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MODERNIZATION OF GEOGRAPHIC EDUCATION AT HIGH SCHOOL: GEOINFORMATION TRAINING MODELS

Abstract. The paper deals with contemporary trends of modernization of higher education in the countries of Europe, emphasizes relation between the quality of education and the level of development of the countries' economy, confirms the importance of digital education and provision of new forms of educational services. The problem of mastering new technologies using geoinformation systems and technologies in the process of training future specialists-geographers and geography teachers is analyzed. It is proved that one of the ways of addressing the outlined problem is the implementation of geoinformation training models, and the place of such models among other types of geography training tools is determined. The paper explains the concepts "training model", "geoinformation training model" and outlines their didactic peculiarities. The system of graphic-sign geographic training models is presented, with geoinformation training models being their subtype. The trends of applying geoinformation systems and technologies in the process of teaching geographic disciplines at higher education institutions are characterized. Based on the experience of application of geoinformation training models, the paper emphasizes that they are tools of students' independent cognitive activities. The paper distinguishes three groups of these models (general, special, combined) and characterizes their varieties. Considerable attention is paid to characterizing special geoinformation models, viz. rendering models, first of all digital elevation models, "draping" models, as well as models of kinematic animation or dynamic interactive visualization of 3D images, routing optimization and self-training models. A considerable didactic potential of electronic maps and atlases is emphasized, which make it possible to study geographic objects, processes and phenomena in the spatial aspect. The conclusion is made that the application of geoinformation training models, on the one hand, allows students to explore independently certain natural or socio-economic objects of the environment. On the other hand, tutors can plan students' efficient training activities at a high level of complexity and in accordance with their interests.

Keywords: geographic education; teaching geographic disciplines at higher education institutions; geography training tools; geoinformation systems and technologies; geoinformation training models.

1. INTRODUCTION

The problem statement. In the conditions of the rapid changes observed in the third millennium, geographic education becomes an essential component of socio-economic and cultural development of society. This is explained by the fact that in the integrated process of economic growth and the global environmental crisis, research and innovations in geographic science and education play a crucial role. Under such conditions, the modernization of teaching of geographical disciplines in higher education institutions should be carried out in the ways conforming to changes in the European educational areas.

Based on analysis of the quality of political institutions and educational principles in 69 regions of Europe, G. Tabellini, an Italian economist, proved that GDP and the pace of socio-economic development of countries were related to prevailing cultural values directly determining the areas of education development [1]. Graphical and statistical processing of data of the global project World Values Survey [2], carried out by G. Tabellini, makes it possible to conclude that European countries with a developed economy and a high standard of living are also characterized by a high quality and continuous modernization of higher education [1], [2].

The World Declaration on Higher Education for the 21st Century: Vision and Action emphasizes the role of education as the most important pillar of human rights, democracy, sustainable development and peace. The document acknowledges the urgent need for transition from the traditional lecture-expert model of training to pedagogy of interaction and collaboration, which will be developing on the basis of technologies as an integral part of modern life [3].

The activities of domestic higher education institutions, which, according to requirements of the European Association for Quality Assurance in Higher Education, should become more diverse in terms of methods of provision of education and cooperation, including the growth of internationalization, digital education and new forms of educational services, are targeted to implementation of this program. As the Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) state, the educational environment in higher education institutions has to "encourage innovations in methods of training and using new technologies" [4, p.14].

Analysis of recent studies and publications dealing with determination of the areas of modernization of contemporary education and geographic education in particular, allows confirming the importance of the chosen problem in Ukraine and abroad.

Social studies in European countries demonstrate change in the priorities of the young people. So, in the article *Why We Need to Future-proof Universities*, T. White [5] states that 73 % of 15- to 18-year-olds prefer the high-speed Internet most of all. At the same time, 87% representatives of the so-called Generation Z believe that universities will help them become independent, thanks to mastering digital communication and information tools [5].

A lot of studies deal with the issues of modernization of education based on the application of innovative techniques and technologies in the sphere of higher education. In particular, O. Mikhaylenko and T. Blayone [6], on the basis of the analysis of educational indicators in the countries of Europe, note that "education is a kind of a bridge between traditional and new values, therefore finding an optimal balance between traditions and innovations is the "underwater" content of any educational reform" [6].

The Commission on the Geographical Education of the International Geographical Union developed in 2016 the New International Charter, which includes a program of actions envisaging further development of world and national geographic education on the basis of mastering the updated technological approaches to it [7].

