DOI https://doi.org/10.30525/978-9934-26-289-0-27

EDUCATIONAL POSSIBILITIES OF USING GEO-INFORMATION RESOURCES IN THE PROCESS OF TRAINING STUDENTS OF GEOGRAPHIC SPECIALTIES

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INTRODUCTION

Currently, the development of the economy and society requires higher education institutions to review approaches to geoinformation training, in accordance with the professional direction of students of geographic specialties. The demand for modern specialists in geography requires the selection and adjustment of disciplines and their saturation with educational material that directly contributes to their professional training.

The analysis of the modern labour market showed that geo-informational training is one of the most sought-after areas of professional training. Therefore, the geoinformation activity of students of higher education is one of the main types of practical training, the results of which directly depend on their future professional activity.

An urgent problem for institutions of higher education is also the selection of geo-informational software and GIS resources, with the help of which students of geographic specialties will have the possibilities to acquire professional competences during specialised training.

The analysis of the modern geoinformation software market showed the presence of a wide range of GIS packages, software and GIS services, which have various functionalities, without the use of which it is impossible to imagine the existence of humanity in the modern world.

Graduates of geographic specialties are employed in various institutions and departments, in addition to educational institutions, they work in hydrometeorological services, geological exploration organisations, territorial planning companies, tourism firms, analytical centres, in state, regional and city management structures, in the field of urban and spatial planning, regional and local management, in analysts centres, where looking at issues of sustainable and safe development of cities and territorial communities, urban land use, deal with issues of environmental protection and monitoring, etc.

The objects of professional activity of geographers are socio-economic, territorial-production, natural and natural-anthropogenic systems of different hierarchical levels.

Therefore, the future professionals – graduates of geographic specialities should possess such competences as the ability to conduct complex studies of

the natural resource potential of the territory and the possibilities of its economic development, the patterns of formation of spatial structures of the economy and forms of organisation of social life, conducting geoeconomic and geopolitical assessments of countries and the world, etc. It should be noted that the use of GIS in the educational process will contribute to the improvement of the quality of training of future geography specialists. Therefore, mastering geo-informational software and web services in the training of future geography specialists is relevant and timely and allows students to acquire relevant competencies.

The analysis of scientific works on the use of GIS in the educational process in the preparation of geographers shows the significant interest of scientists in this technology. Thus, the expediency of implementing a cycle of geo-information oriented disciplines is substantiated in the scientific work of a group of authors headed by V. Berezhny[1], the methodological principles of teaching a block of educational disciplines in geoinformatics and GIS technologies are outlined in the work of S. Kostrikov[2], a methodical system of student training of geoinformation technologies is considered in the work of O. Klochko[3], the use of GIS for remote sensing of the earth is considered in the research by Small Academy Science practitioners[4].

However, the analysis of scientific publications showed that the issue of using the educational opportunities of geoinformation resources in preparation students of geographic specialties are insufficiently disclosed, which determined the purpose of this study.

The purpose of the article is to find out the educational possibilities of using geo-informational resources in the process of training students of geographic specialties – future geography teachers and geographers in higher educational institutions (using the example of the educational process at Sumy State Pedagogical University named after A. S. Makarenko).

1. Educational possibilities of geo-informational software

Today's realities require many branches of the economy to make a clear transition to the widespread use of geographic information systems.

[1] Бережний В. А., Костріков С. В., Сегіда К. Ю. ГІС: перспективи університетського навчального процесу в річищі інформатизації географічної освіти. *Проблеми сучасної освіти.* 2013. № 4. С. 45–54.

[2] Костріков С. В. Про деякі методологічні засади викладення блоку навчальних дисциплін із геоінформатики і ГІС-технологій. *Проблеми сучасної освіти* : збірник науково-методичних праць / укл. Ю. В. Холін, Т. О. Маркова. Х. : ХНУ імені В. Н. Каразіна, 2013. Вип. 4. С. 71–74.

[3] Клочко О. В. Методична система навчання студентів геоінформаційних технологій. *Вісник ЛНУ імені Тараса Шевченка.* 2010. № 17. С. 40–50.

[4] Лабораторія «ГІС та ДЗЗ» – Академія Copernicus МАНУ. URL: https://www.facebook.com/groups/CopernicusUA (дата звернення: 25.12.2022).

A geographic information system (GIS) is a system that provides collection, storage, processing, access, display and distribution of spatially coordinated data[5]. It is an automated system for working with graphic and thematic databases, performing modelling and calculation functions, creating thematic geographic maps and atlases. It is used for scientific and practical purposes, such as urban and regional planning and design, forecasting, study of natural resource potential and inventory of natural resources, etc. Geoinformation technologies are convenient for the analysis of various data and objects, have a high visibility of disparate information display, provide new methods and means of information processing.

GIS has been extremely widely used and today the modern world cannot be imagined without geoinformation systems.

Therefore, the use of GIS in the educational process will contribute to the informatisation of education, which is characterised by the use of new methods and means of learning. It will contribute to the strengthening of interdisciplinary connections, the formation of an idea of a holistic, systemic picture of information processes in society, nature and cognition.

GIS is used in biology, forecasting, tourism, management, economics, geology, meteorology, cartography, etc.

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Therefore, the professionals – graduates of geographic specialities should possess such competences as the ability to conduct complex studies of the natural resource potential of the territory and the possibilities of its economic development, the patterns of formation of spatial structures of the economy and forms of organization of social life, conducting geoeconomic and geopolitical assessments of countries and the world, etc. It should be noted that the use of GIS in the educational process will contribute to the

[5] Часковський О., Андрейчук Ю., Ямелинець Т. Застосування ГІС у природоохоронній справі на прикладі відкритої програми QGIS : навч. посіб. Львів : ЛНУ ім. Івана Франка, Вид-во Простір. М., 2021. 228 с.

improvement of the quality of training of future of students of geographic specialties.

