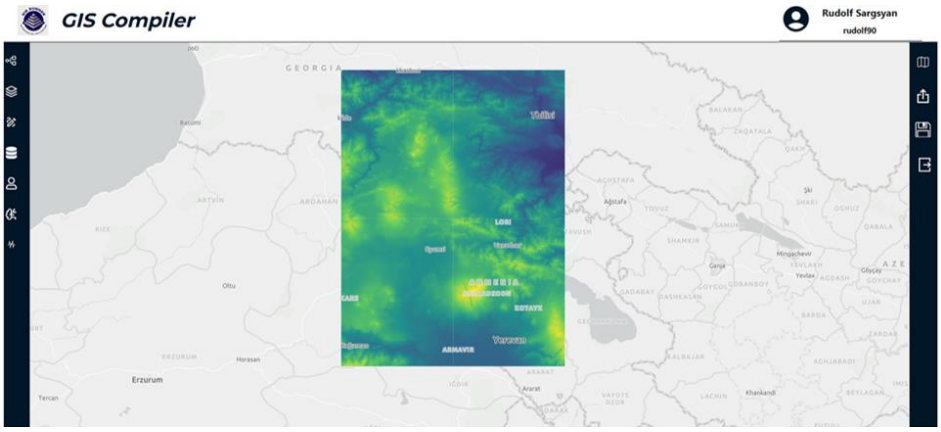


Fig. 2. Vector data visualization in GISCompiler WebGIS platform.

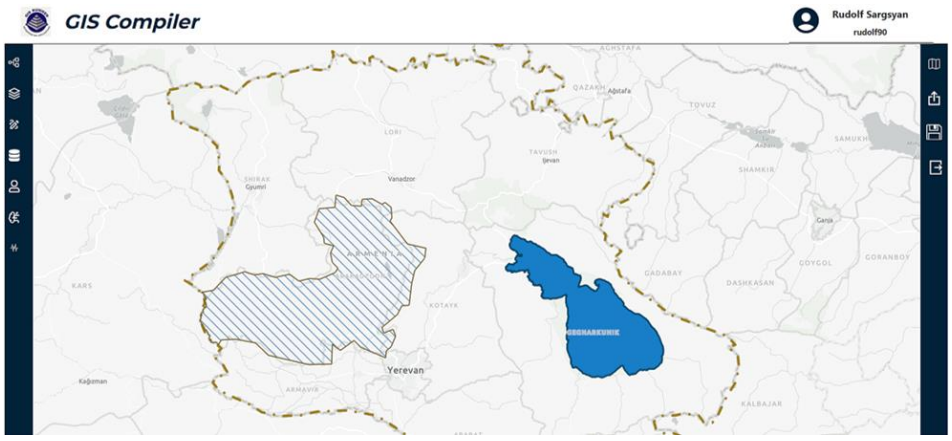


Fig. 3. Raster data visualization in GISCompiler WebGIS platform.

In the “Editor” section, the user can select the appropriate type of vector spatial data, pre-select color properties, and then display various types of objects on the map in dynamic form (Fig. 4). This tool allows you to automatically calculate and obtain some spatial characteristics of the depicted object, for example, in the case of point objects, its geographical coordinates are calculated. In the case of a linear feature, its length, and in the case of a surface feature, its perimeter and occupied area. It can be said that the “Editor” tool is exactly what ensures the interactivity of web cartography for the user and reduces his dependence on the availability of ready-made source data.

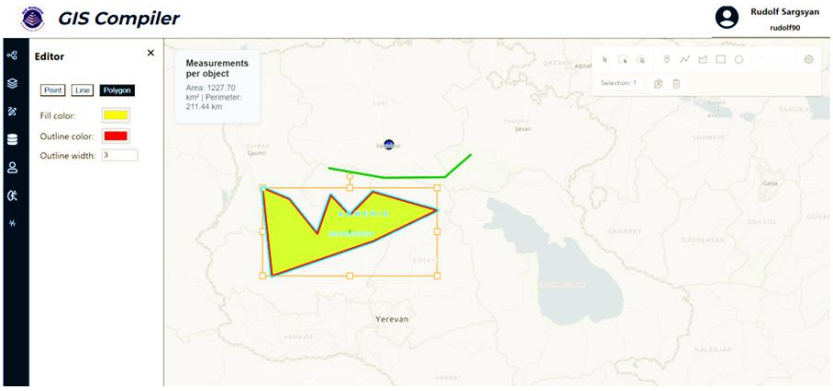


Fig. 4. Editor section in GISCompiler WebGIS platform.

