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Mathematical Culture as Basis for Improving Vocational Training Progress of University Students

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***Abstract*-Mathematics is the queen of sciences. It plays a core role in education. Progress in studying at university, and, later, success in professional activities, depend on the level of mathematical culture development. High level of mathematical culture of a university student ensures a high level of success of vocational training, regardless of the educational programme.**

Keywords-mathematical culture, vocational training, development levels

I. INTRODUCTION

Due to the development of a new technological generation economy — the digital economy, the role of mathematics in the professional development of the future specialists increases even more.

Mathematical culture development is not just a transfer of a certain scope of knowledge and skills acquired by humanity, but also participation in the development of a person's worldview. Effectiveness of task solving depends on the level of culture of modern professionals. A student of any educational programme should be sufficiently prepared for independent analysis, comparison, and integration of scientific facts and phenomena. In the process of cognition, the students should build their thinking and speech in a logical sequence, which helps to achieve depth, accuracy and clarity of reasoning. Without a proper level of mathematical culture, it is impossible to achieve successful professional activity in the current economic situation.

The problem of mathematical culture development was studied from various perspectives in the works of many prominent mathematicians, educators, psychologists, philosophers and methodologists. (V.F. Butuzov, G. Weil, N.Y. Vilenkin, G.D. Glazer, V.A. Gusev, Yu.M. Kolyagin, L.D. Kudryavtsev, G.L. Lukankin, V.L. Matrosov, A.G. Mordkovich, A.D. Myshkis, C.M. Nikolsky, S. Papert, D. Poya, I.M. Smirnova, N.F. Talyzina, M.I. Schwarzburd, G.N. Yakovlev, et al).

G. Ikramov, V. I. Snegurova, H. Sh. Shikhaliyev studied mathematical culture of secondary school students; V. N. Khudyakov — students of primary vocational education; Yu. K. Chernova and S. A. Krylova — students of technical vocational colleges; O. V. Artebyakina — students of pedagogical universities (future primary school teachers); S.A. Rozanova — students of technical universities; G. M. Buldyk — students of economic universities.

However, the issue of mathematical culture influence on the vocational training progress has not been sufficiently studied by the representatives of foreign and domestic pedagogical science, which makes the chosen research relevant.

II. THE ESSENCE OF THE CONCEPT OF MATHEMATICAL CULTURES

Various interpretations of the "mathematical culture" concept are given in the scientific and pedagogical literature.

Thus, G. Ikramov understands it as "a system of mathematical expertise, knowledge and skills organically included in the general culture of students, as well as an ability to operate them fluently in practical activities" [1].

H. Sh. Shakhaliev, revealing the concept of "mathematical culture", distinguishes several meanings. In each meaning, the mathematical culture is identified with aspects of using mathematical language in communication between people and in the reflection of reality: with the totality of all achievements of the mankind, with the level of human development, and with the conscious use of mathematical language [2].

According to V. I. Snegurova, in a student's mathematical culture, there are two aspects: factual and activity-related; each aspect contains intra-subject and general culture components. The intra-subject components include sets of objects, without which it is impossible to study mathematics at school successfully. The factual aspect requires mathematical facts, and the activity-related aspect requires skills. General culture components mean a set of objects of value-based nature in relation to a person's culture. The factual aspect is represented by mathematical ideas that constitute the core of mathematical culture; activity-related aspect includes skills formed in the process of study of mathematics [3].

So, there is no unambiguous interpretation of this concept. Difficulties in interpreting the concept of "mathematical culture of students" are associated with the complexity and ambiguity of the very concept of culture and with its interpretation in the mathematical aspect. Many researchers agree that mathematical culture is a holistic concept consisting of several components.

V. I. Snegurova considered the following components of mathematical culture: algorithmic, logical, graphical, while noting that other components can be distinguished as well: culture of transformations, culture of technical drawing, computational culture. The author identifies the following elements of the graphical component of mathematical culture: the ability to perceive graphical information; the ability to translate information presented in graphical form to another type (verbal, analytical) and vice versa; the ability to convert a graph into a graph; the ability to perform various transformations of information presented in a non-graphic form (verbal, analytical), mediated by a graph. Elements of the logical component are represented by the ability to analyze the condition of the problem with the specified purpose and the ability to conduct evidence-based reasoning. The following elements were considered in the algorithmic component: the ability to perform actions according to the indicated algorithm (familiar or unfamiliar); the ability to create new algorithms aimed at task implementation; the ability to estimate the duration of the algorithm and its complexity.

