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Professionally oriented tasks for learning and using mapping technology with ArcGIS tools

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Abstract. The article substantiates the expediency of using professionally oriented tasks for learning the technology of the mapping process using ArcGIS, taking into account the peculiarities of the training specialists of natural sciences. Socio-economic mapping by means of ArcGIS is an important step for creating management systems to support decision-making by future geographers and others. The main aspects of the introduction of professionally oriented tasks into the educational process of pedagogical institutions of higher education have been clarified. Educational and methodological guidelines for studying and using the technology of mapping with ArcGIS tools have been developed for students and future geographers who expect to perform professionally oriented tasks in the development of maps. For the practical preparation and development of a series of maps that provide visual information for an objective analysis of Ukraine's indicators, we used information from the State Statistics Service of Ukraine, the Main Statistical Offices of Ukrainian regions. A series of maps, created by different methods and connected by one topic, was prepared and developed, among them the creation of a cartogram of the population of the regions of Ukraine using the method of quantitative background. An experimental verification of the effectiveness of the use of professionally oriented tasks for the study and use of mapping technology by means of ArcGIS by future teachers-geographers proved an increase in the level of development according to the specified criteria: motivational, cognitive and personal-reflective with the corresponding indicators. The mapping approaches presented in this paper based on the implementation of professionally oriented tasks allow students to apply the acquired knowledge and skills and give them the opportunity to flexibly adapt to situations arising in the future professional activity of a geographer.

1. Topicality

Nowadays, the use of digital technologies has become ubiquitous [1]. The culture of communication with the computer becomes part of the general human culture. Universities have always played an exclusive role in the education system, and special attention was paid to the quality of professional, pedagogical and scientific training of students. At this stage of society's development, there is an acute question of creating a fundamentally new system of education and upbringing, which will be based on new approaches and trends in the world of informatization. However, it should be noted that the mechanisms of effective use of information technologies to activate the educational and cognitive activity of future teachers when studying professional disciplines in a pedagogical university have not been sufficiently researched, which causes problems in their implementation in practice [2, p. 16].

One of the main tasks of education in pedagogical institutions of higher education is to teach a student to learn, to give him a basis for further self-improvement, to teach him to independently acquire the knowledge needed for his profession [3]. After all, the skills of most teachers to use highly specialized digital software environments in the lessons of physics, mathematics, chemistry, geography, etc. are insufficient. The success of solving this problem largely depends on qualitatively new approaches in the process of informatization of education and on the development and implementation of new schemes for the organization of the educational process. Already in the process of studying at a higher education institution, a student must acquire skills in the use of digital technologies in his/her educational, research and future professional activities.

Informatization of education is a necessary component of the training of specialists in any field of knowledge and is expedient not only as a method of quickly and effectively mastering one or another discipline being studied, but also as a way of life in a modern world saturated with information technologies [4, 5].

Legal relations that arise during the formation and implementation of the National Informatization Program are regulated by the Law "On the National Informatization Program". The following terms have been defined: "information and communication technologies is the result of intellectual activity, a set of systematized scientific knowledge, technical, organizational and other decisions on the list and the sequence of operations for the collection, processing, accumulation and use of information products, provision of information services" [6].

There is an urgent issue of training future teachers who are ready to work in new conditions, implement personal-oriented learning, develop new teaching technologies, implement differentiation and variability of teaching, and implement the latest methods [7, p. 63].

Different approaches to the professional training of students in higher pedagogical educational institutions have been developed in the following scientific works: Gudyreva – introduction of information and communication technologies in the educational process of a higher educational institution. Informatization of the educational process in higher education institutions contributes to the accelerated process of adaptation of the student as a future specialist to his/her professional activity, improves the quality of his/her training, provides an opportunity for the student and specialist to navigate more freely in modern life in general and in the field of professional activity, in particular, [8, p. 105]; Olefirenko – teaching students the method of projects with the use of information and communication technologies, which involves increased requirements for the teacher's professional training, his/her pedagogical competence, erudition, and general culture [7]; Tsidylo et al. – a computer simulation of population reproduction rate on the basis of their mathematical models [9]; methods of future natural sciences teachers training to use smart technologies on the basis of blearning apps – Stepanyuk et al. [10]; the use of professionally oriented tasks in the study of information technologies in pedagogical higher educational institutions has been considered by Velgach and Grod [2, p. 14-24].

