Continuing education potential to form research competence of students

P Y Romanov¹, T P Zlydneva¹, I I Kinzina¹, L S Ryazanova¹, L V Smirnova¹ and A A Tsaran²

¹Department of Applied Mathematics and Computer Science, Nosov Magnitogorsk State Technical University, pr. Lenina, 38, Magnitogorsk, Chelyabinskaya obl., Russia
²Department of Linguistics and Literature, Nosov Magnitogorsk State Technical University, pr. Lenina, 38, Magnitogorsk, Chelyabinskaya obl., Russia

E-mail: kinzina@mail.ru

Abstract. The constantly changing labor market requires the formation of specialists with a desire for self-improvement, capable of moving from one type of activity to another, perhaps not related to the previous one. This task can be called a priority in the field of professional education, which dictates its relevance for mathematics education. When setting the formulated problem and solving it, special attention should be paid to recognizing the importance of the formation and development of the educational potential of the creative activity of students. The article presents an analysis of the possibilities of a continuous education system, put forward theoretical provisions and pedagogical conditions for the effective formation of research skills of students within this system. The characteristic of the structural-content model of the formation of the research competence of future teachers (or specialists of other professions requiring the formation of research competencies) in the system of three-level education is given on the example of studying one of the directions of discrete mathematics.

1. Introduction

Due to the duration of the process of fostering creative activity, the system of continuous education should play an important role. At the same time, the implementation of the idea of continuity lies in the fact that the development of the creative qualities of a person (orientation, abilities, corresponding research skills) must be started from school, continue in research activities at a university and in creative work after graduation in the process of improving the qualifications of a specialist.

However, for this, a school needs a creative teacher, a university needs a teacher, a mentor who participates in innovation processes, in the experimental research activities of the industry, combining the functions of a teacher and a research scientist [1, 2]. This is possible only if a purposeful process of preparing a graduate-researcher is provided, be it a mathematics teacher, a specialist in applied mathematics and computer science.

2. Methods

The aim of our study was to identify the possibilities and principles of implementing the model of the formation of research skills in the study of mathematical disciplines. A special emphasis in our study is
placed on the problem of continuous training of a teacher-researcher, a specialist-researcher, as the basis of the system of research work in the process of continuous mathematical education.

The problem posed was considered by us in the aspect of the mathematical preparation of secondary school students, as well as bachelors and masters of training areas 03.01.02 Applied mathematics and computer science and 44.04.01 (44.03.01) Pedagogical education (profile "Mathematics"), when teaching which we have carried out approbation of the advanced theoretical provisions (methodological approaches, principles) and pedagogical conditions for the effective formation of research skills of students, as well as the developed educational and methodological support.

3. Results
As a result of our research, the theoretical provisions (methodological approaches, principles) and pedagogical conditions for the effective formation of students' research skills were identified, formulated and substantiated; on their basis, a structural and meaningful model of the formation of students' research skills in the system of lifelong education was developed; educational and methodological support for the formation of research skills of students has been developed, one of the sections of which is described in the article.

4. Discussion
We will consider creative activity, the result of which is a product that has novelty, originality and significance. We define research activity as a component of creative activity, i.e. purposeful and largely algorithmic activity, which creates the basis for obtaining a new result. In our research, we relied on the principle of complementarity introduced into the theory and practice of education by G. G. Granatov [3] whose essence lies in the fact that research and creative activity can be considered mutually complementary concepts.

V. I. Zagvyazinsky [4] identified three contradictions that arise in the implementation of the program of introducing students to the creativity of students (whether it is a schoolchild, student or specialist raising qualifications), fostering readiness to formulate and solve problems of a creative nature. The first contradiction is connected with the motivational support of the student's educational activity, namely, the contradiction between the existing or rapidly developing orientation towards the studied subject, towards science and scientific activity and the orientation towards future professional activity. Insufficient stock of knowledge makes it often impossible to strive for creativity - this is the second contradiction. And, finally, the third contradiction comes from the very nature of the creative process: on the one hand, the student must be given some rules and patterns of activity, and on the other hand, creativity does not lend itself to strict regulation and algorithmization.

We see the resolution of the first of these contradictions not only in the disclosure of common elements to the students, a certain internal unity of scientific activity, but also in the organization of professionally oriented research activities of students in the field of science.

The second contradiction can be resolved by using at each stage of the learning process tasks of the appropriate content, allowing to carry out creative activity, and the organization of effective management of this activity.

We see the resolution of the third contradiction in equipping students with a technological component of the creative process (a set of research skills), which creates the basis for obtaining a subjectively qualitatively new result at each stage of the learning process.

We consider two interrelated pedagogical systems: the system of continuous pedagogical education and the system of forming students' research skills.

An analysis of the practice prevailing in our country and abroad led to the conclusion that the system of continuous teacher education should be implemented within the following subsystems (levels) [1]:

1. Subsystem of pre-university training. The purpose of this subsystem is to form students' scientific knowledge, general working skills, methods of creative activity, value orientations, providing a conscious, combining personal interests with social needs, social and professional orientation and the
choice of the path of preparation for professional activity [5]. This goal is implemented by preschool, out-of-school institutions and a general education school.

