ESSENCE AND STRUCTURE OF MATHEMATICAL COMPETENCE OF BACHELORS OF GEODESY AND LAND MANAGEMENT

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It is hardly possible to reach the highest level of professional competence without forming the mathematical competence of Bachelors of Geodesy and Land Management. The success of the process of forming the mathematical competence of Bachelors of Geodesy and Land Management consists of determining the core and the structure of mathematical competence.

The study aims to specify the content and the structure of the mathematical competence of Bachelors of Geodesy and Land Management.

The stated objectives defined the direction of the research. Analysis of scientific literature has been carried out on the subject of the research. Our study identified and defined the main notions and concepts on which our research is based. The specifics of training Bachelors of Geodesy and Land Management on the basis of professional programs of higher educational institutions are studied, emphasis is placed on some legislative documents, which are the basis for professional programs of Geodesy and Land Management. The objectives of the professional activity and the occupational titles of the jobs have been defined, together with the professional training that these programs can target.

The article defines the place and role of the discipline "Higher Mathematics" in the process of forming the mathematical competence of future specialists. The concept of "mathematical competence" for Bachelors of Geodesy and Land Management has been clarified. Investigating the features of professional training, we have identified and characterized the components of mathematical competence of Bachelors of Geodesy and Land Management, and established the link between them.

The results of the study show that the level of mathematical competence formation of Bachelors of Geodesy and Land Management mainly affects both the process of study of specialized disciplines, and the formation of professional competence.

The formation of mathematical competence of the future Bachelors of Geodesy and Land Management can be marked as a process of acquisition and formation of components of mathematical competence, which is characterized by the ability to solve theoretical and practical problems that are significant in professional activity.

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The further direction of research concerns clarifying the stages of technology of mathematical competence formation of Bachelors of Geodesy and Land Management.

Key words: *Bachelor of Geodesy and Land Management, education in the field of Geodesy, educational professional program "Geodesy and Land Management", program competences, professional competence, mathematical competence, the structure of mathematical competence, competence approach.*

СУТНІСТЬ ТА СТРУКТУРА МАТЕМАТИЧНОЇ КОМПЕТЕНТНОСТІ БАКАЛАВРІВ ГЕОДЕЗІЇ ТА ЗЕМЛЕУСТРОЮ

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Досягнення високого рівня професійної компетентності неможливо без сформованості у бакалаврів геодезії та землеустрою високого рівня математичної компетентності. Успішність процесу формування математичної компетентності бакалаврів геодезії та землеустрою, передусім, полягає в чіткому визначенні її сутності та структурних компонентів.

Мета дослідження полягає в уточненні змісту і структури математичної компетентності бакалавра геодезії та землеустрою

Сформульовані цілі обумовили напрямок дослідження. Проведено аналіз наукової літератури за темою дослідження, виділені та окреслені основні поняття, на які спирається дане дослідження. Проаналізовано специфіку підготовки бакалаврів з геодезії та землеустрою на основі освітньо-професійних програм ЗВО, акцентовано на низці законодавчих документів, які покладені в основу освітньо-професійних програм "Геодезія та землеустрій". Визначено види професійної діяльності та професійні назви робіт, на фахову підготовку з яких можуть бути спрямовані дані програми.

У статті визначено місце та роль дисципліни "Вища математика" в процесі формування математичної компетентності майбутніх фахівців. Уточнено сутність поняття "математична компетентність бакалаврів з геодезії та землеустрою". З урахуванням особливості професійної підготовки, виділені та охарактеризовані компоненти математичної компетентності бакалаврів з геодезії та землеустрою, встановлено зв'язок між ними.

Результати дослідження показують, що рівень сформованості математичної компетентності бакалавра з геодезії і землеустрою значною мірою впливає як на процес вивчення фахових дисциплін, так і на формування професійної компетентності.

Формування математичної компетентності майбутніх бакалаврів геодезії та землеустрою можна позначити як процес придбання і становлення компонентів математичної компетентності, який характеризується здатністю вирішувати теоретичні і практичні завдання, значимі в їх професійній діяльності.