The system of professionally oriented tasks needs implementation and constant development. Their structure should correspond to the developed structure of professional skills. This approach provides an opportunity to motivate students, improve indicators of educational activity, and intensify the process of training future specialists due to the professional orientation of tasks and the gradual formation of skills. According to Vlasenko, a professionally oriented task is a task whose conditions and requirements define a model of a certain situation that arises in the teacher's professional activity [11, p. 57].

The set of means, methods and techniques for collecting, storing, processing, analyzing and displaying spatial information is unified under the name "Geographical information technologies". Geoinformation systems form a new technology within which aspects of the interaction between man and the environment are investigated [12, p. 128].

It is worth noting the study by Kozachenko et al. [13], in which the methodological foundations of cartographic modelling are considered, its object, subject and means are substantiated, the main directions of cartographic modelling of the society-nature system are defined, as well as the place and role of geoinformation mapping in the system of cartographic disciplines, the essence, specifics and types of geoinformation, methods of creation and experience of using cartographic data banks, methods of mapping in interactive mode are outlined.

Spatial data provide the formation of “digital” or “electronic” maps. According to Rudenko and Chabanyuk, they can be reproduced in raster or vector format [14, p. 55].

The purpose of the article is to demonstrate the development of professionally oriented tasks for the study and use of future geographers by mapping technology using ArcGIS services.

In accordance with the purpose of the study, the following tasks are set:

(i) to find out the concept of professionally oriented tasks and requirements for their implementation in the educational process in pedagogical institutions of higher education;
(ii) to develop professionally oriented tasks from the course “Digital technologies in education and science” for geography students (to study the theoretical and practical aspects of GIS application, to analyze the possibilities of modern GIS as a teaching tool, to develop training instructions for working in ArcMap).

2. Research methods

A complex of interrelated methods was used to solve the tasks set in the research:

1) theoretical: analysis and generalization of scientific and pedagogical literature, modelling of the educational process;
2) empirical: observation of the educational process in a higher education institution during the “Digital technologies in education and science” training course, test tasks, questionnaires, questionnaire of personal evaluations;
3) GIS software: ArcMap is the main ArcGIS application, which is used to create maps and solve various GIS tasks, both general and highly specialized. It is based on an electronic map and works with a map document (*.mxd);
4) a pedagogical experiment on the study of the effectiveness of the use of professionally oriented tasks for the study and use of mapping technology by means of ArcGIS by future teachers-geographers.

3. Research results

Each professionally oriented task should include a complete cycle of solving it. We implement compliance with all stages of this cycle when performing the developed tasks.

The implementation of the developed tasks was carried out in the software environment, which was chosen according to the criteria defined by us for the compatibility of the software environment with the specified problem:

1) the maximum possible correspondence of the functionality of the software environment to the full cycle of solving professionally oriented tasks;
2) the possibility of a software environment for providing services of a complex nature, i.e. for mapping, editing, analyzing and managing data;
3) intuitive interface and 1-window interface technology;
4) the maximum possible correspondence of the functionality of the software environment to the requirements for displaying specific geographic information, a certain type of objects, for example, rivers, lakes, roads, administrative boundaries or animal habitats.

Among the existing wide range of software environments for creating a series of maps, we analyzed the online services of powerful Web cartographic or GIS portals (ArcGIS Online, Google Earth, Google Maps, Wikimapia, Bing Maps, MapQuest, Yahoo! Maps, MultiMap.com, Map24.com, Expedia.com, MapsOnUS, eAtlas, etc.) [15]. ESRI desktop products of the ArcGIS family (ArcView, ArcEditor, ArcInfo), basic programs ArcMap (solutions to cartographic problems), ArcCatalog (access and management of spatial data in a local network or via the Internet) and ArcToolbox (geoprocessing of spatial data) are united by a common architecture and interface, but they differ in functionality, number of geoprocessing and spatial analysis tools [16, 17].

After analyzing GIS environments, we have concluded that ArcMap is the primary application for mapping, editing, analyzing, and managing data. In ArcMap, you can make maps from layers of spatial data, choose colours and symbols, query attributes, analyze spatial relationships, design map placement, and more.

The ArcMap interface is based on the one-window technology, which involves opening each project in a separate window. The interface's appearance includes the following main elements: table of contents (or TOC), menu panel, toolbars, and status bar.

The program interface may change depending on the version and configuration of the software. The data displaying the cursor coordinates depends on the selected coordinate system and basic project settings (Data Frame properties-General).

