MATHEMATICAL COMPETENCE AMONG HEI STUDENTS: CLUSTER APPROACH

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Abstract

The research is acute due to the increasing role of the competence approach, which has recently expanded from pedagogical theory into socially important phenomenon and is gradually becoming a concept-based educational policy. The article considers issues connected with the formation of mathematical competence among students of higher educational institutions. It discusses fundamental functions of mathematical training of students, gives definition of mathematical competence, and describes its main functional components. The article presents a structure of mathematical competence as a cluster of general cultural, general professional and professional competences within the framework of Federal State Educational Standards of higher education.

Keywords: mathematical competence, teaching mathematics, Federal State Educational Standards, cluster approach, educational process, higher education, student

1. INTRODUCTION

At present time competency building approach as one of the concept-based directions to renew the content of higher school education is deeply established in the Russian educational system in terms of legislation. The Concept of long-term social and economic development of the Russian Federation for the period up to 2020 determines the key tasks to "increase the accessibility of qualitative education complying with the requirements of innovative economic development, contemporary needs of society and every citizen" (Concept, 2008). Particularly, the document denotes the necessity to provide "competency building approach, interaction of academic knowledge and practical skills", "create educational environment providing accessibility of qualitative education".

Federal State Educational Standards of Higher Education outline general cultural, general professional and professional competences necessary to be formed among HEI students. For instance, Bachelor's degree programmes have a universal list of general cultural competences for all majors. General professional and professional competences depend on the level of the education received (Bachelor, Specialist, Master), and as a rule, their quantity increases when passing to the higher level of graduate preparation. Master's competences are kind of deepening and expansion of the formed Bachelor's competences. The development and the formation of each competency is provided by a definite set of subjects united into the existing modules.

2. MATHEMATICAL COMPETENCE

2.1. Elements of mathematical competence

According to Federal State Educational Standard 3+ the quality of training of a HEI graduate is assessed by the formation of a professional competence that is a set of necessary knowledge, abilities, skills, as well as general cultural, general professional and professional competences acquired as a result of studying all cycles of subjects. Consequently, the quality of mathematical training is a direct projection of general cultural, general professional and professional competences to the topical area of mathematics, as well as mathematical knowledge, abilities, and skills (Fedorova and Toktarova, 2016).

Didactic core of a mathematical competence is a set of mathematical knowledge, abilities, and skills, as well as an ability and readiness of a graduate to use them in their professional activity (Shershneva, 2011). In accordance with the Federal State Educational Standard of Higher Education mathematical preparation of students is implemented in competences in the form of "mathematical knowledge and ability to apply them". So we can talk not only about a competence-based paradigm but also a knowledge-based one providing the achievement of high-quality mathematical preparation of students when implementing these standards.

Accordingly, mathematical competence as a tool of measuring quality of mathematical training of a student is an integrative personal quality characterizing presence of sound knowledge in mathematics, readiness and ability to apply them in their professional activity.

When talking about a content-related part of mathematical preparation it is necessary to mention commonality and integration of the framework of categories and concepts of such topical areas as "mathematics" and "informatics" which characterize the last decades. Thus, O.B. Episheva and D.Yu. Trutnikov point out blurring of distinction between areas of scientific knowledge as one of the main reasons of integration appearance in science. According to them it is "not just a simple combination of elements of two sciences, but a newly systematized inner fusion providing deep knowledge of laws of nature, rise of scientific knowledge to the higher theoretical level of some leading scientific fields" (Episheva and Trutnikov, 2010). Such notions as algorithm, model, multitude, discreteness, constructability, object, system, data analysis, process, structure, classification, system analysis, tabulated data, set of lattice points, formal characterization, array, finiteness, symbol, language, function, scheme, etc. are equally necessary both for informatics and mathematics.

Interaction and interpenetration of these two topical areas are evident in the fact that on the one hand, the development of informatics and information technologies requires the attraction of a wide mathematical apparatus technique connected with mathematical modeling, theory of sets, digital methods, optimization methods and variational calculation, theory of information storage and processing, quantitative and qualitative data analysis, theory of numbers, intelligence systems, theory of quantum calculations, methods and algorithms of data encryption and many others. On the other hand, the development of modern mathematics depends directly on a wide and common usage of information technologies: parallel computations, digital method algorithms, computational mathematics, computerized algebra, modelling, etc.