During the study on geographic specialties, of students must acquire certain competencies, among which it is worth mentioning the ability to conduct various complex scientific physical and socio-geographical studies, the ability create interactive electronic cartographic materials, the ability model natural and socio-economic systems, to search and analyse information, predict further processes of socio-economic development of society, etc., as well as monitor the environment to demonstrate the results of the features of anthropogenic influence[6]. And this is impossible without the use of GIS resources.

The analysis of the curricula of the Sumy State Pedagogical University named after A. S. Makarenko of the preparation of students of geographic specialties showed that the study of geoinformation disciplines is preceded by IT training, which is provided for in the cycle of general training. In turn, the geo-information training of students of geographic specialties takes place in the cycle of professional training and consists of both the main disciplines and disciplines chosen by the students.

In the system of training of students of geographic specialties 106 Geography and 014 Secondary Education in Geography) at Sumy State Pedagogical University named after A. S. Makarenko the curriculum provides for the study of a number of pre-geo-information disciplines and geographical, which are closely related to GIS and precede their study, some are taught simultaneously and contribute to the deepening of knowledge in professional training (Fig. 1).

Also in the system of training of students of geographic specialties at Sumy State Pedagogical University named after A. S. Makarenko the curriculum (106 Geography and 014 Secondary Education in Geography) is provides for the study of a number of geoinformation disciplines, which are closely related to pre-geoinformational and geographic disciplines, such as “Geoinformation systems and databases”, “Geoinformation mapping”, “Geoportals and Internet technologies for GIS”, “Geographical analysis and visualisation in GIS”, “Remote sensing of the earth” etc.

Although at Sumy State Pedagogical University named after A. S. Makarenko in geographic specialties there is some experience and diversity in the use of different types of software tools and online resource, which include GIS, their potential for educational purposes remains unexplored. Currently, the different commercial and open GIS packages (Fig. 2).

[6] Korol O., Kornus O., Kornus A. Peculiarities of using geoinformation systems in training of future geography specialists in higher education institutions. *Часопис соціально-економічної географії*. 2020. Вип. 28. С. 35–42. DOI: 10.26565/2076-1333-2020-28-04

Along with the advantages, these packages have significant disadvantages. This is mainly related to their commercial component, functionality and productivity, which is both a desire and an obstacle for implementation in the GIS, because the more functional and productive a GIS package is, the higher its cost.

Open GIS systems have certain advantages. Among software products that can be used in the educational process and become handy tools in the work of future geographers, presented in free access, software such as: PhotoFiltre, XnViewб Picasa, Quantum GIS, also web services Google Earth, ArcGIS Online, Golden SoftWare (Surfer) and other (Fig. 3).

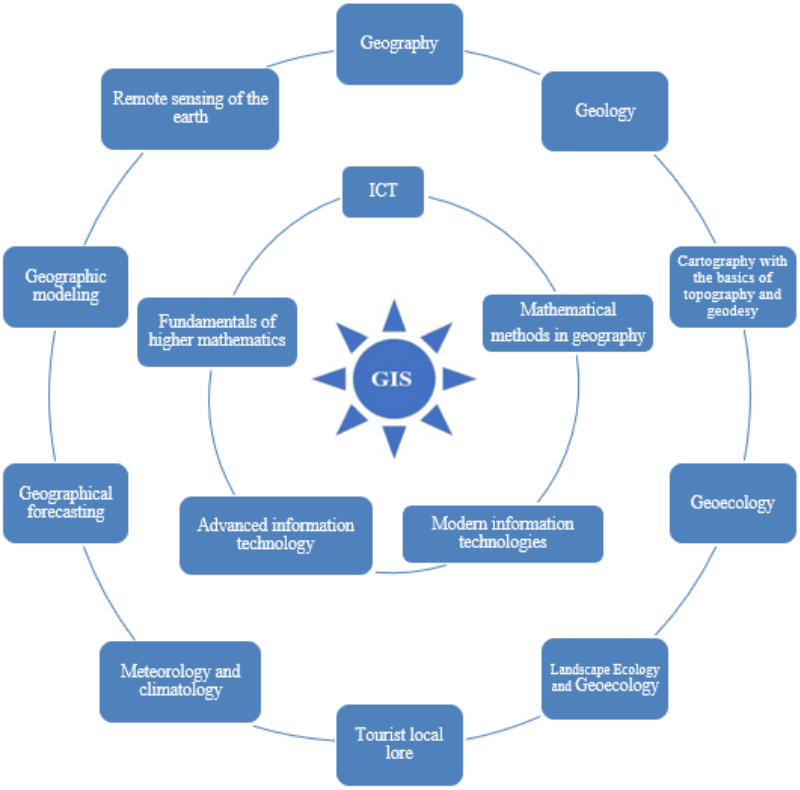

Fig. 1. Connection of GIS with other disciplines

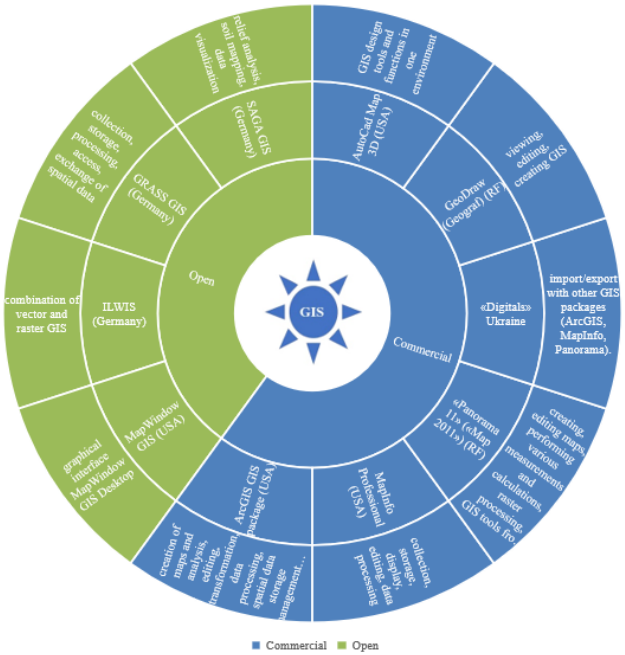

Fig. 2. Analysis of modern GIS packages

PhotoFiltre graphic editors	• map construction
XnView	• view
Picasa	• adding geotags, with which you can specify the location of any photo, using Google Earth and Google maps
Quantum GIS	• can be used as the main platform for teaching students how to use GIS and how to create the highest quality maps
Google Earth network services	• electronic globe
ArcGIS Online	• used to manage and share maps and geographic information
Golden SoftWare (Surfer)	• draw of map surfaces and conversion of the provided data into contour, relief or postal maps, three-dimensional surfaces, 3D frameworks or vector graphics