The use of geoinformation systems (GIS) and technologies in training of geographers and geography teachers is now a mandatory part of educational process in higher education institutions of Ukraine. Issues related to their use were analyzed in publications of T. Dudun [8], S. Kostrikov and I. Chervanyov [9], V. Samoilenko et al. [10], O. Sinna et al. [11] and others. At present, quite a large number of educational materials aimed at mastering GIS-technologies have been created in Ukraine. Textbooks and manuals of relevant subjects of the following authors have become useful for students: V. Samoilenko (2003, 2010) [12, 13]; O. Ishchuk, M. Korzhnyev, O. Koshlyakov (2003) [14]; V. Kozhevnikov, A. Kozhevnikov (2005) [15]; V. Morozov (2006) [16]; O. Svitlichny, S. Plotnitsky (2006) [17]; V. Shipulin (2010) [18], L. Datsenko and V. Ostroukh (2013) [19] and others. The English-Russian-Ukrainian Geoinformatics Dictionary authored by B. Busygin et al. (2007) [20] and the English-Ukrainian textbook *GIS Designing* by V. Samoilenko et al. (2015) [21] were published and gained popularity. According to [21] "GIS (geographic information system, geoinformation system) is an information system, which provides an administration (acquisition, retention, processing, access, visualization, dissemination), examination and simulation of spatial (geographic) data".

All of the above defines the necessity of further development of modern approaches to updating geographic education. Now, a vital question is what kind of progressive professional competencies a university graduate will acquire by choosing a geographical specialty. The problem of mastering the latest technologies by students and, in particular, geographic information systems and technologies, is obviously vital. One of the ways to address this problem is large-scale implementation of geoinformation training models.

The goal of this paper is to highlight the place of geoinformation training models in the system of geography training tools and to describe the varieties of these models and the peculiarities of their use in the process of teaching geographic disciplines.

2. RESEARCH METHODS

During the research, we used the methods of analysis and summing up of psychological, pedagogical and methodological literature in order to understand the state of the problem under research. Pedagogical observation of the methods of use of geoinformation training models was carried out in classes in geographic disciplines (Geology, Hydrology, Physical Geography of Continents and Oceans) at the V.G. Korolenko National Pedagogic University of Poltava. It was aimed at determining the didactic conditions of implementation of these models. Interviewing students and academics with subsequent mathematical and statistical processing of the results made it possible to analyze their feedback. Testing of students, aimed at determining the dynamics of their learning achievements, provided a concrete definition of ways to correct the proposed procedure.

3. THE RESULTS AND DISCUSSION

3.1. Geography training tools

The effectiveness of studying geography essentially depends on technological support of this process, primarily on training tools. We consider the latter as natural and artificial tools that act as geographic information media, tools for creating the information and subject environment of educational process and tools of learning and cognitive activity of students [11].

Geography training tools are differentiated according to various principles. The differentiation of these tools according to their content and application, proposed by us, involves selection of groups of object-natural, object-substitutive, device-natural, hardware-supporting and integrated-information tools (Table 1).

As table 1 shows, cartographic and geoinformation training tools (with geoinformation training models being one of their subtypes) belong to the group of object-substitutive ones. Training tools of this group substitute real geographic objects of study.

Table 1

Differentiation of geography training tools according to content and application

Groups of training tools				
Object-natural	**Object-substitutive**	**Instrument-natural**	**Hardware-supporting**	**Integrated-informative**
Types of training tools				
1) real-geographic; 2) piecewise-geographic.	1) verbal; 2) illustrative-pictorial; 3) audiovisual; 4) cartographic-geoinformation; 5) prototype: 6) combined object-substitutive	1) geodetic-topographic; 2) meteorological; 3) hydrologic; 4) geometric; 5) astronomic; 6) other instrument-natural	1) properly computer tools; 2) autonomous audiovisual; 3) information-capturing; 4) position-navigating; 5) other hardware-supporting	1) multi-object conditionally interactive; 2) multimedia

According to the above-mentioned, cartographic-geoinformation tools are varieties of training models.

It is expedient to clarify the essence of the concept of a "training model" and outline the didactic capabilities of these models. In geography didactics training models mean training-visual tools substituting geographic objects of study with a certain degree of simplification. This simplification aims at identifying those features of objects that need to be studied. The value of these models consists in the fact that they make it possible for students to observe and comprehend the necessary content of the properties of a geographic object, process or phenomenon.