Therefore, in the process of forming mathematical competence of modern HEI students there are three components:

1) mathematical knowledge, abilities, and skills complying with the basic educational HEI programme;

2) ability and readiness to apply mathematical knowledge, abilities, and skills in professional activity;

3) ability to use modern means of information and communication technologies in the process of mathematical modeling and designing questions of professional activity.

2.2. Clustering of mathematical competency

It is important to mention two fundamental functions of mathematical preparation of the students; they are teaching mathematics (basically, acquiring a system of mathematical knowledge, abilities, and skills, formation of mathematical competence, etc.) and teaching through mathematics (intelligence, formation of logical and analytical thinking, development of quantitative literacy).

Modern social and economic state and modernizing of education attach more and more importance to the developing function of teaching mathematics. Ever-increasing flow of new information stipulates the necessity to form readiness to constant retraining and acquirement of new knowledge, ability of self-learning

and self-development. In conditions of information society mathematical teaching of students shall be forward-looking. For this purpose today it is necessary:

– to create the conditions for the development of logical and analytical thinking by means of mathematics, abilities to apply mathematical approach and information and communication technologies in professional activity;

– to arrange mathematical activity in electronic educational environment providing functions of adaptation to individual students' traits and abilities;

– to form students' readiness to constant changes in the society and search of tasks solutions in new conditions by means of development of various forms of thinking.

In accordance with the Federal State Educational Standard of Higher Education mathematical competence of students can be considered as a complicated cluster of general cultural, general professional and professional competences being formed in the process of mathematical training (Fig. 1).