Fig. 3. Open GIS systems software

The proposed GIS software is not exhaustive of this list, but it can be used in work to the students of geographic specialties for use of GIS, in during work with maps (review, qualitative analysis, creation of maps of various topics – mapping and visualization) and also can be used in school geography. As an example, the use of the PhotoFiltre graphic editor as the simplest and most affordable way to build maps, where thematic information can be applied to the contour map thanks to the program's tools, by means of simple superimposition of colours, drawings and alphanumeric symbols.

Open GIS software may not satisfy all modern needs, but it does not threaten the existence of other systems. The attractiveness of using such software, on the one hand, is especially convenient for non-profit organisations, institutions where there are no extra funds and thus the limited functionality of the software can be used. On the other hand, open GIS becomes a tool in learning about new possibilities, which allows users not to stand still, but to familiarise themselves with various features and possibly learn to improve the existing software themselves.

Having outlined the range of disciplines and analysed the market of GIS products, it is necessary to compare these with existing geo-informational applications (Table 1).

Table 1

Basic areas of scientific knowledge

Computer Science	**Geographical Sciences**	**Geoinformation applications**
Informatics and programming	Geology	Spatial management
Mathematical modelling	Geography	Real estate management
Operating systems	Cartography with the basics of topography and geodesy	Transport and logistics
Text editors	Geoecology	Ecology
Spreadsheets	Landscape ecology	Natural resources
DBMS	Tourist local lore	Demographic research
Information networks	Geographic modelling	Regional management
Graphic editors for image processing	Meteorology and climatology	Others

The established relationship represented by individual geographic sciences made it possible to single those GIS applications that can interact with

geographic disciplines presented in the curricula of the of the university for of students of geographic specialties.

It should be noted that the preparation of the professional – future graduates of geographic specialities to master GIS should be preceded by pre-geo-informational training of a professional direction, which should cover the IT topics (fig. 4).

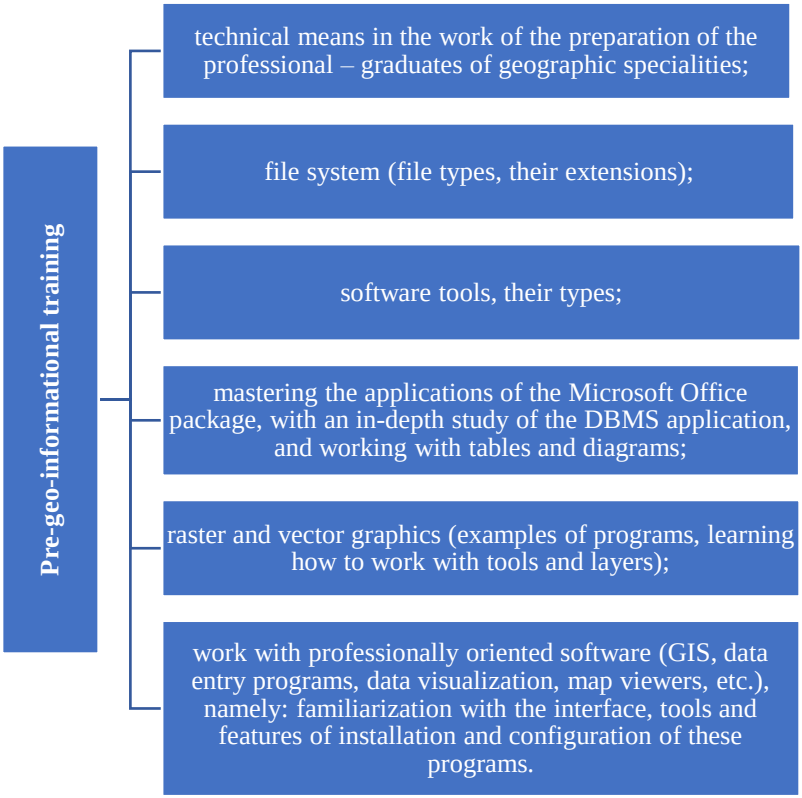

Fig. 4. Topics pre-geo-informational training of a professional direction

It is the professionally oriented pre-geo-information training of students of geographic specialties that will be the basis for successful study of GIS technologies and the guarantee of success of future professional training in GIS.

The pre-geo-information training of students of geographic specialties is practical work with a deliberately simplified GIS interface during IT training.

The mechanism of its construction occurs thanks to the Microsoft Office package, which includes the common and popular Word and Excel programs. Access, PowerPoint, with which they were introduced to varying degrees during classes at school. Usually, the level of school training in IT can be different, therefore, for the purpose of repetition and generalisation, and in some cases to identify gaps in IT during pre-university training and for the purpose of propaedeutic familiarisation with professionally oriented possibilities in the work of future professionals – students of geographic specialties, we consider it necessary instead of the usual study of the specified software products to build classes in the form of a project on creating elementary GIS. During this project, students will be able to repeat topics from the file system (consolidate building skills with directories), work out file extensions in accordance with the chosen program, and consolidate knowledge in the relevant software products of the Microsoft Office suite.

As part of the MS Office package, future geography specialists are offered to acquire practical skills in mastering elementary GIS. This can be done thanks to the introduction of the basic cartographic basis of GIS on the example of any scanned raster map-scheme of the area with all meaningful information, which will later be displayed in separate layers. The set of layers forms the integrated basis of the graphical part of the GIS.