The ArcMap application window consists of a map window for viewing spatial data, a table of contents for listing the layers displayed in the map window, and various toolbars for working with the data. ArcMap is launched through the .exe file of the ArcCatalog-Folder Connections window or through the path Main menu ArcMap.

Each ArcMap session can display only one project. A user can work on multiple projects simultaneously by starting additional ArcMap sessions. If the system registry has not been changed and no additional utilities have been run, the startup window should appear. In the ArcMap environment, it is customary to use the term "project" instead of the term "document", which is related to the nature of these documents, namely individual cartographic and geoinformation projects. The format component of these terms includes two file extensions *.MXD (project) and *.MXT (template).

In ArcMap, geographic information is displayed on maps as layers, each representing a specific type of feature, such as rivers, lakes, roads, administrative boundaries, or animal habitats. The layer does not store real geographic data but data stored in coverage files, shapefiles, geodatabases, images, and grids. In this way, data linking allows map layers to automatically map the most up-to-date information to the GIS database.

The table of contents is a list of all the layers of the map and shows what features each layer represents. A tick box next to each layer indicates whether the layer is enabled, i.e. whether it is visible/hidden in your project. The order of layers in the table of contents determines the order and priority of their display: the layers that are located in the table of contents above are displayed on top of those located below, for example, the layers that make up the background of your map should be at the end of the table of contents.

The layers in a table of contents can be grouped into data frames. A data frame is a group of layers that are displayed together as a self-contained structure. Each time a map is created, a data frame is present on it. It appears at the top of the table of contents under the name "Layers", but the name can be changed. For most maps that the user works with, there is no need to use data frames: the user can simply add layers to the project, depending on how they will be displayed in the table of contents. If a map contains more than one data frame, one of them is always active. Viewing an ArcMap page with an additional data frame is possible via the Table Of Contents tab, where the active frame is highlighted in bold.

To work with a map, the user opens it in ArcMap. If you don't know exactly where it is

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located, you can find it through ArcCatalog by browsing your database folders and opening it in ArcMap. If the ArcMap application is running, the map can be opened directly from it.

The map does not store the spatial data it displays. It simply points to the location of data sources on disk: geodatabases, coverage files, shapefiles, or rasters. This way, when you open a map, ArcMap always checks the data connection. If the application cannot find the data, for example, if the data source was accidentally deleted, renamed, moved, etc. by the user, ArcMap prompts the user to find it. If the data is not available, the user can still include it in the map, however, the layer will be part of the project, but will not be displayed.

Adding spatial data in the ArcMap environment is done using the "Add Data" command in several ways. In any case, a dialogue box for selecting spatial data and sources appears.

Map layouts are created according to the following algorithm. Switch to map layout and layout display mode. We select the size and orientation of the layout using the "File" menu and the "Page and Print Setup" command, where we specify the necessary layout parameters:

- selection of the printer for printing the map (Properties...);
- setting the paper size (Size);
- orientation of the project page (Portrait or Landscape);
- scaling map elements proportionally to changes in page size;
- shows printer margins on the layout.

It is advisable to set the orientation of the page before starting the development of the map. If autoscaling is disabled, the map elements will change according to the new orientation. It is useful to be able to see in Layout View the display of the printer fields so that you do not place map elements outside the print area. If we work with a virtual page, the size of which does not correspond to the size of the page, we can use the printer fields.

ArcMap has two map views: Data View and Layout View. When the user wants to view geographic data on the map, he selects Data type. Data view is a common view for exploring, displaying, and querying map data. This mode does not show map elements such as headings, north arrows, and scale lines, but allows the user to focus on a frame of data for further editing or analysis.

When preparing a map for a wall format, illustration in a report, etc., it is worth working in layout mode. The layout view is the external view of the map, where the user sees the virtual page on which the map is placed. Here, you can perform the same operations as in the Edit View mode, but in addition, you can develop the design of the map.

One of the main characteristics of spatial data is the coordinate system, and its definition for an information project is one of the key tasks. The quality of data, their collection, analysis and display depends on it. Selecting and changing the coordinate system for the project being created is carried out in several ways, one of them is to select the Data Frame Properties command from the pop-up menu by clicking the right mouse button on the cursor within the data frame. After invoking this command, the Data Frame Properties dialogue box appears, which provides access to many frame and map layout properties through one of the following appropriate tabs: Feature Cache, Annotation Groups, Extent Indicators, Frame, Size and Position, General, Data Frame, Coordinate System, Illumination, Grids. For example, the dialogue box for selecting and changing coordinate systems of a geoinformation project is opened through the Coordinate System tab.

