

Concept of the Master's Program "Applied Mathematics and Computer Science in Education and Science"

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Abstract— The article is devoted to the substantiation of the concept as basic ideas that define the substantive, organizational, technological, criterion-diagnostic aspects of the master's program "Applied Mathematics and Informatics in Education and Science" in accordance with the Federal State Educational Standard of Higher Education (FSES HE) in the direction of training 01.04.02 "Applied Mathematics and Computer Science". The design of the educational process in accordance with the ideology of reverse design from the definition of educational results and diagnostic tools in their evaluation allows to optimize the content of the master's program, ensuring the formation of universal, general professional and professional competencies. A core of the concept is the methodology of the poly-paradigmatic approach in the consistent unity of the system, activity, competence and personality-oriented approaches used in solving various pedagogical problems in the process of training graduates. The principles that determine the rational organization of the educational process are described.

Keywords — *applied mathematics and computer science, educational program, master's degree, reverse design*

I. INTRODUCTION

An analysis of literary sources related to the problem of transition to the magistracy in the Russian education showed that universities solve a practical problem and develop an appropriate educational program in a particular area of study. At the same time, the problems of implementing master programs are being investigated. In particular, the problem of developing multidisciplinary programs at a technical university is the subject of the research by A.E. Brom, O.V. Belova [1, 2]. The conditions for the effective implementation of master programs at the university are discussed in the studies by S.V. Abramova and E.N. Boyarov [3]. The significance of master programs for narrow professional graduates is indicated in the work of N. Barinova. [4]. General approaches to the

development of the concept are presented in the studies by Y. Yakovleva, N. O. Yakovleva. [5].

The implementation of the master's degree in multi-level Russian education implies the presence of a master's program in the chosen field of training. In the information space of the Internet one can find samples of educational programs and take one of them for implementation. However, if there is a need to develop such a program, especially in new areas of training, it is useful to develop its concept as a basic part that defines the content, organizational, technological criteria and diagnostic aspects of this program. Despite the specificity inherent in each master's program, determined by its direction, all of them have a certain invariant expressed in universal competencies, as well as general requirements for the definition of professional competencies in terms of pairing educational and professional standards [6].

II. RESEARCH METHODS

The concept development of the master's program "Applied Mathematics and Computer Science in Education and Science" is based on:

A. *Systematic approach in determining the content and interdependence, the relationship between the modules and disciplines of the curriculum of graduates;*

B. *Personality-oriented approach which determines the graduate as a subject of the educational process capable of building an individual learning path taking into account the variable part of the curriculum;*

C. *Competence approach, postulating competence as the result of the master's education, acting as its purpose;*

D. *Activity approach which determines the priority of active technologies in the educational process and in assessing the results of education.*

E. Maintaining the Integrity of the Specifications.

The opening of the new master's program "Applied Mathematics and Computer Science in Education and Science" in accordance with the Federal State Educational Standard of Higher Education (FSES HE) in the field of training 01.04.02 "Applied mathematics and Computer Science" involves the solution of a number of organizational and substantive problems related to the specifics of the field of training [7].

Taking into account the requirements to the structure of the concept [5], as well as relying on the logic of reverse design [8, 9], we concretize the tasks to be solved:

- A. Determining educational results in the form of competencies based on the synthesis of requirements of educational and professional standards.*
- B. Determining indicators of achievement in education results and ways to measure them.*
- C. Distribution of competencies in the disciplines of the curriculum.*
- D. Identification and justification of the optimal content of the educational program, ensuring achievement of the projected results in education.*
- E. Justification of the principles of the educational process, determining the requirements for the choice of pedagogical technologies.*
- F. Justification of the theoretical and methodological basis of the program.*

III. RESULTS AND DISCUSSION

The Federal State Educational Standard of Higher Education - Master's Degree in the field of training 01.04.02 "Applied Mathematics and Computer Science" defines the list and content of universal and general professional competencies [10].