Подальший напрямок нашого дослідження полягає в обґрунтуванні етапів технології формування математичної компетентності бакалаврів з геодезії та землеустрою.

Ключові слова: *бакалавр з геодезії та землеустрою, освіта в галузі геодезії, освітньо-професійна програма "Геодезія та землеустрій", програмні компетентності, професійна компетентність, математична компетентність, структура математичної компетентності, компетентнісний підхід.*

Introduction of the issue. Fundamental education is the basis of the professionalism of any specialist as it forms the ability to reason logically, analyze and systematize facts, make decisions and apply a scientific approach to the study of processes. It is fundamental education that creates the basis for further lifelong learning. Mathematical education is the foundation of any engineering specialty, including Geodesy and Land Management, which enables the study

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of disciplines of the general technical, special and professional directions.

Teaching mathematical disciplines is the basis of the formation of mathematical competence of Bachelors of Geodesy and Land Management, which is an integral part of professional competence, that significantly increases their competitiveness on the labor market and accompanies successful career growth. Achieving professional competence is impossible without the formation of high level of mathematical competence of Bachelors of Geodesy and Land Management. The process of successful formation of mathematical competence of Bachelors of Geodesy and Land Management, first of all, lies in defining the essence and structure of their mathematical competence. Therefore, we believe that the study is an up-to-date issue.

Current state of the issue. The formation of mathematical competence of future specialists is an integral precondition for the formation of their professional competence. Therefore, various aspects of mathematical competence and its formation are studied by a number of national and foreign scientists, including: M. Holovan, M. Minshyn, V. Plakhova, Y. Stelmakh, D. Helfanova, O. Kucheruk, N. Kostenko, T. Torbina, O. Lesher, M. Paleeva, Y. Trius, V. Khomiuk, S. Rakov, I. Allahulov, L. Zaitsev, O. Shalvalov and others.

According to V. Khomiuk, mathematical competence of an engineer is an integrated personal quality that shows the level of basic mathematical methods needed for analyzing and modeling processes and phenomena, finding optimal solutions aimed at increasing production efficiency and choosing the best ways to implement these solutions, processing and analyzing experimental results [9: 215]. M. Paleeva characterizes mathematical competence of a technical student by a set of acquired mathematical knowledge and methods,

experience in using mathematical knowledge in solving beyond the subject of Mathematics, and emphasizes the significance of valuing the acquired knowledge and experience [6: 123]. We agree with the definition given by E. Petrova, who considers mathematical competence a holistic formation of personality that reflects the readiness to study disciplines that require mathematical training, as well as the ability to use their mathematical knowledge to solve various practical issues and theoretical problems, that they may come across in their professional activities [7: 240].

In order to better understand the concept of "mathematical competence", we should investigate its structure. M. Holovan, V. Khomiuk, N. Khodyryeva, L. Ustynova, S. Leiko, L. Stoianina, V. Matveikina and others were engaged in the studies of the content and structure of mathematical competence of future specialists.

In the psychological and pedagogical literature there are different approaches to structure the mathematical competence. Thus, S. Leiko argues, that mathematical competence contains four different components: *axiological, epistemological, praxeological and reflexive-volitional*. M. Holovan identifies five structural components of mathematical competence: *motivational, cognitive, action, value-reflexive, emotional-volitional*, which do not exist if isolated, but are closely interrelated [2: 37]. In the structure of mathematical competence of a university student, V. Matveikin distinguishes *mathematical knowledge and skills, mathematical thinking, willingness for continuous self-education and self-improvement in the study of Mathematics, gaining experience in professionally-oriented mathematical activities*. We support the findings of N. Khodyryeva and L. Ustynova, who include *motivational-axiological, content-procedural and reflexive* components to mathematical competence [8: 137]. The

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motivational-axiological component in its essence combines the conceptual orientations, social values and attitudes, needs, interests, motives, i.e. characteristics of personality orientation. The *content-procedural* component includes special knowledge, skills and methods of actions required to perform high quality mathematical activities. The *reflexive* component involves comprehension, evaluation of their knowledge, skills, and achievements and includes self-awareness, self-control and self-esteem [8: 137].