3.2. Graphic-sign geographic training models

Among training models, graphic-sign geographic training models occupy a dominant position. Their data handling helps students, on the one hand, to realize the features and properties of the structural and functional components of geographic objects of study and their typical changes in space and time. On the other hand, independent construction of various graphic-sign geographic models contributes to formation of the ability to acquire, record, analyze and transform geographic information. There are four groups of graphic-sign geographic training models, namely: analytical-illustrative, cartographic-geoinformation, structural-logic and combined models (Figure 1).

As Figure 1 shows, the following types belong to cartographic-geoinformation training models:

1) cartographic training models – geographic maps, topographic plans, contour maps, choropleths, schematic maps, value-by-area maps, cartographic sketches and cartographic cross-sectional models (hypsometric transverse sections, vertical sections and block diagrams);

2) geoinformation models – a complex of various cartographic models created using

computerized spatial-analytical program-specialized training tools (first of all, GIS tools).

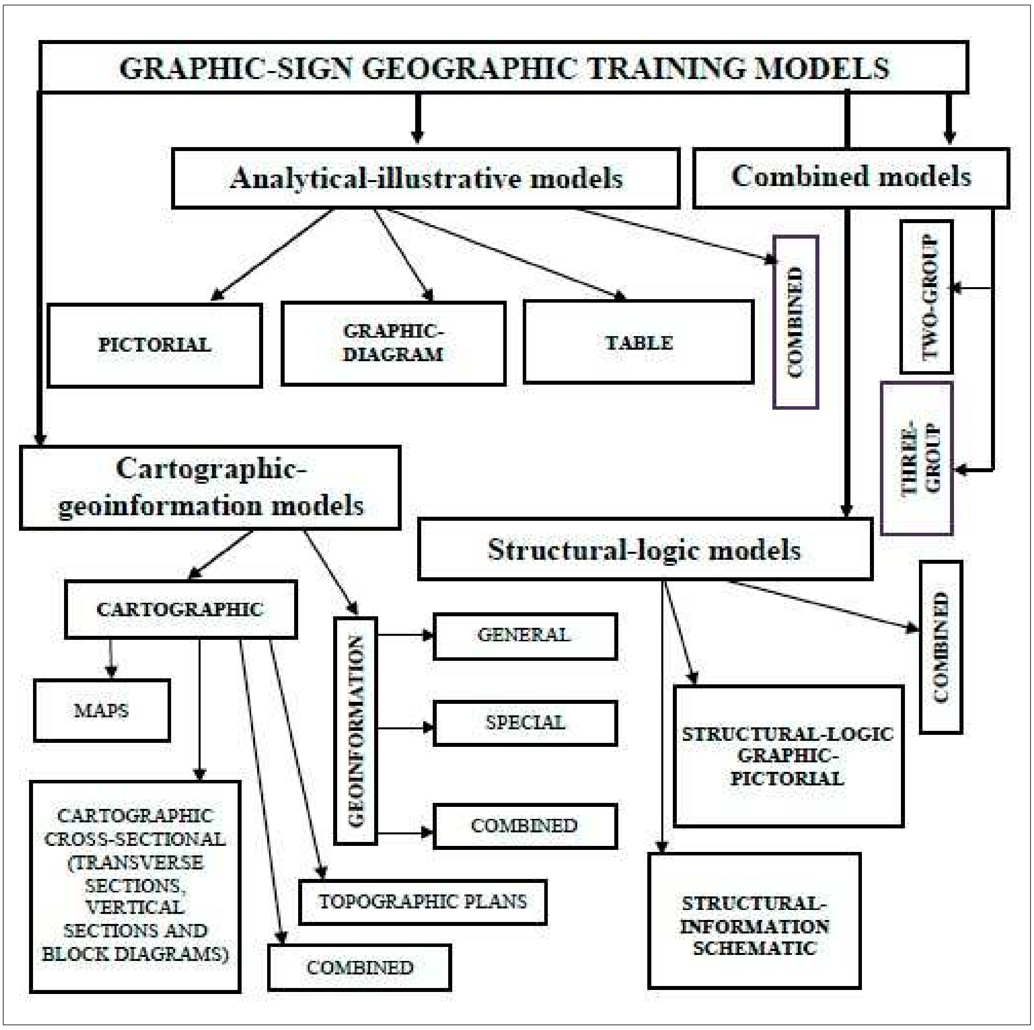

Figure 1. Varieties of geoinformation training models in the system of graphic-sign geographic training models

Among cartographic training models, the leading ones are geographic maps as graphic-sign models which are mathematically defined (with the use of the system of cartographic projections and geographic and rectangular coordinates), reduced and generalized images of the Earth's surface, showing the objects on it or projected on it in the adopted system of symbols [12, p.56].