2. Subsystem of university training. Its goal is to form professional knowledge and skills, experience of creative activity, personal qualities in each member of society, ensuring his active involvement in professional social activities at a certain educational and qualification level (bachelor's level, master's level). This goal is realized by all types of professional educational institutions. More details about the principles of implementation and achievement of this goal can be found in [6].

3. Subsystem of postgraduate training. The purpose of the subsystem is to constantly update, deepen, expand professionally significant knowledge, abilities, skills within the framework of the previously achieved professional level; enrichment of the experience of creative activity of members of society employed in the professional sphere, ensuring an increase in the efficiency of their work in the conditions of the rapid development of science, technology, technology. This goal is realized by all types of professional education.

In the course of the study, three levels of students' proficiency in research skills were identified:

- **practical** - the level that is formed in the process of pre-university mathematical training. The tools for the formation of research skills include specially composed mathematical problems (problems with conflicting data, "provocative" problems, problems with an error in the solution, etc.), problems that allow training using a special structured system of problems and problems of a dynamic nature, problems containing applied aspects of mathematics [7]. The formation of research skills at this level can be continued in the course of university mathematical training;

- **methodological** - a level formed in the process of studying certain special disciplines with a possible solution to applied problems, research tasks. The main means of their formation, in our opinion, are teaching students the methodology for constructing and using the above tasks and business games, the end result of which may be an abstract with elements of research, course work, article. This structural element of the lifelong education system ensures continuity in the formation of research skills in the transition from the disciplines of the mathematical cycle, studied at school and at an early stage of education at the university, to special mathematical disciplines;

- **methodological** - a level that implies the process of designing new professional technologies. The design of technologies includes the analysis and assessment of the level of solution of the task assigned to the specialist, the analysis of the existing scientific and methodological literature, the determination of the main technologies used in its solution, the development of the solution method, the evaluation of the results, and the adjustment of the technology in the light of the results obtained. Thus, the previously formed research skills at this stage are used in a complex, reveal the potential of the listeners, satisfying their need for self-realization.

Thus, the system for the formation of research skills implies a level division of the continuing education system (pre-university, university, postgraduate), the system of research skills (practical, methodological and methodological levels) and the implementation of mutually ordered correspondence. Moreover, each of the components of the system is relatively independent, but hierarchically depends on other components of the system.

Based on all of the above, we can conclude: to train a teacher-researcher, a specialist-researcher at each level of continuing professional education, it is necessary to form by appropriate means an adequate level of research skills of students, while there is a natural relationship between the effectiveness of lifelong education and the level of development of the research skills of students, which is confirmed by our experimental data [1].

As an example of the implementation of the approach developed by us, we propose to consider the multi-level formation of research skills in the system of lifelong education when studying one of the sections of discrete mathematics - the theory of fuzzy sets.
One of the main methods of implementing the formation of research skills and abilities at the pre-university level, from our point of view, is the project method, which is currently very widespread in teaching.

As mentioned above, modern conditions require the formation of students' readiness and ability to independently, creatively master and rebuild ways of activity in any sphere of human culture. The tasks set allow us to effectively solve project activities. It is this type of activity that makes it possible to shift the emphasis from the process of passive accumulation of the amount of knowledge to mastering the methods of activity, which contributes to the formation of the key competencies of the researcher in students [8].

We used a two-component organization of project activities: work on a topic and work on projects [5].

The first component (preparatory) - find out. To implement this component, we have developed an elective course "Introduction to the theory of fuzzy sets", since the study of the basics of discrete mathematics, in particular the theory of fuzzy sets, is not included in the program of the compulsory course of mathematics at school [9]. The purpose of the proposed course is to deepen the knowledge of students in the field of mathematics and teach them how to solve logical problems; the formation of competencies in schoolchildren aimed at developing skills for independent and group research activities.

The second component is done.

After studying the foundations of the theory of fuzzy sets, within the framework of students' research activities, one can proceed to the direct solution of practical applied problems. Separate chapters of the theory of fuzzy sets allow not only to implement the research direction of students' activities, but also to carry out interdisciplinary research projects. Thus, knowledge of various methods of decision-making makes it possible to implement projects that make it possible to choose alternatives in various spheres of human activity related to the economy, social research, and many decision-making algorithms available for the perception of schoolchildren lead to joint projects with informatics.

In a school course, it is not possible to study all types of decision-making problems. The analysis of the literature made it possible to select some algorithms, the implementation of which is available to schoolchildren; these include the problem of making a decision based on a preference relation given on a set of alternatives by one expert, a group of experts equipped with weights. The research activity of students in the implementation of such algorithms consists in the selection of alternatives, in the construction of a membership function. At the same time, the student, having worked with additional literature, must highlight the most important criteria for comparing alternatives, establish their main characteristics.

