MATHMATICAL PROBLEMS AS A MEANS OF DEVELOPING STUDENTS’ RESEARCH SKILLS IN THE CONTEXT OF SCHOOL EDUCATION CONTENT UPDATING

a Alma Abylkassymov, b Akaru Bazhi, c Marat Dyussov, d Almagul Ardabayeva, e Larissa Zhadrayeva, f Yessenkeldy Tuyakov, g Khabiba Kenzhebek

ABSTRACT

Objective: The main goals of school mathematical education are the development of intellectual students, the formation of thought qualities characteristic of mathematical activities and the acquisition of specific mathematical knowledge, the skills and skills necessary for practical application, and the formation of research skills.

Theoretical Framework: The problem and purpose of the study is to identify the possibilities of problem-searching tasks in mathematics as a way for school students to develop research skills in updated content situations.

Method: A method has been developed to build selected skills based on the corresponding system. It has been established that collective or group forms are most effective in creating problem situations in the classroom. Group or individual forms are most effective for testing a hypothesis and finding a solution to a problematic task.

Result and Conclusion: The article also highlights the main blocks of research skills of schoolchildren and problem-search tasks in algebra and geometry developed for these blocks and methods for the formation of these skills. The basic principles for constructing a system of tasks focused on the formation of each block and each skill that we have chosen are determined.

Research Implications: Implementation of these goals necessitates updating the system of school mathematical education, which is designed to ensure a harmonious combination of the interests of the individual and society.

a PhD in Mathematics, Doctor of Pedagogical Sciences, Professor, Academician of the National Academy of Sciences of the Republic of Kazakhstan, Abay Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: aabylkassymova@mail.ru, Orcid: https://orcid.org/0000-0003-1845-7984
b PhD Student in Mathematics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: akarubazhi@bk.ru, Orcid: https://orcid.org/0000-0003-0060-0092
c PhD Student in Mathematics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: dyusov_marat@mail.ru, Orcid: https://orcid.org/0000-0001-9370-5736
d PhD Student in Mathematics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: ardasbayeva@mail.ru, Orcid: https://orcid.org/0000-0001-5364-6364
e PhD in Mathematics, Associate Professor of the Department of Methods of Teaching Mathematics, Physics and Informatics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: lari_6308@mail.ru, Orcid: https://orcid.org/0000-0002-2793-2612
f PhD in Mathematics, Associate Professor, Associate Professor of the Department of Methods of Teaching Mathematics, Physics and Informatics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: t.esen.a@mail.ru, Orcid: https://orcid.org/0000-0002-4682-6778
g PhD in Mathematics, Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, E-mail: khabiba.kenzhebek@mail.ru, Orcid: https://orcid.org/0000-0001-6382-1939
Originality/value: It contributed to the activation of students' activities and their positive motivation for learning activities carried out in the classroom and at home.

Keywords: mathematics, updated content, problem-based learning, problem-search tasks, research skills, development.

Received: 08/05/2023
Accepted: 03/08/2023
DOI: https://doi.org/10.55908/sdgs.v11i4.607

PROBLEMAS MATEMÁTICOS COMO FORMA DE DESENVOLVER AS COMPETÊNCIAS DE INVESTIGAÇÃO DOS ESTUDANTES NO CONTEXTO DA ATUALIZAÇÃO DO CONTEÚDO DO ENSINO ESCOLAR

RESUMO

Objetivo: Os principais objetivos da educação matemática escolar são o desenvolvimento de estudantes intelectuais, a formação de qualidades de pensamento características de atividades matemáticas e a aquisição de conhecimentos matemáticos específicos, as habilidades e habilidades necessárias para a aplicação prática, e a formação de habilidades de pesquisa.

Estrutura Teórica: O problema e a finalidade do estudo é identificar as possibilidades de tarefas de busca de problemas em matemática como uma maneira de os alunos desenvolverem habilidades de pesquisa em situações de conteúdo atualizado.

Método: Um método foi desenvolvido para construir habilidades selecionadas com base no sistema correspondente. Ficou estabelecido que as formas coletivas ou de grupo são mais eficazes na criação de situações problemáticas na sala de aula. Formulários individuais ou em grupo são mais eficazes para testar uma hipótese e encontrar uma solução para uma tarefa problemática.