Before examining the varieties of geoinformation training models, it is advisable to determine didactic capabilities of geographic maps as educational models. In the process of studying geographic disciplines geographic maps contribute to one of the most important tasks – ordering geographic knowledge and facilitating its understanding. In addition, maps give impetus to development of students' independent search activity and creative attitude to geographic objects of study.

Since geographic maps are models of the Earth's surface, they make it possible to study the regularities of location of geographic objects, processes and phenomena within this surface. Geographic maps preserve the studied peculiarities of environment as the original object, and, in addition, allow using them as a visualization tool. Thus, maps have almost unlimited information capabilities.

Analysis of the experience of use of geographic maps (as well as other cartographic-geoinformation models) during classroom activities and students' out-of-class independent work allows determining their following didactic functions. Firstly, they are the source of students’ knowledge about the location of geographic objects of study, change of their position / attributes and development. Secondly, maps serve as tools forming students’ cartographic skills as elements of professional competencies. Thirdly, they promote the development of students' spatial thinking as the basis of their geographic perception of the world.

3.3. Geoinformation training models

The use of geoinformation training models provides an opportunity to show the structure and condition of geographic objects, processes and phenomena and their dynamics, effectively provides geographic training information in certain portions and optimally manages the individual process of geographic knowledge acquisition.

It's worth noting that information technologies are currently upgrading the traditional work of geographers while creating cartographic materials and in the process of their use for the purpose of arrangement of students’ training and their cognitive activities. Powerful tools in this work are geoinformation systems (GIS) and technologies that provide a high level of visualization of diverse information in the form of interactive geoinformation models.

Geoinformation systems and technologies enable the creation of databases for storage, processing, analysis, transformation and visualization of information on spatial features of the environment on query in a given form – primarily cartographic, as well as in the form of tables, graphs, texts, etc.

The use of geoinformation systems and technologies in the students' training and cognitive activity makes it possible to rethink the procedure of work with cartographic tools. It is possible to study the map content not only on the ready map, but also "looking" into its digital basis – the attribute table. Using an electronic map it is possible to measure distances and surface areas, build graphics and diagrams in a much shorter time. The result of such work can be the complex characterization of a particular territory, object or phenomenon. According to T. Dudun, “a map with the use of computer technology GIS allows both to provide information and analyze it by dint of data conversion" [8, p.62].

The experience of using geoinformation training models suggests that it is not enough to consider them only as a tool of visualization of training information for its acquisition [22], since these models also serve as a tool of organizing students’ independent cognitive activities. This combination reflects the so-called law of consciousness, according to which, students realize only the content of that perceived information which appears to them as an object they act on and which is the purpose of their activity.

Geoinformation training models are a complex of various raster and vector multi-layer models that are created primarily using the GIS tools. Geoinformation training models use geographically (or spatially) coordinated data (spatial data) – data on spatial features that contain information on location (coordinates) of these features and their properties submitted through spatial and non-spatial quantitative and qualitative attributes.

Spatial features are elements of the real world, presented as geographic objects of study by the computerized graphic-sign models. Spatial features can be divided into five main types: point features (points), linear features (lines), polygon (area) features (polygons) and volumetric features (surfaces), as well as high-level spatial features (such as networks, including ecological one, etc.)

Geoinformation training models can be divided into the following types:

1) general models;

2) special models with such subtypes as models of rendering, "draping", kinematic

animation or dynamic interactive visualization of 3D images, routing optimization, training and research, self-training, multimedia training tools and other special ones;

3) combined models.

General geoinformation training models are single or combined digital cartographic models of all types (see Figure 1) and combined graphic-sign geographic training models of certain types, such as schematic maps, value-by-area maps etc.

The first subtype of special geoinformation models includes models of rendering – complex building of 3D images, among which, in the scope of geography training, image Digital Elevation Models (DEM) dominate; they require a more detailed description.

The Digital Elevation Model (DEM), syn. Digital Terrain Model (DTM), is a digital image of a topographic surface created, primarily, by dint of a raster elevation model in the form of a set of surface elevations at regular network points (DEM is the United States Geological Survey standard), or by dint of the vector model TIN – the triangulated irregular network, which initially uses a mentioned set at points of the irregular network [12], [13].

The next subtype of special geoinformation models includes "draping" models – overlay (projecting) on a 3D image (usually DEM) of plane digital layers, which can be vector and raster thematic geographic maps, etc., resulting in 3D presentation, which is optimal by visualization.

