

# Mathematical Education as Key Aspect for Human Resources Enhancement in Digital Economy

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**Abstract**—Currently, digital economy penetrates into all spheres of human life and society. Economy digitalization is changing the employment structure and, consequently, the syllabus and methods of the educational process at the university. Mathematical education is one of aspects of human resources enhancement in digital economy, therefore, professional training of future mathematics teachers is of great importance and it should involve advanced educational technologies and new forms of educational process organization. The purpose of the study conducted by the authors is to develop the advanced content of the syllabus and methods of the educational process for educational environment structure of a regional university while training future teachers of mathematics and computer science as the first element in training for digital economy on the basis of the activity approach. Implementation of this component resulted in increase of students' motivation to improve learning quality and facilitated the development of the required professional competencies.

**Keywords**—*mathematical education, human resources, proactive educational environment, digital economy.*

## I. INTRODUCTION

In the era of digital economy, according to Klaus Schwab, the founder and the President of the Davos World Economic Forum, the main asset of any state, the main production factor will be human resources rather than capital assets. Due to accelerating technological development, the Fourth Industrial Revolution will give special priority to the employees' ability to adapt constantly and to master new skills and approaches in a variety of contexts [1].

According to The Future of Jobs research published by the World Economic Forum in 2016, it was stated that “2 million jobs will be added to the global labor market, and 7.1 million will disappear by 2020. Jobs will appear in the intellectual and high-tech spheres, but will be reduced in the real sector of the economy ... and in the sphere of administrative work...”. According to the report authors, “Big Data until 2020 will increase the number of jobs in the field of mathematics and computer engineering by 4.59%, employment growth in computer specialties will amount to 4.54% per year, and in design and engineering development – 3.54%” [2].

In Russia, according to Alexei Kudrin, Head of the Center for Strategic Research, employment restructuring is also reported. In 2017, he said that “digitalization and transition to other management models ... will significantly reduce the need for officials because decisions will be made automatically ... There will be shortage of 1 million

programmers who will perform digitizing tasks in any industry” [3].

Future of Jobs Research 2018 suggests that by 2022 there will be a growing demand for professionals in such spheres as training and development. The research defines the skills that continue to gain traction. Researchers believe that the importance of such skills as technology development and programming is growing sharply, and the growing demand for various technological competences is emphasized. Demand for specialists with analytical thinking, ability to learn actively and develop learning strategies is increasing. At the same time, such abilities as creativity, ingenuity, pro-active approach, critical thinking, ability to persuade and negotiate will also maintain or increase their importance, as well as attention to detail, thinking flexibility and ability to solve problems in a comprehensive manner [4].

Thus, the digitalization process of the Russian economy is changing the employment structure in the direction of increasing the number of people working in computer engineering and information technology, and this, in its turn, creates a need to improve the quality of mathematical education as the basis of modern professions.

As it is known, vocational mathematical education, general mathematical education and mathematical literacy are the main components of mathematical education. The authors' prime interest aspects are general mathematical education and mathematical literacy, since the mathematical culture of modern professionals is built in these structures.

Many developed countries are concerned with the current state of mathematical education and make efforts to improve its quality [5, 6, 7]. The urgency of the problem is primarily due to the global problems of mankind, changing living conditions, and present-day challenges. Computerization and globalization processes developing in the world will also fully affect mathematical education. Education standardization will also affect its quality.

In the modern world, mathematical modeling is used in the high tech sphere, in natural science research projects, in economics, bioengineering, medicine, in forecasting global natural phenomena and processes in the society. Mathematical methods actively penetrate into such traditional humanities as history, philology, applied linguistics and psychology.

Mathematical culture is the basis for university student successful vocational training in any field of study [8].

A certain level of mathematical education, as a combination of mathematical knowledge, abilities, skills and students' creative qualities is acquired in the process of schooling; consequently, proper training of future teachers of mathematics and computer science is the key to successful development of the human resources for the digital economy.

According to A.M. Abramov, V.M. Polterovich, the leading mathematicians and academicians of the Russian Academy of Sciences, the most required human capital investment for Russia today is to train highly proficient mathematics specialists.

The Government of the Russian Federation understands the importance of mathematical education for the economic development, and in 2013, the Government adopted the Concept of Mathematical Education Development in the Russian Federation [9].

One of the most crucial problems, specified in the Concept, is the human resources problem.

Earlier, N.P. Dolbilin, Doctor of Physical and Mathematical Sciences, mathematics communicator, drew attention to this problem. He considered one of the most important causes of the crisis in our mathematical education was in the training system of the mathematics teachers. "The fact that our mathematics teachers train good professionals is universally recognized. But it turns out that at a pedagogical university, in general, a low-attaining high school graduate who wants to become a mathematics teacher is ready to learn how to solve elementary problems and to master skills how to teach elementary mathematics to others. Instead of, so to say, increasing this level, instead of training the student to become a qualified teacher, departments of mathematical faculties, in general, offer very difficult, even excessive mathematical courses, such as functional equations, mathematical analysis, mathematical statistics, probability theory, etc.