Resultado e Conclusão: O artigo também destaca os principais blocos de habilidades de pesquisa de alunos e tarefas de busca de problemas em álgebra e geometria desenvolvidas para esses blocos e métodos para a formação dessas habilidades. São determinados os princípios básicos para a construção de um sistema de tarefas focadas na formação de cada bloco e de cada habilidade que escolhemos.

Implicações da pesquisa: A implementação desses objetivos requer a atualização do sistema de educação matemática escolar, que é projetado para garantir uma combinação harmoniosa dos interesses do indivíduo e da sociedade.

Originalidade/valor: contribuiu para a ativação das atividades dos alunos e sua motivação positiva para atividades de aprendizagem realizadas em sala de aula e em casa.

Palavras-chave: matemática, conteúdo atualizado, aprendizagem baseada em problemas, tarefas de pesquisa de problemas, habilidades de pesquisa, desenvolvimento.

1 INTRODUCTION

1.1 RELEVANCE OF THE RESEARCH TOPIC

One of the main ideas for updating the education content is the implementation of a student-centred approach to learning, characterized by an organization of students’
educational activities that focuses on the personality and student self-esteem, takes into account their subjective experience, creates conditions for the activation of the private functions of the education subject and is the basis for personal development. The student-centred learning model corresponds to the level and profile differentiation, which allows for a combination of two standard functions of mathematical education in teaching: learning through mathematics and mathematical education itself.

The changes are primarily associated with a change in views on the role of mathematics in the system of methodological and psychological-pedagogical disciplines in pedagogical universities, namely, with the consideration of the theory and methodology of teaching mathematics as an independent scientific field with its subject, research methods and concepts of teaching mathematics in secondary school (Hussein S. et al., 2022).

One of the essential tasks of the theory and methodology of teaching mathematics has been developing students’ research skills (Mazhukha, 2020).

In general, the task of the study is to identify the problems and tasks of search as a means of developing the research skills of secondary school students when teaching mathematics. A promising way to solve this problem is to create a scientifically based theoretical concept for using the system of problem-search tasks in mathematics at school.

It allowed us to identify several contradictions between:

• the need to develop students’ research skills when teaching mathematics in high school;
• inconsistency of the content, methods and forms of organization of educational activities of students in the process of teaching mathematics, which is due to insufficient elaboration of the problem under consideration.

2 LITERATURE REVIEW

An analysis of the psychological, didactic and methodological literature showed different interpretations of a problem-search task concept, which is considered within the framework of a research task, a cognitive task, a creative task, and a problematic task. We will discuss each of these approaches in more detail.
2.1 RESEARCH TASKS

The main features of the research task: the absence of not only an algorithm but also various kinds of algorithmic prescriptions; non-standard statement of the problem; non-standard search for solutions; the possibility of creating new problems arising as a result of solving this problem; multivariate solutions and answers. It is necessary to put forward several powerful ideas and hypotheses. The search for its solution is not complete without the guesswork and heuristics (Abylkasymova A.E., 2014; Norton & De Costa, 2018; Dobrovolskaya & Kharchenko, 2019).

2.2 COGNITIVE TASKS

The main features of a cognitive task: unknown solution method; the independence of students in obtaining new knowledge or new ways of solving problems; enough complexity to cause difficulties for students; the possibility of independent search for an answer by students; the relationship of the task not only with new but also with previous knowledge of students; an unknown result with known means to achieve it (Jonsson et al., 2022; Damyanov and Tsankov, 2018).

2.3 CREATIVE TASKS

The main features of a creative task: the problem formulated in the problem may not be explicitly defined; the condition of the problem does not contain instructions on what knowledge needs to be applied; the condition of the problem may contain inaccurate or insufficient data; the problem may have two or more solutions; the result of the task is unknown, and the means of achieving it are unknown. (Abylkasymova A.E., 2018; Yustinskaya, 2020; Utemov et al., 2020; Ramankulov et al., 2019).