Creating a cartographic base is the most time-consuming stage, so we consider it necessary to reproduce the sequence of creating a cartographic base in MS Office using the algorithm of actions. Mandatory steps include creating and saving a base file with images and text captions, linking layer objects to relevant information through hyperlinks, and determining the number of layers that will make up the map.

The creation of the base layer can be done in the Paint program.

MS Word's capabilities allow you to work on layers, especially when working with nodes to modify them. In this activity, we consider it necessary to draw the attention of future specialists – of students of geographic specialties to the implementation of some aspects:

1) the vectorised object must be a polygon – a closed solid object, and therefore editable;

2) objects must be bound to one system of conditional coordinates, thanks to the setting of binding to the grid;

3) to improve the accuracy of spatial data visualisation, you can also reduce the grid step value parameter from 0.32 to 0.03, which will significantly increase the graphic resolution of the entire system;

4) it is necessary to group the selected objects and establish the appropriate order of objects by the analogy of cartographic generalisation. When processing a large number of objects, while working with graphics, you can make an appropriate selection of elements (points, lines, curves, polygons, etc.), including redundant ones, by selecting objects with the mouse using the Ctrl or Shift and context menu commands Group, objects are grouped;

5) link attribute information to spatially distributed geographic objects using hyperlinks. For this, it is necessary to make the created objects active when the cursor is placed on them (for linking hypertext). In order for them to be edited, they must be moved to the foreground.

As a result of performing all the steps of the action algorithm, we get superimposed layers that are grouped. In this way, we get a set that makes up the final map[7]. (Fig. 5).

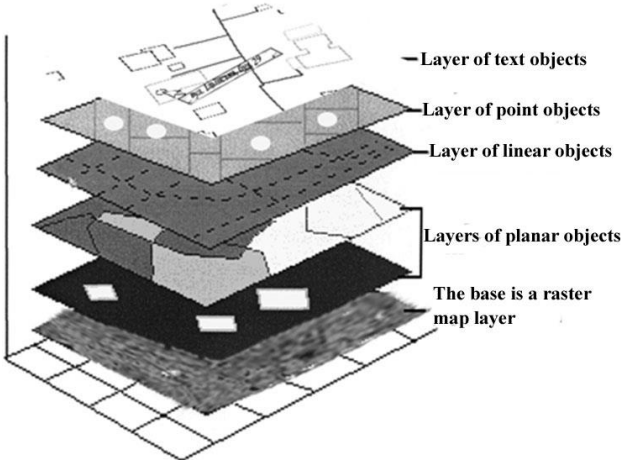

Fig. 5. Scheme of data organisation of elementary GIS

Having familiarised the students with all the preparatory actions, we will move on to the next stage of filling the elementary GIS, thanks to the creation of binding of objects of layers to the relevant information thanks to hyperlinks and determining the number of layers that will consist of the map.

[7] Король О. М. Робота з елементарною ГІС в процесі інформатичної підготовки майбутніх бакалаврів географії. *Фізико-математична освіта* : *науковий журнал.* Вип. 3 (25). Ч. 2. Сумський державний педагогічний університет імені А. С. Макаренка ; Фізико-математичний факультет редкол.: О. В. Семеніхіна (гол.ред.) та ін. Суми : [СумДПУ ім. А. С. Макаренка], 2020. С. 81–87.

After mastering elementary GIS, students are offered a number of geo-information subjects. In order to improve the quality of education of students of geographic specialties in the curriculum of the Sumy State Pedagogical University named after A. S. Makarenko has included the educational subject "Geoinformation systems and databases", "Geoinformation mapping", "Geoportals and Internet technologies for GIS", "Remote sensing of the earth" and "Geographical analysis and visualisation in GIS".

The purpose of studying these subjects is to give students an idea of the computer technology of integrated processing (input, image, representation in PC memory, analysis and visualisation) of spatially coordinated information about geographical objects.

As a result of studying geoinformation disciplines, students of geographic specialties will know:

• classification of modern GIS and leading companies developing GIS tools: ESRI (ArcGIS), ESTI MAP (MapInfo Professional), QGIS, etc.;

• tools for developing new spatial data, layouts, themes, diagrams;

• tools for the development of information systems for processing geographic information with the use of GIS development tools;

• typical hardware and software tools for implementing geoinformation technologies;

• means of presenting data in GIS.

According to the results of GIS courses students of geographic specialties should be able to perform basic activities related to:

• definition of geographic information systems;

• creation of a geodatabase, represented by such data as vector objects, maps, rasters, coordinate networks, topology;

• mastering the main types of geographic information processing that supports GIS (geodatabases, geoprocessing processes and provision of geo visualisation);

• implementation of geo visualisation, during which support for map editing, processing of user requests is provided and content analysis;

• performing geoprocessing, during which spatial data processing functions receive information from a geodatabase, store processing results in new elements of the geodatabase and apply analytical functions to it.

To master these activities, students of geographic specialties should familiarize themselves with structural GIS software, consisting of basic software (OS, network software, software environments and database management systems) and applied software (is implemented in the form of separate modules and utilities).

A set of interrelated databases, data presentation formats, classifiers, digital description rules and a set of relevant documentation make up GIS

information support. It is the great possibilities of working with geographic data that distinguish GIS from other information systems. Geographical or geospatial data describe any objects that have localization – they have coordinates. Houses and countries, cities and villages, weather, fields, terrain, roads, forests all this and much more represent geographic data (objects, processes and phenomena that have coordinates). Geographical data consists of two interrelated parts: related tabular (attributive) data (databases) describing the substantive characteristics of the object and spatial data describing dimensions of the object, shape and the location.

The spatial data are described and determined using coordinates. Spatial models of objects are created on the basis of cartographic images, as a result of certain actions we can get a digital map.

Also, students need to familiarise themselves with the use of certain data models, thanks to which GIS activities are implemented. Among them, vector and raster models are distinguished[8] (Table 2).

The smallest element of the raster model is a raster or pixel (pixel – shortened from English – picture element) (Table 2a). Types of vector data are presented in table 2 (Table 2b).

