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SYSTEM OF COMPETENCIES FOR MINING ENGINEERS

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Abstract. Topicality of the material, highlighted in this article is stipulated by the need to ensure effectiveness of educational process while preparing mining engineers**.** System of competencies for future mining engineers, taken as basis for high school sectoral standard for Mining 6.050301 update is theoretically substantiated and developed. Sources of stateof-the-art foreign educational system and technologies as well as scientific research results of local teachers have been analyzed, enabling development of new sectoral standard. Switching to new high school competencies-based sectoral standards is the necessary step in high education reforming in Ukraine, while the application of competencies-based approach to high school sectoral standards development facilitates tuning of education towards labour market's requirements and demands, further development of educational techniques and educational system as a whole.

Objective of the article: to project system of competencies and to define components of environmental competencies for mining engineers. *Methods:*

- theoretical: analysis, generalization, systematization of legislative framework, educational standards, Internet sources in order to distinguish theoretical basis of research, develop system of competencies for future mining engineers.
- Empirical – improvement of system of competencies for future mining engineers.

Scientific novelty is represented with structured system, consisting of 49 competencies, comprising the core of new sectoral standard for mining engineers preparation;

Practical importance of the outcomes is related to developments: separate constituents of high school draft sectoral standard for Mining engineers bachelors' preparation 6.050301 Mining (system of social & personal, general scientific, toolbased, general professional and special professional competencies.

Research outcomes can be used while developing educational qualification profile and training program for Mining bachelors 6.050301 education field, in course of geoinformation al technologies review by ecology, land survey and geography bachelors.

Key words: system of competencies, future mining engineers, mining, education.

Introduction. Today's processes of high school reforming in Ukraine is mostly perceived and accessed via competency approach and corresponding high school sectoral standards.

Comparative analysis of modern foreign educational systems & technologies as well as research and developments of our teachers [1] enables to conclude following main ways of education development:

– continuous update of high education content to better meet the needs of society, incl. Future needs;

– focus on graduates competitiveness ensuring at labour market;

– formation of professional, social and personal skills on the part of the student, enabling him to fully realize his intellectual potential;

– autonomy boosting and high institutions independency ensuring, strengthening of their relations with employers, being main customers for the staff;

– expansion of students' academic mobility, enabling more comprehensive intellectual potential realization.

Efforts of any expert's are directed to some specific object of activity and imply realization of its distinguished production functions. It is associated with specific system of activity and is realized with the help of corresponding system of tools, related to this activity.

Considering present conditions formation of experts' skills to restructure system of his own professional activity based on corresponding fundamental education and considering socially protuberant objectives and legislative restrictions, thus forming future specialist's personal characteristics becomes more dominant in today's education [2 p. 4]. If main designation of high education system is defined as preparation of such an expert, then educational process shall be arranged in such a way to ensure comprehensive development of future expert's personality. Thus educational technologies become the tool of

personality establishment, teaching staff's object – personality of high institution graduates, who shall be competent not in professional field only but have proactive attitude, high level of civic consciousness, be adequate in solving of problems, the life puts in front of him [3, 4, 5].

Thus switching to new competenciesbased high school sectoral standards is a necessary stage on the way of high education reforming in Ukraine, while application of competencies-based approach in high school sectoral standards developments makes it possible to tune education to labour market's requirements and demands and to further develop educational technologies and educational system as a whole. For that reason educational standard for Mining field of education 050301 «Mining» [6], parts of which have become effective from 2005, shall be revised based on competency approach.

Law of Ukraine on Mining [7, article 5] 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. 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 labour conditions in mining industry, cease of mining companies' activity, etc.

Expert's environmental competency formation used to be the research subject at various levels: at environmental culture and conscious educational level of M. K. Stone (Michael K. Stone) [8], at environmental literacy general professional level (Z. Barlow
(Zenobia Barlow) [9] as well as at environmental competency special professional level C. Bofinger (Carmel
Bofinger) [10].

The notion of environmental competency can be interpreted in a different way.