In the “Data Management” section, it will be possible to link the GIS platform to a spatial database, from where it will be possible to import spatial data for visualization.

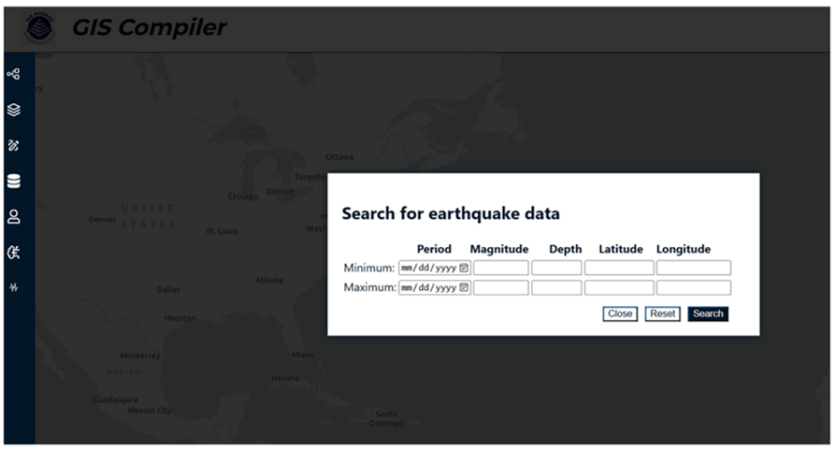
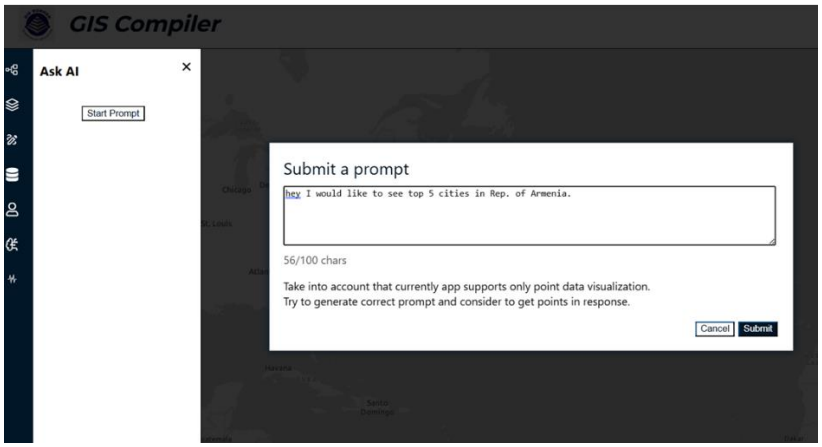


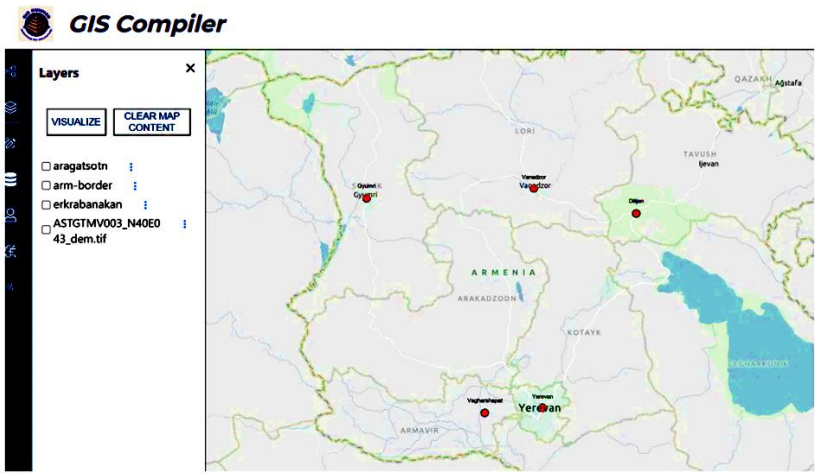
Fig. 5. Eartquake modal in GISCompiler WebGIS platform.