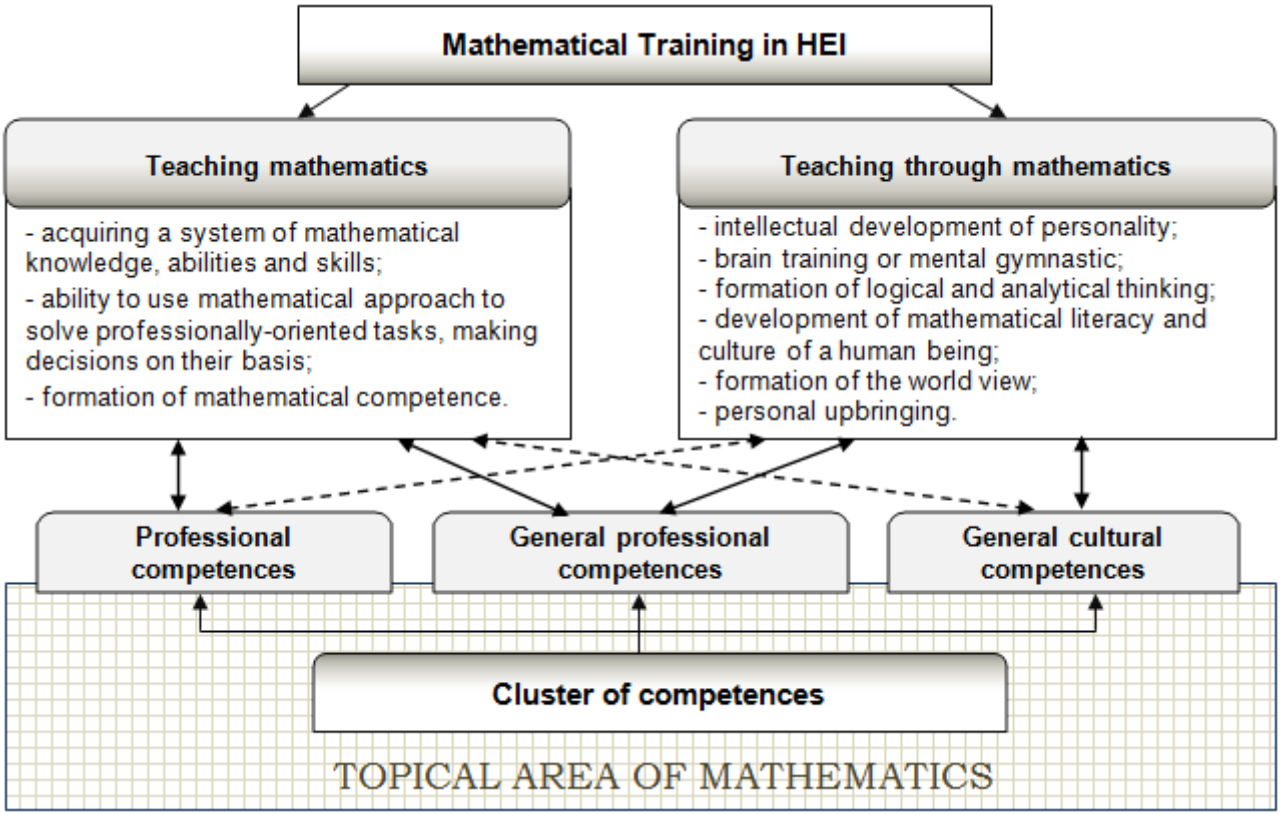

Fig.1. Cluster approach to the mathematical training of students

Notion 'cluster' is used to define groups of entities having a common feature. This notion was first introduced by R.E. Boyatizis (1982) due to the application of cluster analysis to process a significant number of different competencies. The use of cluster analysis is stipulated by the fact that this method allows reducing the quantity of the studied variables and defining the structure of interrelations between them, as well as accomplishing their classification.

In our research we understand cluster of competencies as a structured system of competencies having a common definite feature. The features for the building of such cluster are a type of intellectual activity, topical area, major, specific type of activities (interactions), etc.

Let's apply cluster approach for the analysis of the Federal State Educational Standard of Higher Education Thus, the Federal State Educational Standard of Higher Education for the major 04.03.01 Chemistry (Bachelor) adopted by the Order No. 210 dated March 12, 2015 has a cluster of competencies for chemist students being formed in the process of mathematical training (Table 1).

Table 1. Cluster of competencies

Cluster of competencies for the students of the major 04.03.01 Chemistry being formed in the process of mathematical training		
General cultural competences	ОК-3	ability to apply the basics of economic knowledge in different spheres of living environment
	ОК-7	ability for self-organizing and self-education
General professional competences	ОПК-3	ability to apply basic laws of sciences in professional activity
	ОПК-4	ability to complete standard tasks of professional activity with the use of modern ICT taking into account main requirements of information protection
Professional competence	РК-1	ability to execute standard operations using the techniques suggested
	РК-5	ability to get and process the results of scientific experiments using modern computer technologies
	РК-9	having the skills of basic technical calculations for the technical process

So, the analysis of the standard from the point of view of structure and the content of different competencies being formed during the process of mathematical training of students shows that

– the function of teaching mathematics of future chemists is executed with the help of the formation of competencies OK-3, OPK-3, OPK-4, PK-5, PK-9. At the same time there is no obvious mention of the process of mastering the mathematical knowledge. Belonging of these competencies to the mathematical knowledge can be defined by denoting the key phrases: 'to use economic knowledge', 'to apply the laws of sciences', 'to solve the tasks using ICT', 'to process the results using computer technologies', 'to have skills of making process calculations'. A distinctive feature of this educational standard is an emphasis on the formation of a considerable number of competencies connected with the knowledge of information, communication and computer technologies, as well as the abilities to apply them for solving professional tasks;

– the function of teaching mathematics is executed with the help of competencies OK-7, PK-1. Social and professional functions of specialists have changed in the modern post-industrial society; today such qualities as self-education, self-organizing, learning capability, independence, self-regulation, self-control, etc. are becoming more and more eagerly sought. The developmental and educational functions of mathematical training of students provide the direct development of these qualities, as well as the formation of intellectual honesty, ability to overcome intellectual obstructions, respect for education, etc.

Therefore, taking into account the analysis of the requirements to the formation of student's competencies of different majors it is possible to draw a conclusion that it is important to study those parts of mathematics, the knowledge of which is necessary when studying vocation-related subjects, solving professionally-oriented tasks, and as a consequence, providing the formation of professional competencies. And, vice versa, the parts of mathematics which are not the basis for vocation-related subjects may be studied on the basic level within the framework of individual work of students for form general cultural and general professional competences. Such changes in the structure and the content of teaching mathematics will allow using the reduced hours assigned for its studying in a more effective and qualitative manner, and show better respect of the interests and abilities of students.

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