Environmental Geo-information Technologies as a Tool of Pre-service Mining Engineer's Training for Sustainable Development of Mining Industry

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Abstract. The article highlights peculiarities of geoinformation technologies' application in course of pre-service engineers' training for sustainable development, their functionalities, geoinformation system's role and position in environmental protection acts. Concepts of geoinformation technologies, geoinformation system have been disclosed. The pedagogical experiment was done concerning introduction of the developed method of using geoinformation technologies as means of forming environmental competence profile mining engineers predicted an experemental studying on course «Environmental Geoinformatics». The results of the expert assessment of rational using geoinformation technologies there were given to create an ecological competence of future mining engineering profile.

Keywords: education, mining engineer, sustainable development, geoinformation technologies.

Key Terms. InformationCommunicationTechnology, ICTTool, TeachingProcess.

1 Introduction

1.1 The Problem Statement

Nowadays information and communication technologies (ICT) applying is one of the principle education challenges, which provides the education process improvement, its accessibility and effectiveness and preparing the younger generation for living in the information society. Education must serve for the society needs. Processes reflecting current trends of society transformation provide information technologies development and implementing. At present the ICT usage in education can be a catalyst in solving important social problems connected with increasing the educational resources and services availability and quality, real and equal opportunities in getting

education for citizens despite their residence, social status and income [1]. Currently, high technologies cover almost all areas of our life. Professionals having common practical and theoretical skills of work with different information types are highly wanted.

Nowadays ICT are very actual and necessary for optimal business management of mining industry in the context of sustainable development and one of them are environmental geoinformation technologies.

2 Concepts and Related Works

2.1 Specification of Stakeholders

Law of Ukraine on Mining is main regulatory document, defining legislative and organizational basis of Mining engineer profile-related activity in terms of mining activities arrangement, ensuring emergency protection of mining enterprises, institutions and companies [2, article 5]. The Law stipulates preparation for mining activities and mineral deposits extraction, mining organizations operation, emergency protection and mining safety, peculiarities of environmental safety while mining as well as peculiarities of labor conditions in mining industry, cease of mining companies' activity, etc. These provisions of the Law correspond to the functions of sustainable development of a model of the using of resources aimed at satisfaction of human needs while saving the environment so that these needs can be satisfied not only in modern, but also by future generations [15]. Therefore, the state policy in the mining industry is aimed at sustainable development of the mining industry, science and education.

2.2 The State of the Art

Nowadays mining engineer is the professional, being able to find new solutions of technical problems' resolving, applying scientific knowledge, mathematics, construction and invention using ICT. In recent years both in Ukraine and abroad the problems of ICT implementation in the educational process have been actively explored by V. Yu. Bykov, M. I. Zhaldak, I. V. Robert, Yu. V. Trius and others. Great contribution in geographic information system (GIS) investigating was made by S. S. Zamay, I. V. Zhurkin, Ye. G. Kapralov, A. V. Koshkarev, I. V. Prolyetkin, O. S. Samardak, S. V. Shaytura and others. The methods of using GIS (Geographic Information System) technologies have been reviewed in the profession oriented educational process for high school students (N. Z. Khasanshyna), in teaching geography, geodesy, cartography and land management (G. D. Kulibekova, G. L. Yezhova), and in the educational process in general (L. E. Gutorova, I. V. Lytkina, A. M. Shylman, V. A. Sultanov).

2.3 The Purpose of the Article

The main purpose is the analysis of the most appropriate ways of GIS application in the process of pre-service mining engineers training in the context of Mining industry sustainable development.

3 Presenting the Main Material

The geosystem concept [3, p. 100] describes geographically isolated ecosystems and is a fundamental category of Geography and Geoecology characterizing a set of interrelated geographical envelopes' components, unified by substances' and energy flows. Application of the ICT in Geosystem researching resulted in Geoinformatics occurrence, being a brunch of science, reflecting and exploring the natural and socio-economic geosystems, their interaction and development through PC-based simulation based on information systems and technologies, database and knowledge base [4].