Outline of the unresolved issues brought up in the article. The analysis of recent publications shows that the problems and specifics of training future specialists of Geodesy and Land Management have been studied by S. Voitenko, V. Borovyi, N. Rusina, T. Yevsiukov, O. Lozovyi, V. Tyshkovets, A. Liashchenko, K. Tretiak, R. Shults and others. The question of mathematical training of future specialists in the field of Geodesy and Land Management is studied by Y. Komyssarenko, N. Hordieieva, Y. Manaieva. Despite this, the concept of mathematical competence of Bachelors in Geodesy and Land Management and its structure are not fully investigated by the modern research.

Aim of research is to clarify the content and structural components of mathematical competence of Bachelors in Geodesy and Land Management on the basis of a thorough study of educational and professional programs to train Bachelors of Geodesy and Land Management, the fields of their future professional activities and the place of mathematical training in the system of study of professional disciplines.

Results and discussion. Training of future Bachelors of Geodesy and Land Management is carried out on the basis of the first (Bachelor's) level of higher education of the specialty *193 "Geodesy and land management"* which according to the decree of the *Ministry of Education and Science "On peculiarities of implementation of the list of disciplines and specialties"* is listed among the specialties of the *19 "Architecture and construction"* specialty.

The list of regulations, used as the basis for designing educational and professional programs include: *The Laws of Ukraine "On Education"* of 05.09.2017 № 2145–VIII; *the Laws of Ukraine "On Higher Education"* of 01.07.2014 № 1556–УII; *Resolution of Cabinet of Ministers of Ukraine "On approval of the National Qualifications Framework"* dated November 23, 2011 № 1341.2.5; *National Classifier of Ukraine, Classifier of Occupations (DK 003:2010),* approved by the State Committee of Ukraine of 28.07.2010 № 327 with changes, approved by The *Ministry* of *Economic Development, Trade* and Agriculture of *Ukraine of* 16.08.2012 № 923 and etc.

Professional names of jobs, according to the *National Classifier of Ukraine "Classifier of Occupations" (DK 003:2010),* for the professional training of which the educational and professional programs of the *specialty 193 "Geodesy and Land management"* are aimed at, there are more than 40 professions, among which there are: geodesist, land-surveyor engineer, cartographer, photogrammetrician, state real estate rights registrar; director (head) of the organization (research, construction, engineering); etc. The professional activities of future specialists in Geodesy and Land Management may include the following kinds of activities:

- ✓ production and technology;
- ✓ project and project-survey;
- ✓ organization and management.

Educational and professional programs of training future Bachelors of Geodesy and Land Management in national higher educational institutions, which are based on the concepts of a competent approach, are aimed at forming students' program

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competences. These determine the ability of an individual to successfully carry out professional activities and further studies, and are the result of training at a certain level of higher education. Program competences include integral competence, general and professional (special) competences.

Integral competence of Land Management consists in ability to solve complex specialized tasks and practical problems of Geodesy using modern technologies, theoretical statements and methods of determination of physical surface of the Earth, shape, size and gravitational field of the Earth, conducting measurements on surface of the Earth to indicate it on plans and maps when performing high-precision geodesic works and providing construction of buildings [4: 5].

General competences of Bachelors of Geodesy and Land Management – are universal competences that do not depend on the subject area. They are important for successful professional and social activities of future specialists in different fields and for their personal development.

Professional (special) competences of Bachelors of Geodesy and Land Management consist of the following abilities [4: 5]:

✓ show knowledge and understanding of basic theories, methods, principles, technologies and techniques in Geodesy and Land Management;

✓ show basic knowledge in related disciplines (Physics, Ecology, Mathematics, Information Technology, Law, Economics, etc.), the skill to use these theories, principles and technical approaches;

✓ use knowledge in general engineering sciences in training and professional activities, ability to use these theories, principles and technical approaches;

✓ perform their professional duties in the field of Geodesy and Land Management;

✓ choose up-to-date methods, means and equipment in order to carry out professional activities in the field of Geodesy and Land Management;

✓ conduct field, remote and desk studies in the sphere of Geodesy and Land Management;

✓ be able to use modern geodetic, navigational, geoinformation and photogrammetric software and equipment;

✓ independently collect, process, model and analyze geospatial data in field and laboratory conditions;

✓ aggregate field, desk and remote data on the theoretical basis in order to synthesize new Geodesy and Land Management knowledge;

✓ design projects and programs, organize and plan works, prepare technical reports and document the results of field, desk and remote studies in Geodesy and Land Management;

✓ solve applied scientific and technical problems in the field of Geodesy and Land Management according to the specialty.