Thus, Gagarin O. V [11, c. 57-58] defines environmental competency as:

1) the person's ability to integrate environmental knowledge, skills and means of their usage in different practical activity types, person's willingness in exercising environmental-preservation approach and his experience in environment preservation and environmental problems solving;

2) integrative feature of the individual, encompassing environmental knowledge; concepts of person-environment integration features and norms; concept of the nature, being the value of top-priority; willingness and ability to solve environmental problems; experience in practical environmental preservation and improvement activity; environment-focused personal features (humanity, empathy, preserve attitude, environmental responsibility for activities results).

According to L. E. Pistunova [12, pp. 1112] environmental competency is individual's feature that includes environment recognition as the matter of top-priority as well as knowledge of human-environment interaction norms and impacts; ability to creatively solve training environmental tasks; experience in practical environmental preservation and improvement activity; environment-focused personal features (humanity, empathy, preserve attitude, environmental responsibility for environmental activities results).

L. M. Tytarenko [13, p. 14] views environmental competency as the ability to apply environmental knowledge and experience in professional and daily tasks, following the environmental priorities and non-pragmatic environment-based motivation, considering acknowledgement of individual's involvement in environmental problems and responsibility for ecological effect from his own professional and daily activity.

Thus, it is reasonable to review environmental competency at three levels:

– at general educational level of environmental culture and conscious;

– at environmental literacy general professional level;

– at environmental competency special professional level.

Environmental competency formation requires environmental knowledge and activity introduction in personal values system. S. V. Sovgira indicates that in this case sequence of key components will be as follows: environmental problems acknowledgement (acknowledgement, perception (feeling)); monitoring environmental cause and effect relations (observation, attention, individual experience, memory, imagination);

emotions, thinking (conversion of images and ideas, recorded in the memory, qualitative changes in the structure of consciousness (concept, judgment, conclusions), shaping of individual world's picture); beliefs (structured point of views, related to nature, society, naturesociety interaction, environmental preservation inducement and personal incentive to act in line with her internal position and attitudes); activity (implementation of theoretical and practical environmental-focused and environmental preservation activity)» [14, pp. 294-295].

Despite numerous researches that initiated this problem solving we still believe it is needed to define environmental competency notion.

Environmental competency of future mining engineer is individual formation, characterized by professionally-oriented environmental knowledge, got in course of training (cognitive criteria), adopted means of environmental friendly mining provision (praxeological criteria) by sustainable development (axiological criteria) and by shaped socially responsible environmental behavior (social & behavior criteria), including the following components: 1) ethical behavior norms acknowledgement and perception in relation to other individuals and to nature (bioethical principle); 2) environmental literacy; 3) basic ecology knowledge, required for further usage in professional activity; 4) ability to apply scientific laws and methodologies for environmental assessment, to participate in environment-focused studies, to analyze environmental measures in specific industry, to develop plans, aimed at industry anthropogenic affect reduction; 5) ability to ensure environmental-balance activity, to apply methods of rational and integrated development of georesouces mining potential.

C. Bofinger, having analyzed competency-based Australian standards for coal- [15; 16; 17] and ore- [18; 19; 20] and coal- & ore-dressing miners [21], distinguishes 15 competency groups [22, p. 2]:

1. Risk assessment management system.
2. Environmental management system.
3. Legislation adherence management system.
4. Health & Safety management system.
5. Quality assurance management system.
6. Emergency and rescue preparedness.
7. Mining maintenance system.
8. System of mining infrastructure and equipment.
9. Transportation and manufacturing system.
10. System of explosive activities.
11. System of fastening and mining activities – above-surface activities.
12. System of fastening and mining activities – underground mining activities.
13. Ventilation.
14. Guidance in case of self-ignition.
15. Gas management system.

Materials and Methods.

Mining field of education in Ukraine 050301 (mining development and mineral deposits extraction) presumes following profiles [23]: 05030101 – mining development and mineral deposits extraction (depending on the type of mining activity); 05030102 – mine and underground construction; 05030103 – well-drilling; 05030104 – mine survey; 05030105 – mining safety.