Geoinformatics' tasks are studying of geoinformation's general characteristics, mechanisms and methods of its obtaining, recording, storing, processing and application as well as geoinformation systems' theory, methodology and technology development for spatial-coordinated data collection, classification, storing, processing, transforming and presenting. Geoinformation system functions also encompass geographic (spatial) data analysis and its visualization in the form of charts and schemes it has appeared on the intersection of technology of data processing used in database management systems and graphics visualization in computer-based designing and machine graphics systems.

The importance of Geoinformatics scientific and technical issues in terms of the national economy is to provide information, control and support, decision-making in the area of research, planning and designing in the geosciences and related to them social and economic sciences, in education and culture development, ecological balance maintaining, preventing emergencies and ensuring the state's defensive potential.

Geoinformatics as science explores:

- theoretical and experimental research in the field of geoinformatics' scientific and methodological basis;
- technical means of geodata collecting, recording, storing, transmitting and processing using computer technologies;
- geoinformation systems of various purposes and type (reference, analytical, expert, etc), spatial and thematic content;
- databases and digital data in different fields, as well as database management systems;
- knowledge base from different subjects;
- mathematics methods, GIS mathematical, information, linguistic support as well as GIS software;
- geoinformation mapping and other types of geosimulations, system analysis of diverse and multilevel geodata [5];
- computer geoimages of new kinds and types, animation, multimedia, virtual and other digital products;

- geoinformation infrastructure, methods and technologies of geodata storing and application based on distributed databases and knowledge base;
- telecommunication system of spatial and time-bound geodata collecting, analyzing, processing and distributing;
- interaction of geoinformatics, cartography and aerospace exploration.

Geoinformatics is guided by means of information and communication technologies (a complex of «methods, tools and techniques used for collecting, organizing, storing, processing, transmitting, presenting various information data» [6, 8]) applied for data processing of special form such as spatial-coordinated data. Therefore, under the GIS information and communication technologies (GIS ICT, GIS technology) we mean the set of methods, tools and techniques used for spatial-coordinated messages and data collecting, arrangement, storing, processing, transmitting and presenting.

We define geoinformation first of all as spatial data (spatial-coordinated data), being digital spatial information about spatial objects that include information about their location and properties, spatial and non-spatial attributes [7, p.71]. Spatial attributes includes both positional and non-positional data (description of spatial location and thematic content, topological-geometric and attribute data).

Necessity to consider data dynamics and changeability requires consideration of not only spatial data character but also time-bound data aspects, expanding the concept from spatial data to spatial and time-bound data. Introduction of time-bound data dimension is one of the manifestations of spatial data multi-dimensional characteristics, including four-dimensional GIS. Models or spatial data representations or its structures are means of topological geometric abstract description. The most widely spread relational model showing attributes of spatial data in databases is called georelational data model. Spatial data quality is determined by its accuracy (correctness), reliability, validity, integrity, consistency. Owing to various spatial data the basic functionalities of GIS are as follows: posting, export, import, share, pre-processing, processing, analyzing, output, visualization operations etc. According to Glossary of key geoinformatics terms, GIS has the following definitions:

1. information system providing collection, storage, processing, access, display and distribution of spatial-coordinated data (spatial information). GIS includes digital data representing about spatial objects (vector, raster, quadraphonic, etc.);
2. software tool implementing GIS functionality. It is provided by software, hardware, information, legal, personal and organizational support.

GIS can be classified as per various principles, such as:

- territorial coverage: global (planetary), subcontinent, national (state), regional, subregional, local;
- matter focus: city (municipal), environmental (in particular, land etc.);
- problem focus: scientific (GIS analysis and data evaluation), application (GIS for resource inventory, monitoring, management and planning, decision-making support).

The GIS functionality is a set of functions related to geographic information systems and corresponding software:

- data entry by importing existing sets of digital data or using source digitization;
- data conversion: converting data from one format to another, transforming map projections, changing coordinate systems, data storage, manipulation and management in both internal and external databases, map-dimension activities, survey measurement data processing, overlay operations, cartographic algebra operations;
- spatial analysis: a complex of functions, providing analysis of location, relations or other spatial object interrelations, including analysis of visibility / invisibility areas, proximity analysis, network analysis, creation and processing of digital elevation landscape models, analysis of buffer areas-bound facilities, etc.;
- spatial simulation (geo-modeling): operations similar to mathematical and mapping simulation, and cartographic research methods, visualization of input, derivative or output data (cartographic visualization, planning and creation of cartographic images);
- data display: graphical, tabular and textual documents, including their replication, documentation and report generation;
- decision-making support [8, p. 87-88].