It is possible to assert that mathematical competence of Bachelors of a Geodesy and Land Management is a basis of many professional competences as it shows the analysis of types of professional activities of future Bachelors of a Geodesy and Land Management, the contents of program competences, and also the requirements to results of development of programs of a Bachelor's degree. First of all, mathematical competence consists in the ability to show "basic knowledge in Mathematics, skills to use theoretical knowledge, principles and technical approaches". In the second place, the mathematical competence directly affects the quality of mastering a whole group of basic disciplines and engineering sciences of the specialty. It also forms the ability to independently model and analyze geospatial data, to solve applied scientific and technical problems in the field of Geodesy and Land Management, and so on [5: 5].

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The study of the list of components of the educational and professional program "Geodesy and Land Management" and their logical sequence shows that the discipline "Higher Mathematics" plays a vital role in the process of forming mathematical competence of Bachelors.

The course of Higher Mathematics is designed to provide basic mathematical training to students, and allows to successfully solve modern applied engineering problems in the field of Geodesy and Land Management. In the process of studying this course, the skills of formulating mathematical tasks and mastering analytical methods of problem solving are being formed. The result of mastering the discipline is that students acquire basic knowledge in the fundamental areas of Mathematics to the extent that is necessary to master the mathematical apparatus. It can be applied in professional activities, for processing the information and the analysis of the data in the field of Geodesy, Land Management and Cadastre. Students also develop the skills and abilities to perform mathematical reasoning and mathematical evidence, and to use mathematical analysis in solving applied problems [3: 69].

We can establish a connection between Higher Mathematics and other subject disciplines by familiarizing ourselves with the content of the subject area of the discipline of special and professional cycle:
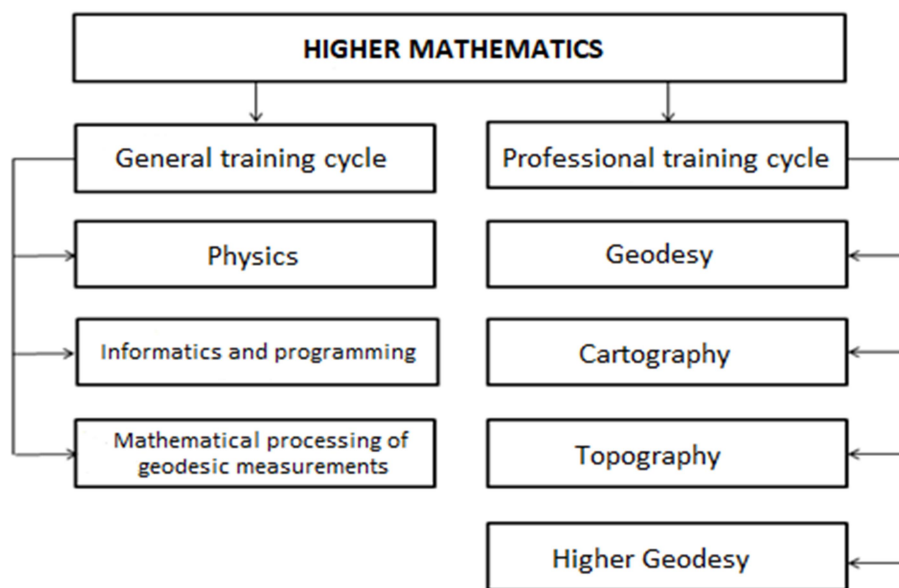

Fig. 1. Correlation between Higher Mathematics and other disciplines

The previous section has shown that teaching Higher Mathematics should be aimed, on one hand, at obtaining fundamental knowledge from the subject, and on the other hand – at orientation of content and methods of teaching, at close correlation between the disciplines of both general and professional cycle, the formation of students' skills to design and investigate mathematical models based on well acquired knowledge.