050303 «Minerals' dressing» in Ukraine was separated from 050301 «Mining development and mineral deposits extraction» vs integrated profile 130400 «Mining» in Russia. As source [24] stipulates, profile 050301 «Mining development and mineral deposits extraction» in Australia is covered by two separate standards: MNC04 – Coal Training Package [173; 174; 175] (preparation of coal mining engineer, Annexure Б) and MNM05 – Metalliferous Mining Training Package [18; 19; 20] (preparation of ore miner [24]. In view of aforesaid direct application of foreign competencies-based standards while high school sectoral standard update in Ukraine for Mining profile is not possible.

Comparison of MNC04, MNM05 and MNQ03 standards [16] makes it possible to distinguish competencies, being common for 0503 «Minerals development» field of education (analysis does not consider competencies, related to benefication, purification, melting and geological survey, associated with other fields of education).

Table 1 shows 4 competencies group, comprising common core of professional competencies for future mining engineers.

Table 1. Common core of professional competencies for future mining engineers (as per MNC04 – Coal Training Package [7;8; 9] and MNM05 – Metalliferous Mining Training Package [10; 11; 12])

Competency	Competency abbreviation
General competencies	MNCG, BSBCMN, BSBFLM, BSBMGT, MNMMSM, MNMG
establish the risk management system	MNCG1003A MNMMSM617A
respond to local emergencies and incidents	MNCG1004A MNMG330A
conduct safety and health investigations	MNCG1008A MNMG326A
communicate information	MNCG1009A
remove, repair and refit tyres and tubes	MNCG1032B
service mine plant and equipment	MNCG1037A MNMG216A
conduct non-slewing crane operations	MNCG1041A MNMG234A
conduct slewing crane operations	MNCG1042A MNMG335A
operate articulated vehicle	MNCG1064A
establish the statutory compliance management system	MNCG1102A MNMMSM616A
initiate, monitor and supervise contracts	MNCG1125A MNMMSM612A
conduct business negotiations	MNCG1126A MNMMSM615A
participate in environmental work practices	BSBCMN215A
promote innovation and change	BSBCMN412A
implement operational plan	BSBFLM405A
implement continuous improvement	BSBFLM409A
manage personal work priorities and professional development	BSBFLM501A
manage operational plan	BSBFLM505A
manage quality customer service	BSBFLM507A
facilitate and capitalize on change and innovation	BSBFLM510A
review and develop business plans	BSBMGT603A
provide leadership across the organization	BSBMGT605A
manage knowledge and information	BSBMGT607A
manage innovation and continuous improvement	BSBMGT608A
Underground mining competencies	MNCU, MNMULH, MNMUMS, MNMMSU
escape from hazardous situation unaided	MNCU1037A MNMUMS218A
provide aided rescue to endangered personnel	MNCU1038A MNMUMS219A
recover equipment	MNCU1045A MNMG318A
apply and monitor mine transport systems and production equipment	MNCU1138A MNMMSU406A

implement mine services and infrastructure systems	MNCU1142A MNMMMG513A
apply and monitor mine services and infrastructure systems	MNCU1143A MNMMSU407A
apply and monitor mine emergency preparedness and response systems	MNCU1153A MNMMSU409A
conduct skip operations	MNMULH204A
operate automated winder	MNMULH205A
conduct cage operations	MNMULH311A
Open pit mining competency	**MNCO, BCGCM,**

Competency	**Competency abbreviation**
	MNMMMG, MNMOLH
Implement pit plan	MNCO1102A MNMMMG502A
conduct bulk water truck operations	MNCO1015A
conduct scraper operations	MNCO1017A MNMOLH308A
lay and recover cables and hoses	MNCO1025A
operate elevated work platforms	BCGCM3001B
Mining management competency	**MNMMSM**
establish ground control and slope stability systems	MNMMSM628A

Table 2. Correlation of environmental competency constituents of future mining engineer to future mining engineer profile constituents