Universal competences (UC) are: systemic and critical thinking; project development and implementation; teamwork and leadership; communication; intercultural interaction; self-organization and self-development. They determine the subject's ability to successfully operate on the basis of knowledge, skills and experience in solving problems common to different types of professional activity [11–13]. These competencies relate to the metasubject content of vocational education, common to different areas of training. They are "multivalent, multifunctional, attractive for personal professional success" [14]. The content analysis of the universal competencies allowed us to reveal them through the level characteristics in the categories of knowledge, skills, and possessions:

1. UC-1 - the ability to carry out critical analysis of problematic situations on the basis of a systematic approach, to develop a strategy for action:

- to know the ways to critically analyze problematic situations;
- to be able to conduct a critical analysis of problematic situations;
- to have the ability to develop a strategy for addressing problematic situations.

2. UC-2 - the ability to manage a project at all stages of its life cycle:

- to know the stages of the project life cycle;
- to be able to develop a project;
- to possess the ability to manage the project at all stages of its life cycle.

3. UC-3 - the ability to organize and manage the work of a team, developing a team strategy to achieve the goal:

- to know the team forms of work;
- to be able to organize a team and manage its work;
- to have the ability to develop a team strategy to achieve the goal.

4. UC-4 - the ability to apply modern communication technologies, including those in a foreign language (s), for academic and professional interaction:

- to know the communication of technological interactions;
- to be able to build academic and professional interactions;
- to possess the ability to apply modern communication technologies, including those in a foreign language (s), for academic and professional interaction.

5. UC-5 - the ability to analyze and take into account the diversity of cultures in the process of intercultural interaction:

- to know that the modern world is diverse, multicultural;
- to be able to analyze the diversity of cultures;
- to possess the ability to analyze and take into account the diversity of cultures in the process of intercultural interaction.

6. UC-6 - the ability to determine and implement the priorities of their own activities and ways to improve them based on self-assessment:

- to know the priorities of their own activities;
- to be able to conduct self-assessment of personal qualities and ways of activity;
- to have the ability to determine and implement the priorities of their own activities and ways to improve them on the basis of self-esteem.

General professional competencies (GPC) defined by this master's program, set interdisciplinary, professionally-oriented and general content for this educational field. These competencies provide the theoretical and practical bases of professional activity in the field of applied mathematics and computer science, as well as the ability to use information and communication technologies to solve problems in the field of

professional activity, taking into account information security requirements:

GPC-1 – the ability to solve topical issues of fundamental and applied mathematics:

- to know typical tasks of applied mathematics;
- to be able to highlight relevant problems of fundamental and applied mathematics;
- to master the ways of solving topical issues of fundamental and applied mathematics.

GPC-2 – the ability to improve and implement new mathematical methods for solving applied problems:

- to know the methods of solving typical mathematical problems;
- to be able to identify and evaluate the performance of individual methods for solving a specific applied mathematical problem;
- to master ways of combining mathematical methods to solve an applied problem.

GPC-3 – the ability to develop mathematical models and carry out their analysis in solving problems in the field of professional activity:

- to know the basics of mathematical modeling;
- to be able to justify the type of a mathematical model for solving a professional problem;
- to own methods of constructing and analyzing a mathematical model for solving problems in professional activities.

GPC-4 - the ability to combine and adapt existing information and communication technologies to solve problems in the field of professional activity, taking into account information security requirements:

- to know the information and communication technologies necessary to solve professional problems;
- to be able to choose the optimal information technological solutions for professional tasks;
- to possess the ability to combine and adapt information and communication technologies to solve problems in the field of professional activity, taking into account information security requirements.

Note that the list and content of universal and generally accepted competencies are defined by the FSES HE.

The greatest difficulty in designing the master's program "Applied Mathematics and Computer Science in Education and Science" of the direction 01.04.02 "Applied Mathematics and Computer Science" is the definition of professional competences according to the profile of the education received.

The list of professional standards, relevant professional activities of graduates who have mastered the master's program in the area of training 01.04.02 "Applied Mathematics and

Computer Science in Education and Science" includes the following standards:

- Professional standard "Teacher (pedagogical activity in the sphere of pre-school, primary general, basic general, secondary general education) (educator, teacher)";
- Professional standard "Teacher of additional education for children and adults";
- Professional standard "Teacher of vocational training, vocational education and additional vocational education."