2.4 PROBLEMATIC TASKS

The main signs of problematic tasks: the task should put the student in a situation in which he should experience surprise and a sense of difficulty; the student intends to overcome this difficulty; the task contains elements that are in conflicting relationships both with each other and with the knowledge available to the student; the task generates a problem situation in the mind of the student; the task requires the discovery (assimilation) of new knowledge; students must independently find ways to solve the problem (Abylkasymova A.E., 2014; Divrik et al., 2020; Gog et al., 2020).
It identified three main types of problem situations, characterized by a different structural place of the unknown in the problem situation (Hofmann & Mercer, 2016): when the unknown coincides with the purpose (subject) of the action; when the unknown coincides with the mode of action; when the unknown coincides with the conditions for acting.

2.5 RESEARCH SKILLS OF SCHOOL CHILDREN

Research activity is a form of creative activity, the product of which is new knowledge, new methods of obtaining new knowledge or new methods of studying an object (Rodríguez-Martín et al., 2020).

Through research activity, we will understand all activities aimed at obtaining new knowledge and carried out without using algorithms and various kinds of algorithmic prescriptions.

The formation of students’ research skills in solving problem-search problems requires the teacher to formulate tasks, determine guidelines for recognizing stable connections and relationships between parts of the objects under consideration, and, when performing tasks, show typical ways of substantiating the formulated sentences, methods of logical construction of mathematical sentences and their possible options (Bakhytkul & Asilkhanovna, 2020).

What is the activity of a teacher? Guruzhapov emphasizes the need to achieve independence for schoolchildren in the performance of research tasks. First of all, in the construction of such tasks that would ensure the creative application of the basic knowledge of schoolchildren (ideas, concepts, methods of cognition) in solving the main tasks of the course available to them, mastering the features of creative activity, and gradually increasing the complexity of the tasks solved by schoolchildren (Guruzhapov, 2018).

2.6 THE ROLE OF PROBLEM-SEARCH TASKS IN THE FORMATION OF RESEARCH SKILLS OF SCHOOLCHILDREN

Any activity is characterized by specific knowledge and skills to perform it and by skills. Psychologists note that to form a skill means to master a complex system of actions (practical and mental) that ensures the perception and processing of information
and its comparison (correlation, selection) with a specific educational situation in which this information should be applied (Popov, 2023).

Tselykh (2019) considers the pedagogical conditions for preparing schoolchildren for research work. The author rightly notes that the low professionalism of a significant part of schoolchildren is explained by the lack of research positions and unformed research skills.

Raatikainen et al., (2022) confirm that students’ learning and research work is used to develop students’ activity, independence, and creativity.

Research activities are carried out independently. Management of such activities is possible but not mandatory. The peculiarity of research activity lies in the fact that various types in the learning process often cease to be such, turning into algorithmic activity.

3 THEORETICAL FRAMEWORK

Our approach to developing students’ abilities is to use a system of problem-solving tasks focused on the purposeful formation of specific research skills necessary for effective teaching and learning mathematics.

The problem and purpose of the study is to identify the possibilities of problem-searching tasks in mathematics as a way for school students to develop research skills in updated content situations. A promising way to solve this problem is to create a scientifically based theoretical concept for using the system of problem-search tasks in mathematics at school (Dwivedi et al., 2023).

4 METHODOLOGY

4.1 RESEARCH METHODOLOGY

The following methods were used in the study: analysis of psychological and pedagogical and scientific and methodological literature, scientific research, programs, textbooks on algebra and geometry for general education schools; questioning teachers and school students; studying and summarizing the experience of school teachers in teaching mathematics to students; analysis of the experience of foreign schools in teaching mathematics; various types of experiments to test the main provisions of the study.
The methodological basis of the study was the main provisions of a systematic approach in the field of theory and methodology of teaching mathematics.

Tables, charts and graphs were used to visualize the experimental data. For statistical evaluation of the results of diagnosing the definition of the legal culture of students, Student’s t-test was used with a one per cent level of significance (p=0.01). To identify differences in the distribution of a feature, we used a non-parametric method with a margin of error of 0.01.

4.2 STAGES AND PROCEDURES OF THE STUDY

The study of the problem has been carried out in three stages:

In the first stage (2019-2020), a study and analysis of the literature on the research topic and a starting experiment were carried out. The main issues to be investigated and verified were identified.

The following research methods were used at this stage: observation of algebra and geometry lessons at school; conversations with students and teachers. The primary attention was focused on finding answers to the following questions: Theoretical questions:

- What skills do students need to be able to practice problem-based learning in mathematics?
- What skills do students need to solve a problem situation?
- What skills do students need to be able to solve problem-search problems?