N. A. Vikulova studied mathematical culture of students and distinguished the following components of an individual's mathematical culture:

1) value-motivational as a system of personal-oriented values, educational motives and orientation of an individual;

2) cognitive-competence component as a system of mathematical expertise, knowledge and skills;

3) operational component as a system of mental operations and actions;

4) creative component as culture of creativity, culture of research, culture of scientific search;

5) communicative component as a system of knowledge and skills for organizing educational interaction;

6) reflexive component as a system of skills that allow subjects of learning to assess the degree of development of all components of mathematical culture and progress of its development activities [4].

According to O. A. Okuneva, mathematical culture in structural terms is a complete unity of value-motivational, cognitive, operational, communicative and reflexive components [5]. Value-motivational component is the basic component for development of all other components. Content of this component is represented by a humanistic orientation, an integrated system of personal motives, value orientations and needs, which not only regulate the development of mathematical culture, but also reflect the orientation towards the development of a given culture as a necessary and internally accepted quality. The cognitive component includes mathematical knowledge of various degrees of generalization, including concepts, categories, theories, laws, mathematical skills, the degree of which determines the type and style of learning and cognitive activity. The operational component is associated with the analysis of the situation (tasks, models, etc.), the choice of methods (language) and means to achieve the target (methods, rules, solutions, etc.), the sequence of actions leading to the target (answer). The communicative component is associated with individual norms of behaviour and attitudes formed through communication as a means of perception, information transfer, development of relations culture, representing social experience as a cultural value. The reflective component includes awareness of information about the state of a person's mathematical culture, understanding the meaning of mathematical information and activities to obtain it. The content of this component is associated with self-esteem, self-determination and self-regulation of students' activities.

Based on the studies of the above-mentioned authors, we distinguish the following components in the structure of mathematical culture, which are also the criteria for the development level of the phenomenon under study (Table 1)

TABLE 1. COMPONENTS OF MATHEMATICAL CULTURE OF UNIVERSITY STUDENTS

Components (criteria) of mathematical culture	Description of components
Motivational	Awareness of the "values" of studying mathematics, understanding the need to study the subject for brain building development and mindset formation.
Cognitive	Mathematical expertise, knowledge and skills, including concepts, categories, theories, laws of mathematics.
Reflexive	Self-assessment of students' activity
Activity-related	Application of information for solving problems of a professional nature. Ability to construct information, to find new connections and relations.

Recognizing the process nature of students' mathematical culture development, we identified the levels (high, medium, low), description of which are presented in Table 2.

TABLE 2. LEVELS OF STUDENTS' MATHEMATICAL CULTURE DEVELOPMENT

Levels of mathematical culture development	Description of levels
High	A student is fluent in translating professional information into a sign form and vice versa, in the problem-solving algorithms, in methods for assessing the correctness of the solution obtained. Feels the need to gain new mathematical expertise, knowledge and skills, realizing their importance for self-realization in the future professional activity.
Average	A student is partially aware of the importance of mathematical knowledge in professional activities. Can translate verbal information into a sign form independently. Identifies the algorithm for solving problems independently and performs it without significant errors. Feels the need for such information, which increases both mathematical literacy and cultural level.
Low	A student's knowledge about the possibilities of applying mathematical concepts and theories for solving problems of a professional nature is fragmentary and unsystematic. A student is not aware of the need to develop a system of mathematical concepts as a fundamental basis of education.

The success of vocational training involves a combination of a number of characteristics or criteria, which include:

- formal (academic performance);

- motivational (striving for self-development, openness for vocational training, which involves participation in the activities of student scientific communities, attendance of additional classes, elective courses, participation in academic competitions, etc.);

- operational (ability to study the material independently: writing notes, essays, associated with independent search of literature, conducting student research; the ability to apply this knowledge in practice).