In the "Coordinate system" tab, the following options are available: in the upper left part, the "Current coordinate system" option, which displays information on the existing coordinate system, in the lower left part, there is "Select coordinate system", which allows you to select the necessary coordinate system. In the right part of the tab there are commands that allow you to modify, create and import properties of coordinate systems; add and remove them from the

Favorites list. Sometimes you need to place several map elements along one line. By clicking on the element/elements of the map, we select them while pressing Shift, press the right key on one of the selected elements, select the command "Align" and one of the required items. Then drag the selected elements with the mouse to the desired place on the map.

Map elements are converted into graphic objects using the "Convert to Graphics" command (from the group of graphic elements). Having ungrouped a group of graphic elements (Ungroup), we can change them separately. After completing the editing process, grouping (Group) should be performed for ease of movement on the map (figure 1).

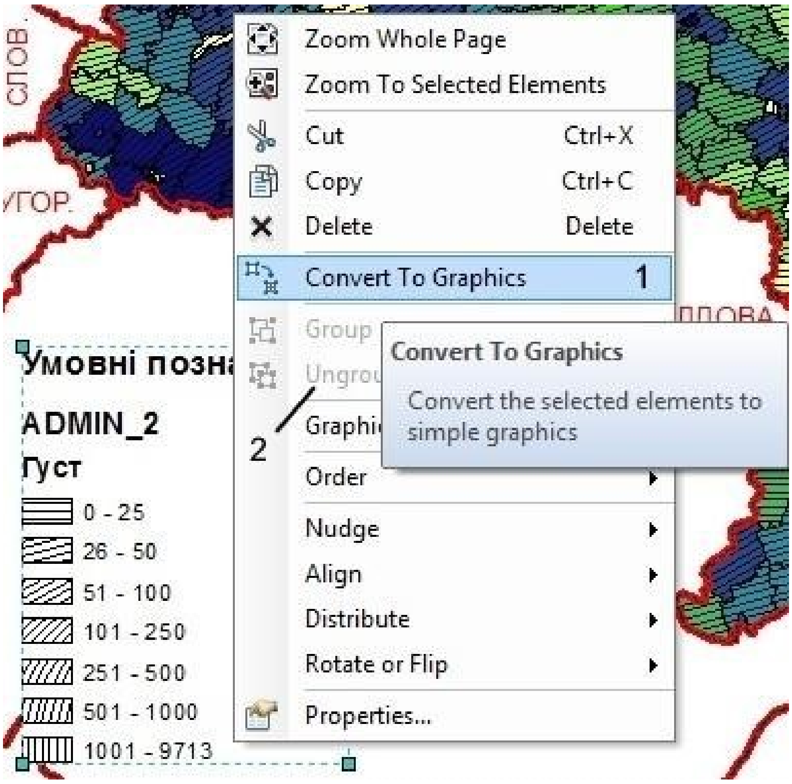

Figure 1. Converting map elements into graphic objects.

After the user has created a map, it must be exported from the map document to a different file format (File Export Map... Save to (specify directories, subdirectories) specify file type specify file name Options (Format) click the save button). You can export maps to several types of image files: .emf, .eps, .ai, .pdf, .svg, .bmp, .jpg, .png, .tif, .gif. Each format fulfils its purpose: AI saves most of the layers; PDF is created taking into account the possibility of working on different platforms; SVG is for XML files specially designed for viewing web pages; JPEG is for compressed image files; PNG is a special compression format for the Internet, etc.

Accordingly, we faced the question of developing tasks aimed at the formation of the professional and technological abilities and skills of future teacher-geographers, completing which students should independently come to the opinion that a teacher's professional activity is not reduced to separate fragmentary knowledge, methods, or educational disciplines. This will be facilitated by the fact that students will transfer certain algorithms and skills from one discipline to another, reflecting on the degree of their development and setting themselves self-educational tasks.

We took the data for creating the map from the State Statistics Service of Ukraine [18] and entered it into the attribute table ("POPULATION" column) (table 1). Excluding the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol.

Table 1. Population (estimated) as of October 1, 2020.