The “User Management” section is a control panel designed for managing users linked to the superuser. The “Earthquake Data” subsection is intended for visualization of earthquake data. In this case, earthquake data comes from open data sources from the EMSC (European-Mediterranean Seismological Center) and the

United States Geological Survey (USGS). In the pop-up window, you must enter additional information about the search period, the boundaries of the search area, the depth and magnitude ranges of earthquake epicenters (Fig. 5).



a



b

Fig. 6. AI prompt modal in GISCompiler WebGIS platform (a) and AI request results visualized in GISCompiler WebGIS platform (b).

The “AI Assistant” subsection is designed to visualize the objects you are looking for by sending a request to artificial intelligence. If it completes successfully, the requested objects will be automatically rendered on the platform (Fig. 6, a and b).

The implementation of a WebGIS platform in the educational process can also address another significant issue that has arisen as a result of the educational reforms being carried out in the public school sector of the Republic of Armenia. Currently, the allocation of hours for geography in high school has changed. According to the relevant guidelines [17] from the Ministry of Education, Science, Culture, and Sports, if a student chooses geography as a targeted subject, then a minimum of 5 academic

hours per week are allocated (with an annual workload of 170 *h* from the individual component). Today, the recommended textbook "Geography 10" by A. Khachatryan and Yu. Muradyan, which we have already mentioned, has only 58 paragraphs. This means that for the minimum of 170 *h* per year (hours from the school component can only increase), the textbook contains only 58 lessons, representing 34 percent of the allocated time. The implementation of a WebGIS platform, in this regard, will only contribute to solving this problem, as by increasing the weight of GIS in the educational process, the volume of practical and thematic work organized through it can essentially be increased, which will be entirely possible to direct towards filling the aforementioned quantitative gap.

Conclusion. The analysis of the literature implemented in the work and the current state of teaching GIS in public schools of the Republic of Armenia allows us to draw a number of reasonable conclusions:

1. It has been established that the problem of introducing geographic information systems in public schools is systemic and is not limited by the lack of technological means. The main obstacles to the effective application of GIS are due to both the insufficient theoretical and applied skills of teachers in the field of GIS, as well as technical and organizational limitations, including software complexity, licensing issues, and limited access to spatial data.

2. It is becoming clear that in public schools of Armenia teaching of GIS, is currently carried out in a strictly limited framework and is mainly based on the "Learning about GIS" approach. In "Geography 10" textbook the topic of representation of GIS, its scope and content does not provide students the GIS thinking and does not promote GIS application as a geographical research tool.

3. The conducted research shows that, despite the inclusion of GIS in the university educational programs of the Republic of Armenia, this knowledge is not passed on to public schools due to the inefficiency of the university–school relationship. The lack of application of GIS knowledge in the course of pedagogical practices hinders the continuity of knowledge transfer and limits the possibilities of implementing GIS at the public school education level.

4. The combination of international experience and studied researches allows us to conclude that WebGIS technologies are the most suitable and realistic solution for the implementation of GIS in public schools. WebGIS platforms significantly reduce technical and licensing restrictions, simplify the learning process, and create favorable conditions for both students and teachers.

Summing up, it can be concluded that effective implementation of GIS in public schools in Armenia is possible only with a systematic approach, which should include a review of educational content, targeted teacher retrainings, strengthening cooperation between universities and schools, as well as the creation of a WebGIS platform and an open source database designed for school education. This approach will contribute not only to increasing the role of the GIS in public schools, but also to modernizing the subject of Geography and changing its perception by society.