Table 2

Graphic primitives

a) element of bitmap graphics		pixel (raster)
b) elements of vector graphics		point (vertex) line (arc) polygon (plane)

Complex element of a geographic object can be represented by a set of simple elements (primitives: point, line, polygon) (Table 2b).

Among the models of GIS technologies, there is another model of data storage in the geoinformation database. It is to base on the principle of a simple concept of relational databases and can use all the power of the database management system (DBMS).

Even from information courses, students should learn the basic rules of working with DBMS. When studying the GIS discipline, future geographers supplement their existing knowledge with new ones related to the assignment

[8] Король О. М. Робота з елементарною ГІС в процесі інформатичної підготовки майбутніх бакалаврів географії. С. 81–87.

of simple tables used to store schemas, rules, basic and spatial-attributive data for each set of geographic data. This process allows you to use a formalised model to store and work with data. Thanks to this, changes can be made, data can be added, and queries can be made to tables and their elements.

Based on the experience of leading specialists in the field of teaching GIS technologies, professionals agree that students should learn to obtain geographic information using GPS, graphical user interfaces and the functionality of leading GIS platforms and geoinformation modeling modules.

In order to acquaint of students of geographic specialties with the possibilities of using ArcGis software (the desktop version of ArcGis desktop and its web counterpart ArcGis-online), the commercial software of the Esri ArcGis family was chosen, which is used in the teaching of the discipline "Geographical Information Systems and Databases". Within this discipline, students get acquainted with the process of creating a geoinformation database, work with projections, learn to work with attributive and spatial data and produce the final product – a map with all the necessary elements pre-drawn.

When using free software, QGIS was chosen, which is used in the teaching of the subject "Geoinformational mapping". Within this subject, students can use free software in the educational process, which they will then be able to use in their future professional activities regardless of the costs.

2. Educational possibilities of web resources

In addition to cellular software, a range of geo-information resources are offered for students of geographic specialties, which are freely available and can be used both during the study of geo-information disciplines, such as "Geographic analysis and visualisation in GIS", "Remote sensing of the earth" , and during the practical solution of problems in the following disciplines "Geoecology", "Geoecological problems of nature management", "Modern technologies of teaching geography" and other disciplines related to anthropogenic factors, as well as for visualization of some processes. These resources will be useful when writing course and qualification papers and will help students to learn practical skills in order to work in different areas.

For the formation of practical skills in visualizing already acquired knowledge about geographical processes, phenomena and their distribution, work on deciphering images from space is proposed. A certain percentage of the practical activity is related to the analysis of those sample images that contain decryption data of specific objects, and the other part of the activity should be devoted to the analysis of images of the territory already known to the students (for example, settlements of the place of study and birthplace).

In the process of assimilating knowledge, students are offered work with the Google Earth service as for a search for geospatial features of the specified territory. They are also offered work on creating simple photo maps, which takes place in the same software product, by editing pictures from space, namely adding contours of objects to the territory, changing them, overlaying new images, etc. The interactive properties of working with the Google Earth service, which can be used as a GIS option, are also demonstrated.

Among the popular web resources for students of geographic specialties, Worldview is offered, which can be used during the teaching of the discipline "Geoecology" and is included in the range of practical tasks "Geographical analysis and visualisation in GIS", "Remote sensing of the earth" and others.

One of the anthropogenic factors affecting the natural environment is light pollution. This is a rather broad term that covers a number of problems associated with the improper use of artificial lighting, primarily due to human economic activity, mainly the processes of industrialisation and urbanisation.

In general, light pollution is a violation of the brightness and temporal shift of the natural illumination of a certain area, as a result of the action of artificial light sources, which cause deviations in the natural life of animals and plants[9].

It is accepted to distinguish the following main types of light pollution: violation of natural lighting, excessive lighting, bright light, light disorder (excessively bright and incorrectly oriented illumination of roads, streets, advertising banners, lighting of buildings, businesses) sky glow (directed or re-reflected light creates a light dome – glowing orange halo).

Negative consequences of light pollution:

– harmful effect on human health;

– excessive energy consumption;

– disruption of the functioning of natural ecosystems and biorhythms of living organisms;

– an obstacle to astronomical and other research related to night observations.

In order to clarify the meaning of the concept of "light pollution", students are invited to investigate light pollution in different regions with the help of the specified service. To do this, it is necessary to select the topic "Earth at night" from the proposed topics of the textbook "Worldview" of this service.

When choosing the desired topic of this service, the students of geographic specialties is offered an 8-step tour – observing the Earth at night, which will give an opportunity to look at its surface in a different way, namely, it is offered to observe city lights, aurora borealis, lights of fishing boats, etc.

[9] *Worldview*. URL: https://worldview.earthdata.nasa.gov (дата звернення: 25.12.2022).

This topic will help to evaluate anthropogenic sources of light radiation in different conditions of natural lighting (during a partial or full moon) when performing the appropriate algorithm of actions[10].

Working with this service will help compare images on different dates of selected periods (provided cloudless time is selected).

To consider the mechanism of satellite detection of fires and thermal anomalies in different regions, we will consider a web resource Worldview that allows to see "Satellite detection of fires".

To acquaint the students of geographic specialties with the worldview of this resource, it is suggested to explore the "Satellite fire detection" tab, namely, you need to go through a 9-step tour – the opportunity to contemplate satellite fire detection. This information about fires and thermal anomalies that occur every day around the world is provided by NASA.

The images used in this web service were obtained using the MODIS (Intermediate Resolution Imaging Spectroradiometer) instrument on board the Terra and Aqua satellites, and the VIIRS (Visible and Infrared Imaging Radiometer Array) instrument on board the NASA/NOAA joint project Suomi NPP (Suomi National Polar Orbiting Partnership) and NOAA-20.

Terra passes over the equator at approximately 10:30 (day) and 22:30 (night) local time, NOAA-20 passes over the equator at approximately 12:40 (day) and 00:40 (night) local time, and Aqua and the Suomi NPP crosses the equator at approximately 1:30 p.m. (day) and 1:30 a.m. (night) local time. Fire information is available in Worldview approximately 3 hours after each satellite flyover.