Regions of Ukraine	Number of population	Regions of Ukraine	Number of population
Vinnytsia	1,534,744	Luhansk	2,232,887
Volyn	1,029,533	Lviv	2,536,053
Dnipropetrovsk	3,285,626	Ternopil	1,033,566
Donetsk	4,332,016	Kharkiv	2,735,862
Zhytomyr	1,200,338	Kherson	1,070,567
Zakarpattia	1,251,697	Khmelnytsk	1,304,602
Zaporizzhia	1,673,914	Cherkasy	1,256,770
Ivano-Frankivsk	1,381,505	Chernivtsi	908,409
Kyiv	1,725,893	Chernihiv	1,062,810
Kirovohrad	984,864	City of Kyiv	2,962,881

Let us consider creating a map of the population of the regions of Ukraine in ArcMap using the quantitative background method. This method is often used to construct population maps, economic maps, and some political-geographical maps. To demonstrate this method, a vector map of Ukraine was used, adding the "POPULATION" column to the attribute table.

Open the Symbology tab, go to the Quantities tab and adjust the required parameters. By choosing the Graduated Colors function, we set the number of classes into which the map legend will be divided. Next, choose a colour scheme for the created map. The next step is the classification of parameters for dividing indicators into classes and choosing a classification method. We chose the Defined Interval method. The final stage of creating a map is setting signatures of regions of Ukraine. By right-clicking on the Ukraine Regions layer, select Properties, and set the necessary text display parameters on the Labels tab. We adjust the labels of areas on the map in the Layer Properties window (Labels tab). To display region labels on the map, select the Label Features option on the Ukraine-Regions layer (figure 2).

After creating the layout elements, the map is ready for printing.

Experimental verification of the effectiveness of the use of professionally oriented tasks for the study and use of mapping technology by means of ArcGIS by future geographer teachers.

The developed professionally oriented tasks were offered to students of the Faculty of Geography when studying the course "Digital technologies in education and science" during two academic years (2021, 2022 and 2023 1st semester) in the preparation of specialists of the educational level of the Master of Ternopil Volodymyr Hnatiuk National Pedagogical University according to the educational programs "Secondary education (Geography)" in the speciality 014.07 Secondary education (Geography), educational program "Ecology" in the speciality 101 Ecology, educational program "Geography" in the speciality 106 Geography, educational program "Earth sciences" in the speciality 103 Earth sciences, educational program "Tourism" in the speciality 242 Tourism. A total of 173 students were involved in the experimental work (table 2).

Students were given the task of creating a cartogram in laboratory-practical classes, the sequence of which is described above. The use of such tasks in the process of training a future specialist provides an opportunity to focus attention on learning: basic modern and promising data processing systems; the possibilities of using digital technologies in the process of preparing and conducting geography classes; principles of processing tabular information collected in the process of practical activity of the future geographer; possibilities of visualization of the results of measurement procedures; analysis and forecasting of processes based on statistical data;