These characteristics and criteria allow us to identify the levels of vocational training progress (Table 3).

TABLE 3. LEVELS OF VOCATIONAL TRAINING PROGRESS

Levels of vocational training progress	Description of levels
High	Average examinations score - 4.5-5. Intrinsic motivation prevails, the value of external positive motivation is greater than the value of external negative motivation. Active participation in students' scientific work, practical experience in their profession.
Average	Average examinations score - 3.5-4.4. The value of intrinsic motivation is equal to the value of external positive motivation, it is equal to or greater than the value of external negative motivation. Periodic participation in students' scientific work, practical experience in their profession only within the framework of the training program.
Low	Average examinations score - 3-3.4. External negative motivation prevails. Does not participate in students' scientific work, practical experience in their profession only within the framework of the training program.

Thus, in order to achieve the goal of the study, it is necessary to identify the levels of mathematical culture and students' vocational training progress and to compare the results. Experimental work was hosted by the Kurgan State University. Third-year and forth-year students in various areas of training were involved in the research work. They were divided into 4 groups. The first group (01) includes students major in mathematics as the basis of their future professional activity: the second group (02) includes students with indirect need for mathematics in their future professional activity: the third group (03) includes students of humanitarian training programmes; and the fourth group (04) includes students of creative training programmes.

To identify the level of students' vocational training progress, their academic performance was taken into account, the diagnostic methodology of educational motivation and the rating of the student’s creative activity were used; and questionnaires, testing and observation were used to determine the level of mathematical culture development.

The results of the first aspect of experimental work, i.e. identifying the students' vocational training progress level, are given in Table 4.

TABLE 4. THE RESULTS OF EXPERIMENTAL WORK TO IDENTIFY VOCATIONAL TRAINING PROGRESS LEVEL

Group Number	Levels of vocational training progress		
	High, %	Average, %	Low, %
01	55	35	10
02	53.8	38.5	7.7
03	64.7	35.3	-
04	20	66.7	13.3

The results of the second aspect of experimental work, i.e. identifying the students' mathematical culture development level, are given in Table 5.

If we compare the experimental data for correspondence of levels in two research aspects, we'll obtain the following results (Table 6).

TABLE 5. THE RESULTS OF EXPERIMENTAL WORK TO IDENTIFY THE LEVELS OF STUDENTS' MATHEMATICAL CULTURE DEVELOPMENT

Group Number	**Levels of students' mathematical culture development**		
	High, %	**Average, %**	**Low, %**
01	45	55	-
02	30.8	46.2	23
03	14.7	73.5	11.8
04	26.7	33.3	40

TABLE 6. CORRESPONDENCE OF VOCATIONAL TRAINING PROGRESS LEVEL AND STUDENTS' MATHEMATICAL CULTURE IN VARIOUS AREAS OF TRAINING

Levels of vocational training progress	**Levels of mathematical culture development from total number of students**		
	High	Average	Low
High	*15.6%*	33%	3.7%
Average	9.8%	*23.2%*	8.6%
Low	1.2%	1.2%	*3.7%*

Thus, 42.5% of the experiment participants demonstrated the level of vocational training progress which corresponds to the level of mathematical culture development. For students of the first group this correspondence is 55%, for students of the second group – 30, 8%, for students of the third group – 35.3% and for students of the fourth group – 53.3%. 45.3% of students demonstrated the level of vocational training progress higher than the level of mathematical culture development.

If we consider the obtained data in more detail, it can be noted that in the case of a lower level of mathematical culture development compared to the level of vocational training progress, the value of the indicator is in the upper limit of the allowable interval, i.e. under certain conditions, the student can move to a higher level of mathematical culture development and the indicators will become equal.

Note that if we sum up the data when the levels coincide and the difference in the level of learning progress and the level of mathematical culture development to one level, we get 87.8% of the total number of students surveyed, which allows to conclude that the phenomena under consideration depend on each other.

Thus, mathematical culture is the basis for vocational training progress of university students and the value of mathematical education cannot be overestimated.

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