Models of kinematic animation or dynamic interactive visualization of 3D images, being a subtype of special geoinformation models, are usually also based on DEM. However, they simulate movement of "viewers" (students) across a particular geographic terrain under study, with a possibility of stops in the required places of such virtual trip. Quite often, this terrain is simulated from a bird-eye view or an aircraft board (the so called "interactive fly-around models"); in addition weather conditions, etc. are visualized to enhance the presence effect.

The next subtype of models under consideration is routing optimization models, which generally solve a certain geoinformation routing task.

Routing is a geoinformation model task for finding the most efficient route between nodes of a network. This route means the least-cost (by resources, efforts, etc.) distance between two points of a digital layer.

Routing optimization models can be very useful in the process of geography training, in particular, for regional studies. For example, these models are used when determining optimal, from the point of view of training purposes, physical load of students and other factors of the route and the rules of movement along real geographic objects of study (including by motor transport), hiking or ecological trails, etc., as well as for choice of such routes and trails. It is expedient to use mobile computer and position-navigating hardware-supporting training tools during the work with routing optimization training models directly in the field. Such approach can contribute to direct use of available digital geographic training and research information and its storing.

Modern training and research geoinformation models are intended for formation and development of students' creative abilities. Due to this use, specific features of the course of geographic processes and phenomena or factors of deterioration of the environment conditions etc. become available for monitoring, study and research.

A typical example of self-training models, being a subtype of special geoinformation models, is the MAP data raster model, which is successfully applied worldwide [13] as a training tool in geoinformatics, and which is effective for students to acquire expertise of computer-aided constructing (organizing) of spatial databases.

Special geoinformation training models include an electronic map that plays a special role among multimedia training tools; in addition, it is a component of appropriate electronic textbooks and manuals, electronic atlases, libraries, databases etc.

The electronic map is a set of thematic digital layers of data and their visualization software with storage of this map (layers) on certain holders of information storage media, including information network storage media [12].

Visualization process (graphic-sign presentation, displaying) means in the geoinformation terminology both projecting and generating of text, images, including geoimages, map images and other graphics more often on the monitor screen based on specific output digital data and rules and algorithms of their conversion.

As a rule students use not only separate electronic maps but also electronic atlases. The electronic atlas is a multimedia integrated information tool, stored on a holder of information storage medium. It contains a systematized set of electronic maps, developed according to the unified program and selected thematic scope, as well as other types of digital information and the necessary visualization software of the atlas. For example, students work fruitfully with the electronic National Atlas of Ukraine (2007), while forming the ability not only to acquire necessary information, but also to use it in order to solve applied creative training tasks [23].

The following models, not considered above, can be qualified as "other special geoinformation training models", in particular:

– models of digital layers overlay contributing to development of students' combinative skills;

– models of information-network viewing of spatial data, provided by Internet resources, first of all, by the cartographic-geoinformation service for 3D visualization of the Earth's surface, as the project "Google Earth" (web-site http://www.earth.google.com). The user friendly interface of this service is designed for unprepared users, allowing them to create even their own layers with a given classification and assigned attributes and ability to exchange spatial data, etc. (see additionally [24]).

Combined geoinformation training models, being the third type, combine useful visual and training properties of general and special geoinformation models. The most interesting examples of such combination are:

– models of general digital maps of points and contour lines and special image DEM in the form of a digital block diagram with a given viewing angle;

– models of a general digital map of a topographic surface presented in contour lines with DEM image.

4. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The application of geoinformation training models allows students to explore independently certain natural or socio-economic objects, processes or phenomena, choosing their pace of work, as students communicate with the computerized system individually. The tutor, according to a certain didactic purpose, specific conditions and interests of students can plan effective individual and group activities at the appropriate level of difficulty.

The use of geoinformation training models and technologies in the process of geography training makes it possible to reinterpret the procedure of work with cartographic tools. Prospects for further research include the development of geoinformation training models and the improvement of the procedure of their implementation in higher education institutions. Geoinformation training models have applied significance and aim at modernization of national geographic education.