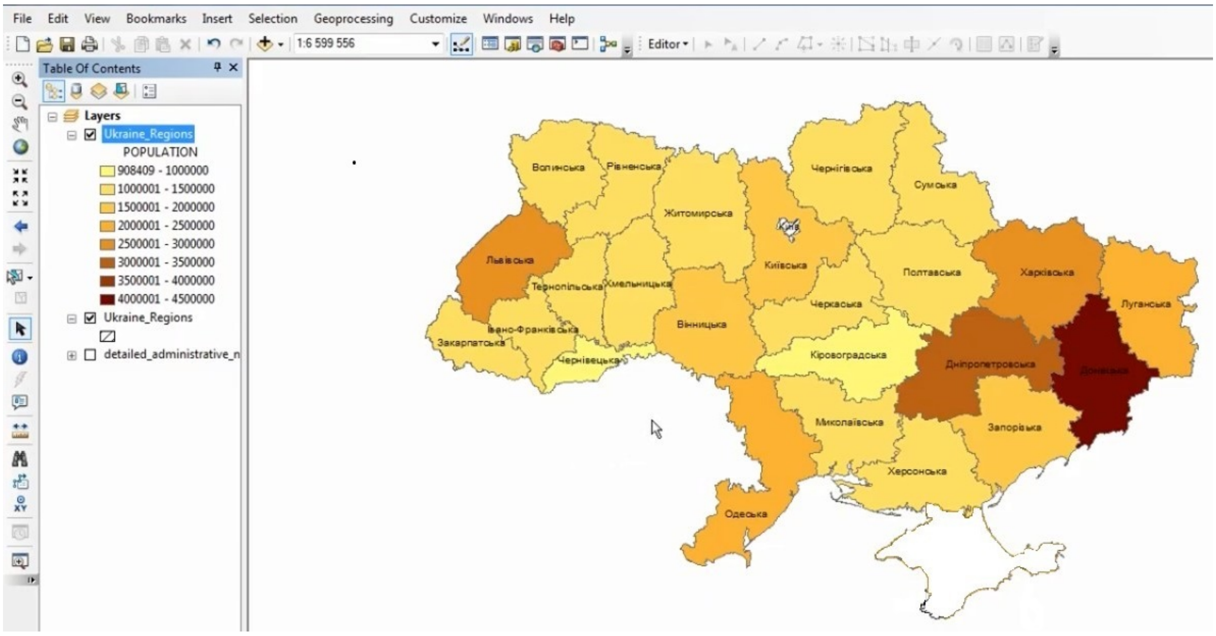

Figure 2. Map of the population of the regions of Ukraine, created using the quantitative background method.

Table 2. Population (estimated) as of October 1, 2020.

Academic year	014.07 SE(G)	106 G(ES)	103 T(ES)	101 Ecology	242 Tourism
2020/21	30	5	5	8	8
2021/22	25	5	5	6	8
2022/23	17	7	9	16	19
Total by prog.	72	17	19	30	35
Total	173				

methods of statistical processing of experimental data; search functions for quick viewing of the required information.

In order to analyze and establish the quantitative and qualitative characteristics of students' ability to study and use mapping technology, the following criteria were defined: motivational, cognitive and personal-reflective with the corresponding indicators: students' awareness of the importance of using the acquired knowledge in future professional activities and the IT environment; application of active and interactive forms, methods, educational technologies of organizing professionally-oriented training aimed at practising skills and developing professionally significant (intellectual, communicative, reflective) abilities of students; formation of experience of future professional activity in the process of education. Based on the defined criteria and their corresponding indicators, three levels of students' ability to study and use mapping technology are distinguished: high, average, and low.

To determine the levels of formation of the specified quality, test tasks, questionnaires, and a questionnaire of personal evaluations were used, which formed the basis of the methodology of experimental confirmation of the criteria and corresponding indicators defined by us. A questionnaire was used for the motivational criterion, cognitive test tasks, and personal-reflective questionnaire of personal evaluations.

At the beginning of the research, it was established that according to all the defined criteria, the students have a low level of ability to study and use mapping technology (53%). There is a significant (33%) indicator of the average level and a small number of students (14%) who have a high level of ability to study and use mapping technology, and therefore the investigated problem is timely for solution.

The effectiveness of the introduction of professionally oriented tasks into the educational process is confirmed by the positive changes that were detected after the completion of the formative phase of the experiment (table 3).

Table 3. Indicators of students' ability to learn and use mapping technology.

Level	Motivational				Cognitive				Personal-reflective			
	Before the experiment		After the experiment		Before the experiment		After the experiment		Before the experiment		After the experiment	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
High	28	16,1	69	39,9	24	13,9	65	37,6	24	13,9	65	37,6
Avegare	56	32,4	77	44,5	57	32,9	78	45,1	59	34	80	46,2
Low	89	51,4	27	15,6	92	53,2	30	17,2	90	52	28	16,2

As evidenced by the data of the experiment, the high level of student's ability to study and use mapping technology in the groups has increased by 24% since the beginning of the study, the average level has increased by 12%, and the low level has decreased by 36% after the completion of the formative phase of the experiment. According to statistical calculations, changes in the level of student's ability to study and use mapping technology due to the implementation of the methodology of using professionally oriented tasks are statistically significant, that is, probable.