The orientation of the program on teacher training in the system of training for a bachelor degree, specialist, graduate and additional professional education determines the standard 01.004 for this program "Teacher of vocational training, vocational education and additional professional education" [15].

Based on the generalized work function, teaching in undergraduate, specialty, master's and Additional Professional Programs, focused on the appropriate level of qualification, level of qualification 8, labor functions are defined. These include:

- teaching courses, disciplines (modules) under the bachelor's program, specialty, graduate and (or) Additional Professional Programs (code 1 / 01.7);
- development of scientific and methodological support for the implementation of supervised training courses, disciplines (modules), undergraduate programs, specialties, graduate programs and (or) Additional Professional Programs (code 1 / 04.8).

As part of mastering the master's program, graduates are preparing to meet the challenges of professional pedagogical activity. Education and science are the areas (spheres) of graduates' professional activities.

In accordance with what has been said, the following competencies are defined as professional competencies (PC) to be formed:

- PC-1 – the ability to teach mathematics and computer science in general education organizations, professional educational organizations and educational institutions of higher education;
- PC-2 – the ability to develop teaching materials for e-learning.

The indicators for assessing the formation of competencies are substantiated.

For PC-1: a person knows the content of the taught discipline in accordance with the requirements of the FSES HE; they are able to effectively use various forms, methods, tools and technology of education, distance learning technologies and e-learning; they have the ability to implement the teaching methodology of the discipline in teaching.

For PC-2: a person knows the requirements for the development of an educational and methodological complex for e-learning discipline; they are able to develop individual components of the educational-methodical complex of the

discipline, including the fund of assessment tools, in accordance with sections of the work program; they have the ability to develop an educational and methodological complex for implementation in the conditions of e-learning.

Given the activity nature of any competence, as a result of the assignment of competence, we note that the competence is formed and manifested in the activity. Therefore, to assess the level of development of competence as an integral personal characteristic, it is necessary to use the activity: design, solution of case assignments, etc. [16].

To assess PC-1, expert assessments are used when attending classes by external experts with their written conclusions. The competence of PC-2 is evaluated on the basis of the presentation of the developed teaching and methodological complex and the activity of students on its use in the educational process, recorded in the electronic environment.

The carried out substantiation of universal, general-professional and professional competences allows optimizing the content of the educational program, ensuring the achievement of the predicted results of education in the form of these competencies.

Let us note that the content of the master's program "Applied Mathematics and Computer Science" is a projection of applied science of mathematics and computer science as a sphere of scientific activity aimed at solving practical issues. Despite this, it is difficult to clearly distinguish the scientific methods of fundamental and applied research. One can only speak of their different combinations and define the fundamental and applied as successive stages in the scientific process. Naturally, research aimed at analyzing new phenomena, processes and discovering laws explaining the processes that determine the possibilities of controlling them, is the subject of fundamental science. Fundamental science implements a systematic approach to the study of objective reality, determines the methodology of any research. Applied research, included in the field of mathematics and computer science, solves practical issues using the results of basic research, realizing a rational way of knowledge [17]. The above allows substantiating the optimal choice of curriculum disciplines that provide fundamental training, the result of which is the formation of competencies:

GPC-1. A future specialist is able to solve topical issues of fundamental and applied mathematics.

GPC-2. They are able to improve and implement new mathematical methods for solving applied issues.

GPC-3. They are able to develop mathematical models and analyze them in solving issues in the field of professional activity.

GPC-4. They are able to combine and adapt existing information and communication technologies to solve issues in the field of professional activity, taking into account information security requirements.

The basic part of the curriculum, the complexity of which is 30 unit credits, providing a fundamental component of the preparation of graduates in this area, includes disciplines that

ensure the formation of relevant competencies. They are presented in Table I.