It turns out that a future teacher becomes a first year student of a teacher training college, and he somehow knows how to solve elementary mathematical problems. While graduating, he solves the problems much worse than he did during his first year. As a result, teachers, as experience shows, on average, have very little knowledge of school course content. They do not know how to solve problems that are a little more difficult than a middle level, and a non-standard task, which is taken from *Mathematical Know-how* by Boris Kordemsky, could already be a problem. As a result, such teachers cannot foster interest in mathematics in their students ... Each of us who came to mathematics knows for sure that neither the textbooks nor the program defined our choice. It was the teacher who determined the choice. I am just 99 percent sure of that. It seems to me that the problem of raising the competence level of a mathematics teacher is a central problem" [10].

Obviously, these are mathematics teachers who act as a vanguard in training personnel for the digital economy, so it is very important that future mathematics teachers understand the value of mathematical education for training personnel in the digital economy while studying at the university.

The purpose of this research is a brief description of the scope of content and methodological component of the educational environment model, implemented in our university when preparing students in the field of training

44.03.05 "Pedagogical Education" profile "Mathematics and Computer Science."

## II. RESEARCH METHODOLOGY

The methodological basis of the study was an activity approach. The essence of its implementation at the university is to organize such an environment that is focused on intensive educational, social, practical and scientific activities, as well as on the development of professional self-determination.

To achieve the purpose, it is necessary to create additional conditions or mechanisms that will be aimed at organizing intensive, diverse and complicated activities that ensure the student's becoming the subject of the educational process. In accordance with these provisions, a special role in this study is assigned to the content and methodological component of the educational environment model, which includes various forms, methods and technologies of students interacting with the modern educational community.

The necessity in developing this component is determined by the fact that the classical model of training does not provide an appropriate level of students' interaction with various educational organizations and institutions and it is not sufficiently focused on students' intensive activity, their early "entry into the profession". Introduction of this component into the educational process of the university, as shown by observation and student performance analysis, allows for increasing a motivational component of training and professional self-determination. Assessment of student motivation changes was made using the diagnostic methodology of students' educational motivation by A.A. Rean and V.A. Yakunin, modified by N.Ts. Badmaeva [11].

## III. RESULTS

Digital Economy of the Russian Federation Program approved by the Government of the Russian Federation (No. 1632- p dated July 28, 2017), claims that one of the primary goals of human resources and education development is to create a motivation system for developing the required competencies and participation in the development of the digital economy in Russia [12].

During students' training, the future teacher should have a motivated active position, which can be achieved through didactic, scientific and educational activities that are closely interconnected.

Didactic activity is associated with the content of students' knowledge, development of their cognitive abilities, and a possibly early immersion in research activities. Students' research activities should be aimed at the development of didactic materials using information and communication technologies that will update and expand knowledge of future teachers and enrich their methodological experience. Educational activities at the university should be organized in such a way that the student, while studying, would develop an ability to establish relations with peers and build a constructive behavior model.

If to consider interrelation between the education levels and levels of digital training, then general secondary education, secondary vocational and higher education (bachelor degree level) correspond to a basic level of digital training, which is characterized by presence of the following skills in information and communication technology:

- network access,
- basic skills in programming and algorithm presentation,
- product development and exchange of information in individual or collective work,
- proficiency in computer technology,
- ability to use the web environment,
- interpretation and representation of information using ICT tools.

Moreover, the future mathematics teacher should have methodological, mathematical, psychological, pedagogical and communicative competencies.

Therefore, for professional training of mathematics teachers, it is necessary to create a new educational environment in a higher educational institution, which allows developing the above competencies.

The experiment in creating an active educational environment for students in the field of training 44.03.05 "Pedagogical Education", profile "Mathematics and Computer Science" started in 2018/2019 academic year.

The purpose of this experiment was to create an educational environment in which students could effectively acquire their professional expertise, knowledge and skills.

An active educational environment is an environment with special conditions to promote a deeper, faster and more efficient subject acquisition, to stimulate students to work intensively and independently.

Its structural components are spatial-semantic, content-methodical, and communication-organizational ones [13].

Spatial-semantic and communication-organizational components of the environment are standard, therefore, we will concentrate on describing the content-methodological component of the environment.

This component, in addition to the content sphere (training and education concepts, degree programs and syllabi, curriculum, textbooks, teaching aids, etc.) includes forms and methods of education organization, among which it is necessary to note project activities, as well as application of various methods and strategies of collaboration both during classroom lessons and students' individual work.