This section will help to the students of geographic specialties evaluate anthropogenic sources of light radiation in different conditions of natural lighting (during a partial or full moon) when performing the appropriate algorithm of actions.

Also, with the help of the appropriate actions of the service, it is possible to determine the coordinates of the centres of fires and thermal anomalies, and to create and compare the corresponding gif files for time ranges for different periods of time. This is possible if appropriate layers of daytime and night-time fires and thermal anomalies are selected.

The data collected by the satellites uses an algorithm that captures the intense radiation in the mid-infrared range that comes from fires and thermal anomalies. These fires and thermal anomalies are shown as orange (MODIS)

[10] Король О. М., Корнус А. О. Дистанційний моніторинг навколишнього середовища засобами геоінформаційних Web-сервісів : методичні вказівки для здобувачів освіти спеціальностей 014 Середня освіта (Географія) і 106 (Географія). Суми : СумДПУ імені А. С. Макаренка, 2022. 44 с. URL: http://repository.sspu.edu.ua/handle/123456789/12703 (дата звернення: 25.12.2022).

or red (VIIRS) dots. Each point represents the centre of a pixel within which one or more fires occurred. For the MODIS instrument, the point represents the centre of a 1-km pixel, for the VIIRS instrument, the point represents the centre of a 375-meter pixel. Need to the eye icon to toggle the day and night MODIS and VIIRS firepoints on and off to see the differences between the sources.

It is important that students understand the importance process of the active fire detection of MODIS on Earth.

To detail the work of MODIS fire detection, we note that satellites take a "snapshot" of events when they fly over a certain point above the Earth. Each "hot spot/active fire detection" is the centre of a pixel (approximately 1 km) marked as containing one or more fires or other thermal anomalies (e.g., volcanoes).

The "fire location" is the centre point of the pixel (not necessarily the coordinates of the actual fire). Actual pixel size depends on scanning and tracking. Also, the size of the fire is often less than 1 km. MODIS cannot determine the maximum fire size, but only confirms that at least one fire is within 1 km of this pixel (Fig. 6).

Sometimes you can see several active fires in a row. This usually means a fire front.

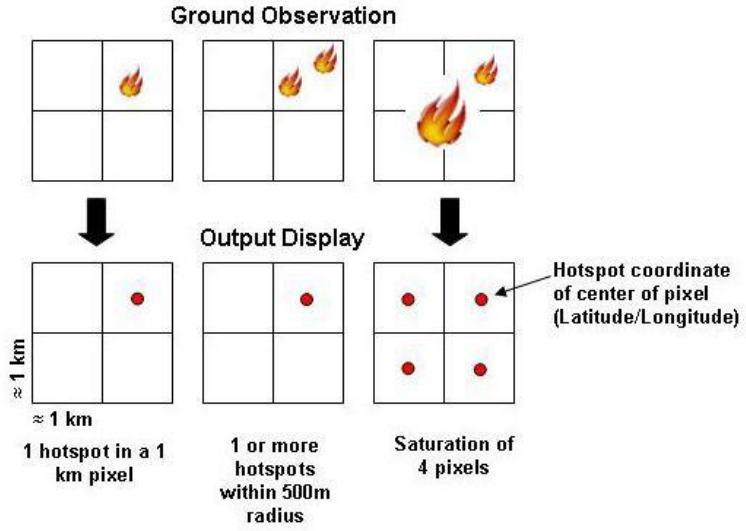

Fig. 6. Algorithm for satellite detection of fires and thermal anomalies

It is also important the students of geographic specialties to understand what it means to scan and track.

The scan value represents the spatial resolution in the east-west direction, and the track value represents the spatial resolution of the scan in the north-south direction.

It should be noted that the pixel size is not always 1 km along the entire scan track. This 1 km is only along the nadir (exact vertical from the satellite). The pixel size on the "eastern" and "western" edges of the scan exceeds 1 km. Therefore, the values shown for scan and track represent the actual spatial resolution of the scanned pixel.

It is also important the students of geographic specialties to understand what the temperature brightness is.

The brightness of a fire pixel is measured (in Kelvin) using MODIS channels 21/22 and channel 31. The brightness temperature is actually a measure of photons of a particular wavelength received by the spacecraft, but is expressed in units of temperature.

In order to find out the spread of fires and thermal anomalies thanks to the Worldview service, it is necessary to first determine the coordinates of the centres of fires, and after they are established, it is possible to visualise the centres of fires and thermal anomalies on the world map using the cartographic web service Google Map.

Thanks to working with the sections of this service, it is possible to study the following anthropogenic factors: the level of illumination of cities, the spread of fires and thermal anomalies, etc.

There is another mechanism that allows you to detect fires and thermal anomalies by means of the EFFIS service.

It is for this purpose that the capabilities of the EFFIS service are used during the educational process[11].

Note that active fires are localized on the basis of so-called thermal anomalies arising above them. Algorithms compare the temperature of a potential fire with the temperature of the ground cover around it; if the temperature difference is above a given threshold, the potential fire is confirmed as an active fire or "hot spot". EFFIS uses active fire detection provided by NASA's FIRMS (Fire Information for Resource Management System).

It should be noted that the MODIS sensor on board the TERRA and ACQUA satellites identifies areas on the ground that are clearly warmer than their surroundings and marks them as active fires. The difference in temperature between areas that are actively burning versus neighboring areas

[11] *EFFIS*. URL: https://effis.jrc.ec.europa.eu/apps/effis_current_situation/ (дата звернення: 25.12.2022).

allows active fires to be identified and mapped. The spatial resolution of an active fire detection pixel from MODIS is 1 km.

In addition, the students of geographic specialties are recommended to familiarise themselves with the MODIS active fire product[12].

It should be noted that VIIRS Active Fires (Visible Infrared Imaging Radiometer Suite (VIIRS)) uses algorithms similar to those used by MODIS to detect active fires.