TABLE I. BASIC PART OF THE CURRICULUM

Name of discipline	Competences		
	UC	GPC	PC
Current research in education	UC-1; UC-6		PC-2
Modern educational technologies	UC-1		PC-4
Methodology of research work	UC-2; UC-6	GPC-1	PC-2
Modern problems of informatization of education	UC-1; UC-4	GPC-4	PC-1
Mathematical modeling	UC-1	GPC-3	PC-4
Automated workplace of the teacher	UC-6	GPC-4	PC-1
Discrete mathematics	UC-1	GPC-3	PC-2
Translation of the qualification requirements of the employers in the planned learning outcomes	UC-2		PC-1

Expansion of the basic part of the curriculum is presented in its variable part and includes the following disciplines (Table II).

TABLE II. VARIABLE PART OF THE CURRICULUM

Name of discipline	Competences		
	UC	GPC	PC
Compulsory subjects			
Mathematical methods in pedagogical research	UC-1; UC-2	GPC-4	PC-2
Modern problems and applications of probability theory and mathematical statistics	UC-1; UC-2	GPC-2	PC-3
Legal and regulatory support of educational activities	UC-1; UC-6	GPC-4	PC-4
Modern information technologies in educational and scientific activities	UC-1; UC-6	GPC-4	PC-1
Methods of teaching mathematics in vocational education	UC-1; UC-2	GPC-3	PC-1; PC-3
Information and analytical methods of statistical data processing	UC-1; UC-2	GPC-4	PC-2
Methods of teaching informatics in vocational education	UC-2; UC-6	GPC-4	PC-3

Elective courses that allow for individualization of the educational trajectory are presented in Table III.

Subjects of the curriculum allow students to form fundamental ideas for the implementation of the master's thesis. The obtained fundamental knowledge in the field of mathematics and computer science is applied to solving scientific issues of improving the quality of education at the level of modern requirements [18].

The development of the content of the master's program by students is carried out using procedural technologies of education, immersed training in an independent, active, cognitive activity in solving case studies, project activities, discussions and intellectual competitions.

TABLE III. ELECTIVE SUBJECTS IN THE CURRICULUM

Name of discipline	Competences		
	UC	GPC	PC
Elective courses			
Training of professional communication	UC-3; UC-4; UC-5; UC-6		
Project planning and implementation	UC-2		PC-1
MATLAB, MATHCAD in educational and scientific activities	UC-6	GPC-4	PC-1
History and methodology of mathematics and informatics	UC-1,		PC-2
Information and coding theory	UC-1	GPC-4	PC-2
Visualization technology in education	UC-6	GPC-4	PC-1

The organization of the educational process is based on the methodology of the poly-paradigmatic approach, as a consistent unity and interaction in the use of systemic, activity, competence and personality-oriented approaches. The system approach allows us to consider all modules of the curriculum in a systematic unity, united by the aim of ensuring the mandatory results of education in the form of competencies. Activity approach, postulating the development of human activities, determines the expediency of priority used for active (procedural) learning technologies. Competence-based approach is defined by the purpose and result of education in the form of formed competencies, distributed by modules and disciplines of the curriculum [19].

Based on the methodology of the poly-paradigmatic approach in the organization of the educational process, we identify the principles that determine its rational organization:

- the student-centered principle in the framework of the implemented personality-oriented approach, allowing for the creation of conditions for the development of graduates in accordance with the personal significance and meaning of education for them, the ability to adapt the content of the program to the needs of the student;

- the principle of integrity and harmonization in the content of the fundamental and applied components of the training program in accordance with the systematic approach determines a reasonable combination of these components of the program with a strong practical and professional focus on the sphere of professional activity in science and education;

- the principle of learning in activities in accordance with the activity approach determines the priority of active (procedural) educational technologies, including project training, solving case assignments;

- the principle of diagnostic certainty of the results of education supplemented by monitoring the process of formation of competencies;

- the principle of continuity and discontinuity between the levels of bachelor's and master's degree allows to observe consistency at the substantive, technological and effective-evaluation levels of the master's degree;

- the principle of openness through the participation of social partners and employers in the design of the results of education of graduates and in the educational process.

IV. CONCLUSION

The concept of the master's program "Applied Mathematics and computer science in Education and Science" presented in the article sets the theoretical basis for the algorithm and its development. Despite the fact that the concept refers to a specific master's discipline, the basic ideas and approaches are universal and can be used in solving similar pedagogical issues for other areas of training.

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