Practical questions:

- How do these research skills develop in schoolchildren?

Firstly, the survey’s primary purpose is to establish how much students understand the essence of the problem, problem-search task, problem situation, and problem-based learning. Secondly, to identify their main difficulties in using these concepts in mathematics classes.

In the second stage (2020-2021), requirements for the system of problem-search tasks were developed, a search experiment was conducted to test specific provisions, and an updated program in algebra and geometry for schoolchildren was tested.

The specific objectives of the experiment were:

- Approbation of problem-search tasks in the lessons of algebra and geometry;
In the experimental groups, schoolchildren performed the same diagnostic tests before and at the end of the experiment.

For all these works, for each task, the same evaluation criteria were applied: completed completely and correctly; performed partially and correctly; not performed at all and performed incorrectly.

In the third stage (2021-2022), a training experiment was conducted, the study results were analyzed, and conclusions were formulated. Seventy students of secondary schools attended it.

The experiment was educational. Its main goal was the comprehensive implementation of the methodology for the formation of research skills for schoolchildren based on a built-in system of problem-search tasks that meets certain principles.

5 RESULTS AND DISCUSSION

5.1 RESEARCH SKILLS OF SCHOOLCHILDREN NECESSARY FOR PROBLEM-BASED TEACHING OF MATHEMATICS

Since problem-oriented learning means a system of problem situations that a teacher specially creates in a lesson with the help of an appropriate system of problem-search tasks, this reveals the need to single out separate blocks of students’ primary research skills within the framework of problem-based learning. Let us focus on each skill block.

The first block of skills refers to “problem situation”. Here you can choose the following skills.

1. Skills related to the analysis of a problem situation:
   a. determine the purpose of creating this problem situation in the lesson (why, for what?);
   b. identify the leading causes of this situation (why, how?);
   c. identify ways to resolve this problematic situation with students in the class (how?).

2. Skills related to the construction of problem situations:
   a. highlight the topics (questions) of the school mathematics course, in the study of which it is advisable to create a problem situation in the lesson;
   b. identify ways to create a problem situation using the proposed task.
3. Skills related to the organization of educational and research activities of students to resolve problem situations:
   a. choose a method (heuristic, research) and put it into practice;
   b. choose the form of learning activity for students (collective, group and individual) and put it into practice.

   The **second block** of skills relates to “problem-search tasks”.

4. Skills related to the problem-search task:
   a. transform the learning task into a problem-search task (how?);
   b. determine the place of a specific (practical, historical, etc.) task in the educational process in order to create a problem situation for students (where, at what stage of the lesson, when studying what topic?).

   The **third block** of skills is related to the problem lesson of mathematics.

5. Skills related to the hard lesson:
   a. justify the answer with a solution to the problem situation;
   b. choose an effective method for solving the problem-search problem;
   c. find similar problematic tasks.

   Thus, in this section, we have identified the research skills that underlie the student’s activity in problem-based teaching of mathematics.
Figure 1. The system of problem-search tasks for students and its implementation in the mathematics school course

5.1.1 First block of tasks

When solving various problems of algebra, we adhere to the following algorithm:

- statement of the problem;
- division of the task into component (elementary) subtasks;
- comparison of the studied task concerning other tasks;
- drawing up a mathematical model and research plan;
- plotting the functional dependence of variables;
- solution of the problem according to the algorithm.

This algorithm should be constantly implemented in the process of meaningful and didactic work on a mathematical problem, which is impossible without its study.

When studying algebra in grades 7-9, students develop the ability to study the behaviour of a function on the set of its definition according to its schedule and analytically (monotonicity, intervals of sign constancy, periodicity, symmetry of the function graph, maxima and minima of the function). For example,

1) “Plot a graph of the function if you know that the line is its axis of symmetry. Using the constructed graph, find at what values of the variable x the function takes: a) positive values; b) negative values; c) the largest or smallest value (if possible); d) indicate the intervals of monotonicity of the function.

2) Construct a graph of the function if it is known that its smallest value is - 4. Using the constructed graph, find at what values of the variable the function takes: a) positive values; b) negative values; c) find the axis of symmetry of the graph of the function; d) indicate the intervals of monotonicity of the function.

When performing similar problem-search tasks, students develop the ability to conduct simple research using existing mathematical knowledge.