VIIRS active fire detection devices complement MODIS active fire detection and provide improved spatial resolution compared to MODIS. The spatial resolution of the active fire detection pixel for VIIRS is 375 m. In addition, VIIRS can detect smaller fires and can help delineate the perimeters of ongoing large fires.

In addition, the students of geographic specialties are recommended to familiarize themselves with the VIIRS active fire facilities[13].

Mapping of active fires is carried out to provide a geographical view of current fires in Europe and as means to further map burnt fire perimeters. Information on active fires is typically updated 6 times per day and becomes available in EFFIS within 2–3 hours of receiving MODIS/VIIRS images.

When interpreting hot spots displayed on the map, the following must be taken into account:

• The hot spot location on the map is accurate only within the spatial accuracy of the sensor;

• Some fires may be small or hidden by smoke or cloud and go unnoticed;

• Satellites also detect other sources of heat (not all hot spots are fires).

To minimise false alarms and filter out active fires that do not qualify as wildfires (such as agricultural burning), the system only displays a filtered subset of hotspots detected by FIRMS. For this purpose, a knowledge-based algorithm is used, which takes into account the scale of the surrounding land cover categories, the distance to urban areas and artificial surfaces, and the level of confidence in the hot spot.

The identification tool provides key information attached to each active fire, such as geographic coordinates, administrative district, and the main land cover category affected.

Another source for identifying active fires is generated by fire news: news is selected from a large set of RSS feeds published by various wildfire-related sites and news filtered by relevant keywords. Items from the selected feeds

[12] *Earthdata.nasa MCD14DL-NRT*. URL: https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/c6-mcd14dl (дата звернення: 25.12.2022).

[13] *Earthdata.nasa VIIRS I-Band*. URL: https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/viirs-i-band-active-fire-data (дата звернення: 25.12.2022).

are then geo-located and published on the EFFIS website in the FireNews section[14].

In addition, the students of geographic specialties are recommended to familiarise themselves with the analysis of the capabilities of the EFFIS service – European Forest Fire Information System for detecting fires and thermal anomalies involves determining the probable causes of fires and their consequences and analysing the importance of avoiding fire-threatening situations in the selected zone. When analysing the relevant information about the fire, paying attention to the temperature is crucial. It is correlated in the Kelvin and Celsius temperature measurement units (formula 1)[15].

$$K = \_\_\_^{\circ}C + 273.15. \quad (1)$$

To find out the possibility of the EFFIS service for characterizing active fires in the selected territory, it is necessary to use the appropriate tools of this resource and set the appropriate range of dates during which the fire occurred, which are responsible for detecting active fires and burned places.

Also, in addition, the students of geographic specialties are recommended to familiarize themselves with the mechanism of satellite detection of fires and thermal anomalies using the EO Browser resource.

A number of Internet resources allow not only to see our planet from space without leaving home, but also to download a space photo to your device for further work with it. One of such services is EO Browser, which we will consider in more detail.

Monitoring the surface of our planet is an urgent need today. To do this, It is also important the students of geographic specialties to understand what is capabilities of the EO Browser service[16].

EO Browser is a viewer of available online medium and low resolution images from the European Space Agency, which provides access to images from the following satellites: Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P, Landsat, Envisat Meris, MODIS, Proba-V, GIBS.

Working with this service is preceded by the preliminary creation of an account on the EO Browser portal, selection of the appropriate territory, setting the desired time period, auxiliary settings, and subsequent visual analysis of the received space images based on data from various satellites. In addition to direct visualisation within this resource, it is possible to further

[14] Copernicus firenews. URL: https://effis.jrc.ec.europa.eu/apps/firenews.viewer (дата звернення: 25.12.2022).

[15] *EFFIS*. URL: https://effis.jrc.ec.europa.eu/apps/effis_current_situation/ (дата звернення: 25.12.2022).

[16] *EO Browser*. URL: https://apps.sentinel-hub.com/eo-browser/ (дата звернення: 25.12.2022).

download the received image in a regular format with different spatial resolution of the image.

An important point of using this service for the students of geographic specialties is the prospect of saving a high-resolution and georeferenced space image to be able to open it in any cellular GIS program (e.g., ArcGis/QGis) for subsequent analysis.

Need to use short-wave infrared (SWIR) measurements, which allows us to estimate how much water is in plants and soil, because water absorbs SWIR wavelengths.

Short-wave infrared ranges are also useful for distinguishing types of clouds (water or ice), snow and ice that appear white in visible light. In this composition, vegetation appears in shades of green, soils and built-up areas are various shades of brown, and water is black.

Freshly burned land is highly reflective in the SWIR bands, making them valuable for fire damage mapping. Each type of rock reflects short-wave infrared light differently, making it possible to build a geological map by comparing the reflected SWIR light[17].

The Copernicus Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same heliosynchronous orbit, phased by 180° to each other. It is aimed at monitoring the variability of land surface conditions with a band width of 290 km and a long revisit time (10 days at the equator with one satellite and 5 days with 2 satellites in cloudless conditions, which gives up to 2–3 days in mid-latitudes), which will support monitoring changes in the Earth's surface.

In addition, the students of geographic specialties are recommended to familiarise themselves with the Copernicus Sentinel-2 mission planning and with the information about the coverage status[18].

Important for the students of geographic specialties is the normalised burn ratio the NBR index (Normalised Burn Ratio) – is an index developed for the selection of burned areas in large fire zones.

$$\mathrm{NBR} = \frac{(\mathrm{NIR}-\mathrm{SWIR})}{(\mathrm{NIR}+\mathrm{SWIR})}. \qquad (2)$$

Formula (2) is similar to NDVI, except that the formula combines the use of near-infrared (NIR) and short-wave infrared (SWIR) radiation.

Analysis of service capabilities EO-browser and assessment of anthropogenic causes of fires and thermal anomalies on of the relevant

[17] SWIR – Short Wave Infrared RGB Composite. URL: https://custom-scripts.sentinel-hub.com/sentinel-2/swir-rgb/ (дата звернення: 25.12.2022).