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МОДЕРНІЗАЦІЯ ГЕОГРАФІЧНОЇ ОСВІТИ У ВИЩІЙ ШКОЛІ: ГЕОІНФОРМАЦІЙНІ НАВЧАЛЬНІ МОДЕЛІ

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Анотація. У статті розглянуто сучасні напрями модернізації вищої освіти в країнах Європи, окреслено зв'язок якості освіти і рівня розвитку економіки країн, встановлено значення цифрового навчання та нових форм надання освітніх послуг. Проаналізовано проблему опанування новітніх технологій шляхом застосування геоінформаційних систем і технологій у процесі підготовки майбутніх фахівців-географів і учителів географії. Доведено, що одним із шляхів вирішення окресленої проблеми є впровадження геоінформаційних навчальних моделей і визначено місце таких моделей поміж інших видів засобів навчання географії. Розтлумачено поняття "навчальна модель", "геоінформаційна навчальна модель" та окреслено їхні дидактичні особливості. Представлено систему графічно-знакових географічних навчальних моделей, підвидом яких є геоінформаційні навчальні моделі. Схарактеризовано напрями застосування геоінформаційних систем і технологій у процесі викладання географічних дисциплін у закладах вищої освіти. На основі досвіду застосування геоінформаційних навчальних моделей доведено, що вони є інструментом організації самостійної навчально-пізнавальної діяльності студентів. У роботі виокремлено три групи таких моделей (загальні, спеціальні, комбіновані) і схарактеризовано їхні різновиди. Значну увагу приділено характеристиці спеціальних геоінформаційних моделей – моделей рендерингу, передусім цифрових моделей рельєфу, моделей "драпування", а також моделей кінематично-анімаційної або динамічної інтерактивної візуалізації тривимірних зображень, маршрутно-оптимізаційних і навчально-тренінгових моделей. Відзначено великий дидактичний потенціал електронних карт і атласів, застосування яких уможливлює вивчення географічних об'єктів, процесів і явищ у просторовому аспекті. Зроблено висновок, що застосування геоінформаційних навчальних моделей, з одного боку, дає змогу студентам самостійно досліджувати певні природні чи соціально-економічні об'єкти довкілля. З іншого боку, викладачі можуть проєктувати ефективну навчальну діяльність студентів на високому рівні складності та відповідно до їхніх інтересів.

Ключові слова: географічна освіта; викладання географічних дисциплін в закладах вищої освіти; засоби навчання географії; геоінформаційні системи і технології; геоінформаційні навчальні моделі.

МОДЕРНИЗАЦИЯ ГЕОГРАФИЧЕСКОГО ОБРАЗОВАНИЯ В ВЫСШЕЙ ШКОЛЕ: ГЕОИНФОРМАЦИОННЫЕ УЧЕБНЫЕ МОДЕЛИ

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Аннотация. В статье рассмотрены современные направления модернизации высшего образования в странах Европы, обозначена связь качества образования и уровня развития экономики стран, установлено значение цифрового обучения и новых форм предоставления образовательных услуг. Проанализирована проблема освоения новейших технологий путем применения геоинформационных систем и технологий в процессе подготовки будущих специалистов-географов и учителей географии. Доказано, что одним из путей решения обозначенной проблемы является внедрение геоинформационных учебных моделей и определено место таких моделей среди других видов средств обучения географии. Разъяснены понятия "учебная модель", "геоинформационная учебная модель" и обозначены их дидактические особенности. Представлена система графическо-знаковых географических учебных моделей, подвидом которых являются геоинформационные учебные модели. Охарактеризованы направления применения геоинформационных систем и технологий в процессе преподавания географических дисциплин в высших учебных заведениях. На основе опыта применения геоинформационных учебных моделей доказано, что они являются инструментом организации самостоятельной учебно-познавательной деятельности студентов. В работе выделены три группы таких моделей (общие, специальные, комбинированные) и охарактеризованы их разновидности. Значительное внимание уделено характеристике специальных геоинформационных моделей – моделей рендеринга, прежде всего цифровых моделей рельефа, моделей "драпировки", а также моделей кинематически-анимационной или динамической интерактивной визуализации трехмерных изображений, маршрутно-оптимизационных и учебно-тренинговых моделей. Отмечен большой дидактический потенциал электронных карт и атласов, применение которых позволяет изучать географические объекты, процессы и явления в пространственном аспекте. Сделан вывод, что применение геоинформационных учебных моделей, с одной стороны, позволяет студентам самостоятельно исследовать определенные природные или социально-экономические объекты окружающей среды. С другой стороны, преподаватели могут проектировать эффективную учебную деятельность студентов на высоком уровне сложности и в соответствии с их интересами.

Ключевые слова: географическое образование; преподавание географических дисциплин в высших учебных заведениях; средства обучения географии; геоинформационные системы и технологии; геоинформационные учебные модели.