Environmental competency constituent	**Competency code**
Acknowledgement and perception of ethical behavior norms in relation to other individuals and in relation to nature (bioethics principle)	CSP-01
Environmental literacy	CSP-10
Ability to apply basic ecological knowledge, needed in professional activity	GSC-06
Ability to apply scientific laws and methodologies for environmental assessment, to participate in environment-focused studies, to analyze environmental measures in specific industry, to develop plans, aimed at industry anthropogenic affect reduction	GPC-17
Ability to ensure environmental-balance activity, to apply methods of rational and integrated development of georesouces mining potential	CSP-01

Results. As per above-stated interpretation of environmental competency for future mining engineer, it is formed in course of bachelors' professional training for 6.050301 Mining field of education, for that reason in order to define environmental competency's constituents let's refer to the constituents of already developed system of social and personal, tool-based, general scientific, general professional and special professional competencies of future mining engineer (Table 2).

First constituent of environmental competency (Acknowledgement and perception of ethical behavior norms in relation to other individuals and in relation to nature (bioethics principle)) we define via main norms adherence:

1) ethics:

personal ethics;

regulatory ethics;
social ethics;
professional ethics; 2) bioethics:
medical ethics;
animals protection ethics;
environmental ethics.

Second constituent of environmental competency (environmental literacy) we define via:

acknowledgement of the nature as living environmental;

understanding of basic principles of living systems functioning, understanding, reproduction and application of systems' models, processes and surrounding elements for mankind problems solving;

adherence to environmental paradigms and sustainable development boosting;

organizational skills and abilities for environmental cooperation and environmental preservation;

abilities and skills to operate the environmental monitoring instruments.

Notion of other three constituents of environmental competency shall be defined via abilities to be formed by future mining engineer in course of professional training.

Third constituent of environmental competency (ability to apply basic ecological knowledge, needed in professional activity) results in ability of mining engineer's in course of professional tasks solving:

1) under production conditions:

to apply basic environmental legislation, system of regulatory

environmental safety acts;

to forecast environmental problems in mining based on environmental protection

legislation;

to apply understanding of body-environment correlation to forecast environment and human's health;

to make use of environmental dynamic balance law, to forecast environmental principles of natural resources usage;

to make use of environmental principles of natural resources rational usage, to make environmental calculation for environment preservation activity (infringed land reclamation);

to define air cleaning methods, using the Earth air target values;

to define methods and means of water purification, using environmental protection regulatory documents;

to forecast reasons of agricultural areas and forests areas reduction, using the law of dynamic balance;

to forecast environmental-induced energy problems, using the law of dynamic balance;

to apply radiation knowledge, to forecast radiation effect on living organisms; 2) under lab conditions:

to define physical and organoleptical potable water properties, based on environmental regulatory documents, using proper tools and reagents;

to forecast reasons of soil fertility degradation, using the law of dynamic balance;

to use modern methods of environmental quality assessment and pollutants measurement;

to conduct biotest of environmental quality based on environmental regulatory documents and using required tools and reagents.

Fourth constituent of environmental competency (ability to apply scientific laws and methodologies for environmental assessment, to participate in environmentfocused studies, to analyze environmental measures in specific industry, to develop plans, aimed at industry anthropogenic affect reduction) results in ability of mining engineer based on the analysis of environmental survey results and using proper methods and methodologies to assess environmental and social effects that requires him:

1) to know:

basic notions, laws and models of organic, colloid and physical chemistry;

physical, chemical and biochemical processes, taking place in atmosphere, hydrosphere and lithosphere as a result of mining activities, incl. cryolithozone;

scientific and organizational basis of production processes environmental safety and mining ecologization;

principle of main facilities and environmental protection systems calculation;

principles and methods of

environmental expertise; 2) to be able:

to calculate concentration of solutions various components;

to define thermodynamic characteristics of chemical reactions and balancing substances;

to purify substances under laboratory conditions;

to define main physical characteristics of organic substances;

to select protection means and methods;

to assess mining production effect on environment, considering specific climate conditions;

to identify main hazards of mining industry for humans and environment;

to assess risk of key mining hazards realization;

to use main means of environmental quality control;

to forecast environmental situation progress of mining industry area;

to make designer calculations for actions, aimed at negative impact reduction;