Based on the presented algorithms, students develop the following projects:

- Creation of an expert system for selecting a specific type of product (laptop, phone, washing machine, etc.), taking into account the system of preferences on a set of product characteristics with a preliminary survey of the buyer to determine the degree of importance of the criteria.
- Creation of an expert system for the selection of the class leader, the president of the school students' committee, etc.

When developing projects, both an individual student and a group of students with various interests from psychology (development of tests that assess the quality of candidates) to informatics (development of computer programs for information processing) can be involved. Also important is the practical application of the developed universal tables and programs that solve the problem of choosing alternatives [10].

At the university, the theory of fuzzy sets is studied in the course of discrete mathematics. In contrast to the school level, the formulation of research tasks and possible approaches to their solution should be carried out at a higher scientific level. We have identified the following methods for choosing the best
alternatives, provided that the criteria for comparing them are unclear and uncertain, which may be useful in the student's further professional activity:

- Multi-criteria choice of alternatives based on a fuzzy preference relation.
- Multi-criteria choice of alternatives using fuzzy inference rules.
- Ranking of alternatives on the set of linguistic vector estimates.
- Multi-criteria choice by the method of maximin convolution.
- Method of analysis of hierarchies.

This article presents only some of the possibilities of using decision theory in the design and research activities of students. But even in this presentation, the various possibilities of the proposed course are seen, including interdisciplinary integration, which contributes to the formation of a holistic worldview, learning through experience and cooperation, taking into account individual characteristics and needs, interactivity (work in small groups, simulation, use of ICT)[11].

The completion of the study of the presented methods is the defense of the project developed by the student. This can be the development of universal spreadsheets, allowing the selection of the most successful alternative, and the solution of a specific selection problem, and the creation of an expert system that compares and ranking alternatives, as well as the solution of various economic problems associated with a specific enterprise [12,13].

As at the school level, the organization of research activities in the framework of the study of decision theory leads to the satisfaction of individual educational interests and needs of students. If an elective course can be considered only as propaedeutics in organizing the research activities of students, then due to the wide variety of decision-making tasks there are great opportunities for setting research scenarios that are subsequently solved by students and future specialists. So already at school for each student it is necessary to form an individual direction of research with the prospect of its development at the university. In the future, students interested in programming can be offered topics related to artificial intelligence, with the creation of computer decision-making systems. Those who are interested in economics or socio-political issues can be offered topics related to the study of assessing the performance of enterprises and banks, with the development of rating systems, as well as strategies for selecting candidates for filling vacant positions. All of the above has great prospects for building an individual trajectory for the development of research skills in a future specialist-researcher [14].

References

[1] Romanov P Yu, Zlydneva T P, Romanova T E, Velikh A S and Smirnova L V 2020 Organization of Research Activities in the Process of Teaching Natural Science Subjects in School and University (Moscow: INFRA-M Publishing House) Ser. Scientific Thought p 260
[2] Bochkareva T N, Akhmetshin E M, Osadech E A, Romanov P Yu and Konovalova E 2018 Preparation of the future teacher for work with gifted children Journal of Social Studies Education Research B 9(2) 251-65
[3] Granatov G G 1991 Complementarity Method in Pedagogical Thinking (Self-knowledge, Dialectics and Life) (Chelyabinsk: CSPI) p 129
[4] Zagvyazinskij V I 1987 Pedagogical Creativity of the Teacher (Moscow: Pedagogy) p 160
[5] Kovalenko A V 2016 Designing tasks for motion on a mathematical circle Scientific and methodical electronic journal "Koncept" B 9 41-5
[6] Romanov P Yu, Smirnova L V and Torshina O A 2019 Teaching ways of compiling tasks as the fundamentals of the development of professional competence of future mathematics teachers Perspectives of Science and Education 38(2) 442-52
[7] Smirnova L V and Smirnova S S 2012 Software of systems in the industrial and social fields (Magnitogorsk: NMSTU) 256-69
[8] Symanyuk E E, Pecherkina A A and Zakrevskaya O V 2019 Peculiarities of professional selfdetermination of older adolescent students Perspectives of Science and Education 42(6)
[9] Rotshtein A P and Shtovba S D 2001 Fuzzy multicriteria analysis of variants with the use of paired comparisons Izvestiya Akademii Nauk. Control theory and systems 3 150-4

[10] Bellman R and Zadeh D 1976 Decision-making in fuzzy environment Questions of analysis and decision-making procedures: Collection of translations (Moscow: Mir Publ.) p 240

[11] Saati T 1993 Decision Making. Hierarchy Analysis Method (Moscow: Radio and Communication Publ.) p 278

[12] Apatova N V, Gaponov A I and Mayorova A N 2017 Modern high technologies 4 7-11

[13] Apatova N V and Gaponov A I 2019 Perspectives of Science and Education 40(4) 484-96

[14] Agrashenkov A V, Mal’kov N R and Musienko T V 2015 Scientific Letters of Russian Customs Academy the St.-Petersburg branch named after Vladimir Bobkov 3(55) 234-51