The difference between our model and the classical one is that the content-methodical component was supplemented with obligatory communication of our students with the modern educational community, which included not only the high school students community, but also those studying in preschool educational institutions, vocational school students, university students, mathematics and computer science teachers, heads of educational institutions and structural units of the Kurgan Region Department of Education and Science.

This communication involved outreach activities, project activities, as well as educational, research, and cognitive activities, during which a more efficient motivation system was developed to acquire the required universal competencies and some professional competencies.

Organization of student activities will be described in the framework of this model.

At the beginning of the academic year, the student group leaders are given the task to design and conduct outreach activities aimed at disseminating and explaining scientific knowledge in mathematics and computer science as well as other socially significant information. These events should be organized in such a way as to interest schoolchildren and students of secondary vocational schools with the issues related to informational support of the community, with acquisition of new knowledge by students. These events should be both entertaining and informative.

Several socially significant events aimed at popularization of mathematics and computer science could be mentioned, such as *Information QUEST*, *IT-battle*, *Mathematical QUIZ*, which were attended by more than 40 people. These events were held within the framework of *Science Days* in the Kurgan Region and required from students certain organizational skills, substantial knowledge of the basics of programming, computer science, mathematics, as well as creative thinking, and ability to solve complex, multi-stage problems.

The next direction in organization of students' activities was connected with activities related to extending knowledge in mathematics, computer science and teaching methodology. It deals with participation in academic contests of various levels in elementary mathematics, higher mathematics and teaching methodology, which allowed students to evaluate their level of training, compare it with the level of the students' knowledge in similar areas of training, with the students from other universities.

The students' participation in forums, academic contests, scientific and practical conferences contributed to increasing the educational motivation of the students.

The 5<sup>th</sup> year students participated in preparing and conducting a seminar for computer science teachers on training students for the computer science academic contest.

Communication with the representatives of the administration of the Kurgan Region Department of Education and Science allowed expanding the horizons of future specialists regarding the problems and prospects of development of mathematical education and digital economy across the region.

It was equally important to use interactive and gaming techniques in extracurricular activities for the first-year students who have not had sufficient competencies to conduct more complex events yet, but are competent enough to participate in scientific games, for example, in the Science Game.

The Science Game was created and developed at Tomsk Polytechnic University, where they decided to create a game in which all participants could try and prove themselves during a few hours as scientists in various fields, such as chemists, nuclear engineers, programmers, electronics engineers, etc.

The Science Game popularizes science in the most striking and accessible way for young people, it also gets students involved in real-world innovative business. In the game, they are "charged" to have the most active life in school, science and business.

As a result of participating in this team game, the students increase their scientific potential and also develop communication skills.

And, finally, the last direction is connected with the Federal Project “Human Resources for Digital Economy” of the National Program “Digital Economy”.

Within the framework of the project, Campuses for Youth Innovations are being created throughout Russia, the mission of which is to create a unique practice-oriented educational environment aimed at training future professionals among children and youth who can be competitive in the global labor market in the digital economy era.

Through active participation of students in the above mentioned activities, young people were ready to work as operators and tutors during creativity fostering sessions at CAMP IT with students aged 13-17. During this camp session, the students from the Kurgan Region and the city of Kostanay (Republic of Kazakhstan) were trained in Discrete Mathematics and Combinatorial Theory, Computer Science, and Fundamentals of Digital Technologies as part of the Federal Project under our students’ guidance.

Summing up the results of this experimental work, it should be noted that the developed active educational environment has allowed not only increasing the students’ motivation to improve the quality of their educational activities, but also introducing future mathematics teachers to modern trends in the field of mathematical education, society computerization, and to the fundamentals of the digital economy. The diagnostic results of the university students professional motivation showed that the motivation of the second-year students increased by 26% and amounted to 67.2%; of the third-year students — by 29.1% and amounted to 76.3%; of the fourth-year students — by 32% and amounted to 88.8%; of the fifth-year students — by 34% compared to the initial data and amounted to 92.4%. The positive results of the research can also be attributed to the fact that 75% of the total number of the fifth-year students began to receive increased scholarships, and 68% of the fourth-year students were actively involved in scientific student projects.

#### IV. CONCLUSIONS

We consider that the content of the methodological component of the educational environment model proposed by the authors complies with the Concept for Development of Mathematical Education in the Russian Federation, which suggests the following:

- improvement of the content of mathematical education should be ensured primarily through advanced training and supplementary professional education of teachers on the basis of leading practices in mathematical education developed in general educational organizations;

- educational institutions of higher education and research centers should participate in mathematical literacy activities and popularization of mathematical knowledge among the population of Russia.

The results of the experiment demonstrate that enrichment of the content-methodological component of the model by including the student in the modern educational space determines a special role in the student’s transition from the position of an object to the position of the subject of educational activity. The observation and the analysis of the results of the students’ activities allow to conclude that the content of the model structure proposed by the authors increases the motivational component of the students’ training and their professional self-determination.

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