Taking into account the main directions of professional activities of future Bachelors of Geodesy and Land Management and the list of their professional competences, we will clarify the concept of their mathematical competence. Under the mathematical

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competence of the Bachelor of Geodesy and Land Management we understand the integral quality of personality, which is expressed in the profound knowledge in the disciplines of the mathematical cycle, in the ability to apply knowledge to studying and solving problems that occur in the field of Geodesy, Cartography and Land Management, the ability to achieve significant results and quality in all professional activities.

Let us define the structure of mathematical competence of Bachelors of Geodesy and Land Management, taking as a basis the structure suggested by N. Khodyryeva and L. Ustynova and characterize its structural components, taking into account the need for professional orientation in teaching mathematical disciplines.

The motivational and value component of the mathematical competence of Geodesy and Land Management is a system of motives, goals, needs that ignite a cognitive interest in studying mathematical disciplines as the basis of studying the disciplines of the professional cycle (Geodesy, Cartography, Higher Geodesy, Topography, Mathematical processing of geodesic measurements). The abovementioned component also affects the desire for self-education, self-organization, as well as the realization of the need of lifelong learning. The main goal of the motivational and value component of the mathematical competence of Bachelors of Geodesy and Land Management is to encourage future specialists to grow and develop independently.

The content-procedural component of the mathematical competence of Bachelors of Geodesy and Land Management contains basic knowledge, skills and abilities of the fundamental areas of Higher Mathematics, which are necessary for further study of professional disciplines. These areas and skills are listed in the following *Table 1*.

Table 1

Contents of skills in the fundamental areas of Higher Mathematics

Areas of Higher Mathematics	Skills to be acquired by a Bachelor of Geodesy and Land Management
Linear Algebra	compute the determinants, perform operations on matrices, solve Systems of linear equations with the Cramer's rule and Gaussian elimination
Vector Algebra	perform operations on vectors, described by coordinates; calculate module and directional cosines of a vector, dot product, cross product and vector triple product vector, apply it to calculate areas; spread the vector along the basis vectors; decompose a vector on the basis vectors
Analytical Geometry	calculate distance between two points, coordinates of the segment dividing point in the given ratio, triangle area; solve basic problems about the line on the plane, define a variety of second-order line and build its image in the coordinate system, set up equations of a plane and a line in space, find angle between planes, lines, the plane and the line, distance from the dot to the plane, build an ellipsoid
Introduction to Mathematical Analysis	*calculate the limits of sequences and functions, find continuity of functions*
Differential and integral calculus	find the derivative and differential of the function and calculate their values at these points, apply the derivative to solve various geometric problems, study the function and build its graph, integrate indefinite integrals directly or using

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	methods of replacing variables and parts; calculate certain integrals by the Newton–Leibniz axiom, find the area of a curvilinear trapezoid and the volumes of solids of revolution
Differential equation	solve differential equations of the 1st and 2nd orders, find partial solutions of these equations; methods of construction of mathematical models on the basis of the theory of differential equations
Numerical and function series	investigate the convergence of positive terms and alternating numerical series according to the necessary and sufficient signs of convergence; find interval and radius of convergence of the power series, determine the McLaren series
Probability theory and Mathematical statistics	calculate the numerical characteristics of random variables, solve problems on the basic laws of distribution, find the sample characteristics of a sample series, formulate statistical hypotheses

The skills that students acquire during their studies of mathematical disciplines include: solving professionally oriented problems, mathematical modeling, independent processing of mathematical texts, practical use of methical and visual manuals.

Thus far, the content of mathematical disciplines, which are included in educational and professional programs to train future specialists, should not only be ensured by a set of knowledge in the subject area, but also the possibility of its application in solving professional problems.