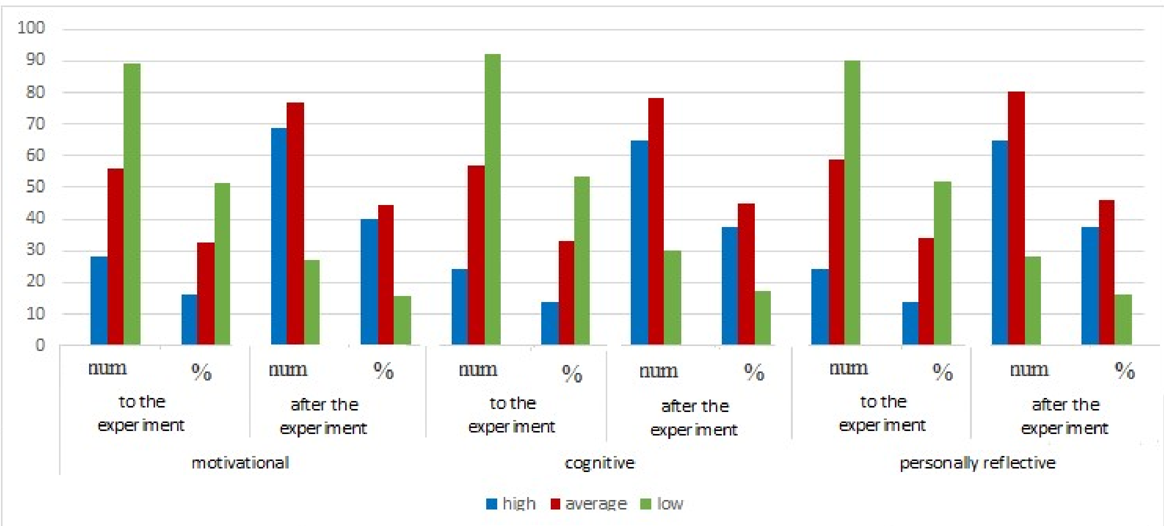

Figure 3. Indicators of motivational, cognitive and personal-reflective criteria.

The obtained results confirm the effectiveness of the implementation of the methodology and its impact on increasing the level of student's ability to study and use the mapping technology of future specialists.

4. Discussion of research results

A specific feature of professionally-oriented technologies is the professional-activity focus of training on students' mastery of professional activities in the educational process, which is ensured by the following factors: orientation of the educational material to solving the tasks of professional training of the future teacher; the complex nature of the specialization, which covers all connections of the course with relevant disciplines, course and master's design and other types of research activities of students; preferred solution in practical classes of applied tasks, which are necessary for the student to master the chosen profession; focus on the development of the creative personality of the future teacher, who is capable of independent professional activity; development of professional value orientations, formation of a professional position, development of the need and readiness for professional and personal self-improvement [19].

The practical value of ArcGIS for the development of cartographic materials in educational institutions is not limited to one stage of creating maps but is actually a tool for the full cycle of creating and preparing maps for their publication. With a wide range of tools, methods and ways to display information about the terrain, ArcGIS offers a wide range of options for presenting certain data on the map, which perfectly emphasizes the statement that the map is a model of the terrain and its representation.

5. Conclusions

The significance of the practical application of web cartography for highlighting the peculiarities of the use of web technologies in mapping is characterized by a low level of geoinformation support and, therefore, requires appropriate cartographic resources, which will include information and operational tools intended mainly for scientific, educational, geo-monitoring, tourist-recreational and local history-cognitive purposes. This is ensured by the existing toolkit of visualization, search and formation of geospatial queries and analysis.

Completion of professionally oriented tasks encourages students to analyze, comprehend and systematize information, promotes better motivation to study, and, most importantly, increases their level of professionalism. Quantitative and qualitative analysis of the results of research and experimental work confirms the effectiveness and expediency of the approbation of the methodology of using professionally oriented tasks with the use of mapping technology by means of ArcGIS. Prospects for further scientific research are possible in the direction of analyzing the results of the implementation of specially organized professionally-oriented training, substantiating the interdisciplinary connections of professional training subjects, as well as developing professionally-oriented tasks.

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References

[1] Vakaliuk T A and Antoniuk D S 2023 The use of digital technology in general secondary education in Ukraine: current state and future prospects *Proceedings of the VIII International Workshop on Professional Retraining and Life-Long Learning using ICT: Person-oriented Approach (3L-Person 2023), Virtual Event, Kryvyi Rih, Ukraine, October 25, 2023* (*CEUR Workshop Proceedings* vol 3535) ed Papadakis S (CEUR-WS.org) pp 17–31 URL `https://ceur-ws.org/Vol-3535/paper01.pdf`

[2] Velhach A and Grod I 2021 The use of professionally oriented tasks in the study of information technologies in pedagogical higher educational institutions *Scientific notes of Ternopil National Pedagogical University named after Volodymyr Hnatiuk. Series: Pedagogy* **1**(1) 14–24 URL https://doi.org/10.25128/2415-3605.21.1.2

[3] Tkachenko T, Yeremenko O, Kozyr A, Mishchanchuk V and Liming W 2022 Integration Aspect of Training Teachers of Art Disciplines in Pedagogical Universities *Journal of Higher Education Theory and Practice* **22**(6) 138–147 URL https://doi.org/10.33423/jhetp.v22i6.5236