3.1 Materials and Methods

The study is carried out in Kryvyi Rih National University according to the plan of joint research laboratory of using cloud technologies in education process of Kryvyi Rih National University and the Institute of Information Technologies within the research project «Adaptive system of mining engineer individual teaching based on the integrated structure of artificial intelligence» – a digital tutor» [9]. The author analyzes sources devoted to investigation of ecological competence formation problem and application of geoinformation technology while future mining engineers training [10; 11]. This research also improves the system of competence of future mining engineers, gives its theoretical explanation and represents geoinformation technology tools used in education process [12-14].

3.2 The Ways of Implementation

Functionalities of ecology GIS:

- digital map and environmental data posting, acquisition and processing;
- build-up of thematic maps (based on data, obtained), reflecting current ecosystem's status;
- examination of environmental change dynamics (dimensional- and time-bound), development of charts, tables, diagrams, etc.;
- simulation of environmental situation development and investigation of ecosystem's health correlation to weather conditions, characteristics of pollution sources, background concentration values, etc.;
- obtainment of environmental objects' integrated assessment based on various data [7, p. 7].

Role and position of GIS in environmental protection measures:

- prevention of environmental degradation (GIS are used to create maps, showing flora and fauna's degradation in remote, satellite, field images, for land degradation assessment, etc.);
- pollution prevention (it is convenient in impact and expansion simulation from point to spatial sources, placed in some particular location, in the air; outcomes of simulating calculations can be put on the map and evaluate possible future emergencies);
- protected areas' management (collection and management of data from protected areas: reserves, national parks, performing multiuser tasks that ensure minimal environmental impact and environment preservation);
- non-protected areas monitoring (GIS enable continuous data collection & update, traceability of land use borders, development of environmental protection measures, etc.);
- rehabilitation of living environment (GIS is an effective tool for living environment exploration as a whole and particular species of plants and animals in terms of both dimensional and time-bound aspects, animals life monitoring, determination of problems and ways of their solving);
- scientific research and technical support (GIS enable determination of interrelations between population's health and variety of factors: environmental, demographical, economical);
- data digest structuring and publication (application of GIS simplifies publication of various mapping products);
- environmental-focused education (it is possible to get large number of various map that are used by environmental-focused education) [7, p. 8-10].

4 Organization, Conduct and Results of Experimental Work

Pedagogical experiment of the introduction of the methodology of using geoinformation technologies as means of forming the ecological competence of pre-service engineers of the mining profile which included for experimental training on a special course «Environmental Geoinformatics». The multifunctional geoinformation systems were used in the laboratory classes of the special courses in the control groups, the multifunctional GIS, mining and environmental GIS and software of program-methodical complex «Eco Krivbas» were used in the experimental groups. After the completion of the experimental studying, there was found that in 49.33% of the students in the control groups, environmental competence was formed at the average level, and in 20% - on sufficient, while the students in the experimental groups were dominated by sufficient (37.33%) and medium 36%) level of environmental competence formation.

5 Conclusions

Application of environmental geoinformation technologies is the fundamentals of Mining company's optimal management as well as of ambient environmental forecast and control, leading to reasonable and environmentally balanced development of

natural resources in mined areas. Amount of work on impact of mining production on the environment, considering specific character of natural and climate conditions determined selection of geoinformation technologies which were presented as methods, tools and techniques, used for spatial-coordinated messages and data collection, classification, storing, processing, transmitting and introduction. Application of geoinformation technologies' tools in mining profile engineer's professional activity ensures fulfillment of key environmental-focused requirements for mining via: geosimulation of mining production areas' location, remote monitoring of environmentally friendly mining technologies' application on the Earth surface, systematic analysis of multilevel and diverse geoinformation in course of open mining advanced technologies implementation, aerospace probing of mineral wastes usage for recycling purposes, geoinformation mapping, etc.

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