The reflexive component of the mathematical competence of the Bachelor of Geodesy and Land Management includes:

• contentment with their activities in Mathematics;

• perception of the attitude to the current and final results in mastering mathematical knowledge, skills and abilities;

• readiness to exercise self-control and evaluate their achievements;

• self-organization and self-improvement in the process of forming mathematical competence.
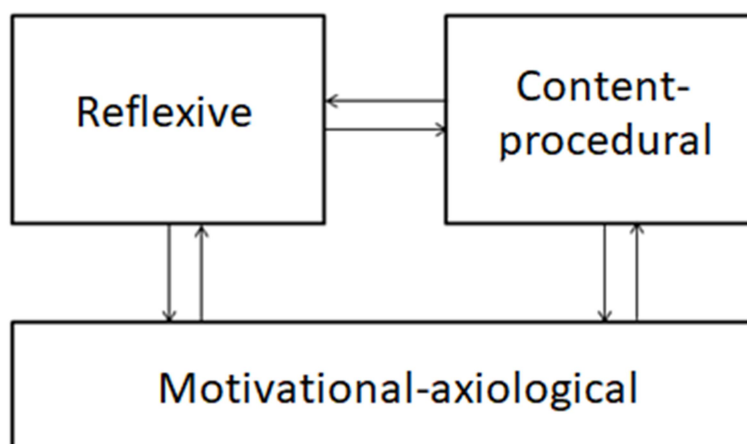

Fig. 2. Correlation between the structural components of mathematical competence

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The *motivational-value* component forms a cognitive interest in the acquisition of basic knowledge in Mathematics and in mastering different approaches to solving mathematical problems. The purpose of the component is to fully master the disciplines of the professional cycle, and, thus, the component affects the *content-procedural* component by improving the quality of gained knowledge, as well as on the reflexive component, and helps to set goals for self-development.

The *content-procedural* component covers the knowledge, skills and abilities that future specialists receive in the process of studying mathematical disciplines. The impact of this component on the *motivational-axiological* component is evident in the understanding of the importance of mathematical methods for solving applied and professional problems. Its influence on the *reflexive* component is evident in the ability to exercise self-control over the results of learning the program material. The *reflexive* component affects the *motivational-axiological* and *content-procedural* components, thus contributing to the discovery of creative potential and the desire to achieve significant results in the process of studying mathematical disciplines [8: 137].

Our work has led us to conclude that mathematical competence of Bachelors of Geodesy and Land Management is a valuable formation that integrates fundamental knowledge and skills, command of mathematical apparatus for solving professional tasks. The process of formation of mathematical competence of future Bachelors of Geodesy and Land Management can be represented as a process of acquisition and formation of components of mathematical competence, which is characterized by the ability to solve theoretical and practical tasks that play an important role in their professional activities.

Conclusions and research perspectives. Over the course of our research we have thoroughly analyzed educational and professional higher education programs in the specialty 193 "Geodesy and Land Management" at higher education institutions, which train Bachelors of Geodesy and Land Management; educational conditions for training Bachelors of Geodesy and Land Management (list of program competences), content and place of the discipline "Higher Mathematics" in the system of training future specialists); direction of professional activities training and list of professional jobs for future specialists.

Based on the conducted research we have been able to specify the essence of mathematical competence of the Bachelor of Geodesy and Land Management as an integral quality of a personality, which is expressed in the thorough knowledge he disciplines of the mathematical cycle, the ability to use knowledge for research and solving problems that arise in the field of Geodesy, Cartography and Land Management, the ability to achieve significant results and quality in all types of professional activity.

The structure of mathematical competence of Bachelors of Geodesy and Land Management includes: a reflexive, motivational-axiological, content-procedural components. The study characterizes the structural components of the mathematical competence of Bachelors of Geodesy and Land Management and determines the correlation between them.

The results of our study show that the mathematical competence of Bachelors of Geodesy and Land Management is the main precondition for the process of studying professional disciplines and the formation of professional competence. That is why special attention should be paid to the formation of mathematical competence of future specialists. The results of our research could be made use of in order

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to characterize the stages of technology of the formation of mathematical competence of Bachelors of Geodesy and Land Management.

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