considering peculiarities of aforesaid system, using widespread schemes of components interaction and interrelation in natural, social and technogenic spheres, to define strategy and tactic of activity, ensuring live sustainable development in the Earth;

based on the dynamic balance law of the environment to define technology of infringed mined soils reclamation; 3) to know:

methods of experimental study in chemistry (experiment planning, arrangement and processing);

substances segregation and purification methods;

method of substance components identification;

method of possible chemical

reactions and their kinetic processes forecast;

perspective analysis methods of mining activity environmental impact;

methods of environmental situation assessment, tendencies in corresponding technologies and tool-based means development;

procedure of environmental expertise making;

engineering methods of technology processes calculation, of developed system elements, mining works process schemes, operated levels development, pollutants emissions and disposal into the air and water.

Fifth component of environmental competency (ability to ensure environmentalbalance activity, to apply methods of rational and integrated development of georesouces mining potential) requires from mining engineer while his production and social activity:

to know organizational and technical basis of emergency avoidance and maninduced emergency response, arrangement of operation, principles and methodologies of engineering and design solutions, considering requirement for mining effectiveness and environmental safety;

to apply key regulations of health & safety legislation, population and area civil defense from emergencies and

environmental hazards;

to identify problem and system based on the results of informational analysis, characterizing environmental situation, based on the information, related to subject pattern and his designation, functions, etc, making use of system features;

based on the information related to sectoral-focused measures (or innovations), using profile-based regulatory, methodological, scientific information and depending on environmental analysis methodologies:

а) to define and classify the objective

of the measures (or innovations);

б) to define adequacy of technologies, being applied, selected methods, forms and means of objective achievement;

в) to determine external and internal factors, boosting or hindering achievement of objective;

г) to forecast objective achievement

progress (innovation progress);

д) to define measures, able to ensure distinguished objectives achievement or to improve results of the activity;

– to apply basic principles of environmental friendly production ensuring, methodology, legal methods and means of rational nature management, incl.:

а) land resources and its reclamation;

б) subsoils;

в) water resources and their purification;

to comprehensively apply environmental protection measures while mineral deposits extraction and underground construction;

to develop means and measures of mining harmful effect reduction; – while explosive works:

а) to make use of engineering safety

actions ensuring, incl. environmental safety;

б) to substantiatedly choose optimal technology and explosive activities arrangement,

to calculate their optimal parameters and to develop corresponding design documentation, considering its environmental effectiveness, safety and environmental consequences;

в) to be familiar with regulatory documents, related to explosive works arrangement to diminish environmental impact.

to comply with requirements of legislative and regulatory acts and technical regulations in the field of safety and environmental protection at transport;

to determine resource preservation technologies, based on the laws on subsoil use and protection;

to define rational minerals usage technology based on the laws on subsoil use and protection;

to be familiar with means and technologies of humans and environmental protection from negative mining impact;

to know methods of environmental management

Formation of last two environmental competency constituents requires comprehensive approach in application of information & communicative technology means for various dimensional and timebound characteristics analysis, processing and simulation, related to mining industry impact on environment.

Conclusions. Based on the results of theoretical analysis and expert questionnaire processing results system of 49 competencies has been projected, making the core of new sectoral mining engineer preparation standard. Among 11 socially-significant competencies of future mining engineer the most important for successive professional activity are as follows: 1) acknowledgement and perception: bioethics principles; healthy lifestyle norms; living activity and labour safety rules; 2) abilities: to teach; to think in a systematic, creative and critical way; 3) personal qualities: adaptability and communication skills, tolerance, persistence in objective achievement, caring about the quality of the work; 4) ecological literacy. There are 6 competencies, comprising general scientific basis for professionally competent mining engineer preparation, which reflect professionally oriented knowledge: 1) fundamentals of philosophy, psychology, pedagogy, history, economics and law; 2) fundamental branches of mathematics, physics, chemistry, computer science and modern information technologies; 3) basic information on the ecology. Acknowledgement of general scientific competencies becomes possible with the help of 5 tool-based competencies, key of which are communicative, research and ICT ones. 29 professional competencies are split into two uneven groups: 22 general professional competencies and 7 special professional competencies.

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