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ՎԵԲ ԱՏՀ ՏԵԽՆՈԼՈԳԻԱՆԵՐԻ ԿԻՐԱՌՄԱՆ ՀԵՌԱՆԿԱՐՆԵՐԸ ՀՀ ՀԱՆՐԱԿՐԹԱԿԱՆ ԴՊՐՈՑՆԵՐՈՒՄ

Ամփոփում

21-րդ դարը նշանավորվում է գիտության և տեխնոլոգիայի արագ զարգացմամբ, որն արտացոլվում է վերջին տարիներին արհեստական բանականության և մեքենայական ուսուցման աննախադեպ զարգացումը: Աշխարհագրական գիտության շրջանակներում աշխարհագրական տեղեկատվական համակարգերը (ԱՏՀ) կարևոր տեղ են գրավում, քանի որ դրանք աշխարհագրության և ժամանակակից տեղեկատվական տեխնոլոգիաների սինթեզն են: Առաջարկելով տարածական տվյալների հավաքագրման, վերլուծության և պատկերման լայն հնարավորություններ՝ ԱՏՀ-ն մեծապես ընդլայնում է աշխարհագրության մեթոդաբանական գործիքակազմը և նպաստում տվյալների վրա հիմնված տարածական մտածողության ձևավորմանը: Միևնույն ժամանակ, այս տեխնոլոգիաները բարենպաստ պայմաններ են ստեղծում տեղեկատվական տեխնոլոգիաները հանրակրթական դպրոցական կրթության մեջ ինտեգրելու համար՝ թույլ տալով դասավանդել աշխարհագրություն և ընկալել այն սկզբունքորեն նոր տեսանկյունից: Հիմնվելով միջազգային հետազոտությունների արդյունքների և ժամանակակից կրթական պրակտիկայի վրա՝ սույն հոդվածում դիտարկվում է ՀՀ հանրակրթական դպրոցներում ԱՏՀ-երի ուսուցման ներկա վիճակը: Հատուկ ուշադրություն է դարձվում դպրոցական ծրագրում ԱՏՀ-երի ներդրման հետ կապված հիմնական խնդիրների բացահայտմանը, ներառյալ ուսուցիչների պատրաստվածությունը, տեխնիկական և ենթակառուցվածքային սահմանափակումները և առկա ուսումնական նյութերի բովանդակության բնութագրերը: Ուսումնասիրությունը ընդգծում է ՎԵԲ ԱՏՀ տեխնոլոգիաների ընդհանուր կրթական համակարգում ինտեգրման համակարգված մոտեցման անհրաժեշտությունը և մատնանշում դրանց հնարավոր դերը առկա խոչընդոտները:

Р. С. САРГСЯН, А. С. ПИЛОЯН, А. О. НЕРСИСЯН

ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ ВЕБ-ГИС-ТЕХОЛОГИЙ В ОБЩЕОБРАЗОВАТЕЛЬНЫХ ШКОЛАХ АРМЕНИИ

Резюме

XXI век ознаменован быстрым развитием науки и технологий, что свидетельствует о беспрецедентном развитии искусственного интеллекта и машинного обучения в последние годы. В географической науке географические информационные системы (ГИС) занимают особенно важное место, поскольку представляют собой синтез географии и современных информационных

технологий, предлагая широкие возможности для сбора, анализа и визуализации пространственных данных. ГИС значительно расширяют методологический инструментарий географии и способствуют формированию пространственного мышления, основанного на данных. В то же время эти технологии создают благоприятные условия для интеграции информационных технологий в общеобразовательное школьное образование, позволяя преподавать географию и воспринимать ее принципиально с новой точки зрения. Особое внимание уделяется выявлению основных проблем, связанных с внедрением ГИС в школьную программу, включая подготовку учителей, технические и инфраструктурные ограничения, а также характеристики содержания доступных учебных материалов. В исследовании подчеркивается необходимость системного подхода к интеграции Веб-ГИС-технологий в систему общего образования и указывается на их потенциальную роль в преодолении существующих барьеров.