[18] *Sentinel online*. URL: https://sentinel.esa.int/web/sentinel/missions/sentinel-2 (дата звернення: 25.12.2022).

territory by means of this service, of the students of geographic specialties are recommended to begin by determining the required fire period and calculating the area, which covered by the fire (site area in hectares)[19].

The Sentinel-2 satellite image is used for the analysis. and is set the cloudiness mode to no more than 30 %. Sentinel-2 provides high-resolution visible and infrared imagery for monitoring vegetation, land and water cover, inland waterways and coastal areas. Spatial resolution: 10m, 20m and 60m depending on the wavelength (ie only details larger than 10m, 20m and 60m can be seen). Revisit Time: Maximum 5 days to revisit the same area using both satellites. Data availability: from June 2015. Full global coverage since March 2017. Level 2A data is high-quality data that excludes the influence of the atmosphere on the light reflected from the Earth's surface and reaching the sensor. Data is available worldwide as of March 2017.

Need to use the SWIR mode to investigate fires that occurred in the selected area in the mode of short-wave infrared radiation. To measure the area of the selected territory, which was consumed by fires during the set period of time, you should use the EO Browser toolkit.

It will also be useful for students of geographic specialties to use additional functions of EO-browser, such as comparison and visualisation.

The NBR index (normalised fire index) is used during the fire season to determine its peak. This index shows the impression of territories by fire.

For the student of geographic specialties, of the possibility to detect air pollution are offered, which can be explored by means of various web services, as well as by means of the EO Browser. Among the selected services for detecting air pollution, we suggest using the capabilities of the Ventusky web application[20], the online map of the state of the real-time Air Quality Index[21], Windy[22]. As well as the capabilities of the Copernicus Sentinel-5P service[23] and the Mapping Portal[24].

These resources allow you to detect air pollution, namely: analysing the capabilities of the Ventusky web application can be installed, the areas most polluted by air pollutants according to PM2.5. Windy web resource can be used to analyse a possible situation with the actual current state of air pollution. Analysis of the Quality web resource provides an opportunity to identify the actual current state of air pollution in a certain area. Analysis of the web resource Waqi makes it possible to establish air pollution in the

[19] *EO-browser*. URL: https://apps.sentinel-hub.com/eo-browser/ (дата звернення: 25.12.2022).

[20] *Ventusky*. URL: https://www.ventusky.com/ (дата звернення: 25.12.2022).

[21] *Waqi*. URL: https://waqi.info (дата звернення: 25.12.2022).

[22] *Windy*. URL: https://www.windy.com/?51.505,31.285,5 (дата звернення: 25.12.2022).

[23] *EO-browser*. URL: https://apps.sentinel-hub.com/eo-browser/ (дата звернення: 25.12.2022).

[24] *Mapping Portal*. URL: https://maps.s5p-pal.com/no2/ (дата звернення: 25.12.2022).

world – Air Quality Index in real time. An analysis of an online map of the state of the air makes it possible to show the situation with the actual current state of air pollution in a certain area.

The considered GIS resources will help students of geographic specialties not only to study various geographic disciplines in depth, but also to investigate the impact of various anthropogenic factors on the required territories and use the information obtained during their own scientific research.

CONCLUSIONS

The analysis of the modern labour market showed that geoinformational training is one of the most sought-after areas of professional training for future specialists – graduates of geographic specialties. Therefore, geo-information activity of higher education students is one of the main types of practical training, the results of which directly depend on their future professional activity.

Now, during the last few years, it is difficult to imagine the preparation of students of geographic specialties 106 Geography and 014 Secondary Education (Geography) without the use of geo-informational resources in the process of their education. The article shows how software and web services can reveal the educational possibilities of modern geo-informational training of students of geographical specialties of Sumy State Pedagogical University named after A. S. Makarenko

In order to connect geoinformation disciplines with other educational disciplines, the article describes the topics of pre-geoinformation disciplines, the mastery of which will help students master GIS technologies without hindrance.

The article presents a model of pre-geographical training of students. Models of raster and vector graphics are also considered. The main advantages and disadvantages of using these models are indicated. The main competences that students of geographic specialties should acquire during the study of educational geo-informational disciplines have been determined. This can create the foundations for the formation of a sufficient level of a competitive future specialist.

The market of modern GIS packages, the variety of which is huge, has been analysed. The classification of GIS software products is presented. Among them are GIS packages with an indication of their functional and instrumental capabilities.

The material of the article is represented by the capabilities of various commercial and open software tools (ArcGis and QGis) and popular GIS services, including: Worldview, EO Browser, EFFIS, Ventusky, Quality

Windy and Waqi. They are intended to demonstrate the results of the features of anthropogenic influence and help to carry out environmental monitoring.

The presented educational opportunities of geoinformation resources (software and web services) can be used in the study of the disciplines "Geoecology", "Geoecological problems of nature management", "Modern technologies of teaching geography" and other disciplines related to anthropogenic factors and can become theoretical base during training and practical work in the disciplines "Remote Earth Sensing" and "Geographical analysis and visualisation in GIS".

SUMMARY

Geoinformation training is one of the modern areas of work performed by students of higher education majors 106 Geography and 014 Secondary Education (Geography) and is one of the main types of geoinformation activity, the results of which directly depend on their future professional activity.

The article describes the topics of pre-geoinformational disciplines, the mastery of which will help students master GIS technologies without hindrance. The model of pre-geographical training of students is presented.

Models of raster and vector graphics are also considered. The main advantages and disadvantages of using these models are indicated.

The main competences that students of geographic specialties should acquire during the study of educational geo-informational disciplines have been determined.

The material is represented by free and commercial software (QGis and ArcGis) and various services that open opportunities for environmental monitoring. Among them are Internet resources, namely: Worldview, EO Browser, EFFIS, Ventusky, Quality Waqi and Windy.

The article presents recommended software and web services designed to demonstrate the results of the features of anthropogenic influence and help to monitor the environment.

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