[4] Malykhin O, Aristova N, Dichek N and Dyka N 2021 Formation of top job skills of tomorrow among computer engineering and information technologies undergraduate students in the process of learning english *ENVIRONMENT. TECHNOLOGIES. RESOURCES. Proceedings of the International Scientific and Practical Conference* **2** 249–254 URL https://doi.org/10.17770/etr2021vol2.6642

[5] Blavt O, Iedynak G, Pereverzieva S, Holub V and Melnyk S 2023 Increasing the reliability of test control using information technologies in inclusive physical education *Physical Education Theory and Methodology* **23**(4) 607–613 URL https://doi.org/10.17309/tmfv.2023.4.16

[6] Verkhovna Rada of Ukraine 2022 Pro natsionalnu prohramu informatyzatsii URL https://zakon.rada.gov.ua/laws/show/2807-20?lang=en#Text

[7] Olefirenko N V 2010 Teaching students the method of projects using information and communication technologies *Scientific research work of students as a factor in improving the professional training of future teachers* (*Collection of scientific works* vol 1) ed Bilousova L I (Fakt) pp 63–66 URL https://kafinfo.org.ua/files/Sbirnyk_1.pdf

[8] Gudyreva H M 2010 Introduction informatively communicative technologies in educational process of higher educational establishment *Journal of Information Technologies in Education (ITE)* 101–112 URL https://doi.org/10.14308/ite000153

[9] Tsidylo I M, Shevchyk L O, Hrod I M, Solonetska H V and Shabaga S B 2022 A computer simulation of population reproduction rate on the basis of their mathematical models *Journal of Physics: Conference Series* **2288**(1) 012014 URL https://doi.org/10.1088/1742-6596/2288/1/012014

[10] Stepanyuk A, Mironets L, Olendr T and Tsidylo I 2021 Methods of Future Natural Sciences Teachers Training to Use Smart-technologies on the Basis of Learning Apps *Proceedings of the 17th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume I: Main Conference, PhD Symposium, and Posters, Kherson, Ukraine, September 28 - October 2, 2021* (*CEUR Workshop Proceedings* vol 3013) ed Ermolayev V, Esteban D, Mayr H C, Nikitchenko M, Bogomolov S, Zholtkevych G, Yakovyna V and Spivakovsky A (CEUR-WS.org) pp 411–418 URL https://ceur-ws.org/Vol-3013/20210411.pdf

[11] Vlasenko K V 2005 Formation of abilities and skills of students of engineering at higher educational institutions in the process of heuristic activity *Ridna shkola* 55–58

[12] Svitlichnyi O O and Plotnytskyi S V 2006 *Fundamentals of geoinformatics. Tutorial* (Sumy: University book)

[13] Kozachenko T I, Parkhomenko I O and Molochko A M 1999 *Cartographic modeling: A teaching manual* (Vinnytsia: Antex-U LTD)

[14] Rudenko L H and Chabaniuk V S 2004 GIS in modern geographical research: application and development problems in Ukraine *Ukraine: geographical problems of sustainable development* vol 1 (Kyiv: Obrii) pp 273–287

[15] Kholoshyn I, Nazarenko T, Bondarenko O, Hanchuk O and Varfolomyeyeva I 2021 The application of geographic information systems in schools around the world: A retrospective analysis *Journal of Physics: Conference Series* **1840**(1) 012017 URL https://doi.org/10.1088/1742-6596/1840/1/012017

[16] Demeuov A, Tilekova Z, Tokpanov Y, Hanchuk O, Panteleeva N and Varfolomyeyeva I 2021 Use of GIS technology in geographical education *E3S Web of Conferences* **280** 11010 URL https://doi.org/10.1051/e3sconf/202128011010

[17] Bondarenko O V, Hanchuk O V, Pakhomova O V and Varfolomyeyeva I M 2023 Digitalization of geographic higher education: Problems and prospects *Journal of Physics: Conference Series* **2611**(1) 012015 URL https://doi.org/10.1088/1742-6596/2611/1/012015

[18] 2024 State Statistics Service of Ukraine URL https://www.ukrstat.gov.ua/

[19] Yermolenko A O 2011 Peculiarities of the methodology of formation of professional skills of future teachers of history *Bulletin of the Chernihiv National Pedagogical University named after T. H. Shevchenko* (93)