Among the geometric research tasks aimed at developing the research skills of students, the following types of tasks can be distinguished: tasks for detecting a property (feature) of an object; establishing a pattern; tasks for using the method of mathematical modelling; search for an object with specified properties; tasks to justify the existence or impossibility of the existence of an object that satisfies certain conditions; substantiation or refutation of some mathematical statement; description of the spectrum of variations of the phenomenon depending on the conditions.

Let us turn to the design of problem situations in geometry lessons.
Task 1. In an equilateral triangle, a height is drawn. What are the properties of the resulting triangles?
Task 2. Is there any relationship between the values of the angles and the lengths of the two sides of the triangle?
Task 3. The sum of the interior angles of a triangle is 180°. Is the sum of the interior angles of a quadrilateral equal to 180°? Hexagon?
Task 4. The middle line of the triangle is parallel to the base. Does the midline of a trapezoid have the same property? Parallelogram? Quadrilateral?
Task 5. In a triangle, the bisectors intersect at one point. Can the same be said about the bisectors of the angles of a quadrilateral?
Task 6. Is it possible to apply the trapezoid area formula to calculate the area of a parallelogram? Rectangle? Rhombus? Square?

Note: These tasks can be offered to students as a test or differentiated homework.

5.1.2 Second block of tasks
Solve the given problems. Determine the problem level of tasks (1)-(3).
Task 1. One of the adjacent angles is 60° or two times larger than the other. Look at those corners. Is there any additional data in the task? Create a task without unnecessary data (various options are possible). Solve it.
Task 2. One of the adjacent angles is 60° or three times larger than the other. Look at those corners. Is there any additional data in the task? Do they contradict each other? Create a task that does not have these disadvantages (various options are possible). Solve it.
Task 3. One of the adjacent angles is larger by a certain amount than the other. Look at those corners. Is there enough data to solve the problem? Add some data to the problem statement and solve it.

Note: These tasks can be offered to students as a test or as differentiated home tasks.

5.1.3 Third block of tasks
a. Problem-related tasks.
Following the previously identified blocks of skills, we will single out the following components in the structure of this system:
I. Tasks aimed at developing students’ research skills related to the “problem situation” concept.

II. Tasks aimed at forming research skills of students associated with the concept of “problem-search tasks”.

III. Tasks aimed at forming students’ research skills related to the solution of these tasks during a problem lesson in mathematics.

b. Efficiency of implementation of the methodology developed by us

The experiment was educational. Its main goal was to implement the methodology for forming research skills for schoolchildren based on a built-in system of problem-search tasks that meets certain principles.

When choosing the criteria for training effectiveness, we proceeded from the intended purpose of the system of problem-search tasks. It consisted not only in the full development of each student’s personality but also in overcoming weaknesses (shortcomings) in the organization of educational and research activities of students and classes in mathematics, organization of homework, and the formation of specific research skills for students.

The concrete expression of the successful implementation of the proposed methodology for the formation of students’ research skills was the following indicators characterizing the readiness of students for mathematics:

1) students’ understanding of the essence of problem-based learning, a problem situation, a problem-search task;

2) the formation level of students’ skills in applying the methodology we developed.

The methodology implementation effectiveness developed by us was assessed by the completeness and awareness of students’ knowledge.

The measure for determining the amount of student knowledge in the study was the standard of knowledge, which reflects the issue’s content. The volume of knowledge and skills of schoolchildren revealed during the experiment characterizes the volume of knowledge formed by schoolchildren.

The results of the knowledge gained by the students were established by analyzing the tests performed individually. The measure of revealing the formation of the research skills of schoolchildren was - the amount of time allocated for the performance of the
control work and the quality of its performance: entirely and correctly; partially and correctly; wrong and not done.

To assess the level of formation of students’ skills, following the selected criteria, we identified:

1. Low level (possession of a different skill). This action is performed intuitively without relying on special knowledge. It is characterized by the lack of the ability to perform a specific action that is part of this skill.

2. The action characterizes the average level as not entirely performed or is not sufficiently justified.

3. A high level of possession of a particular skill. It is characterized by students’ awareness of the action being performed and skillfully operating with special knowledge.

The students were offered a questionnaire at the beginning and after the training experiment.

Table 1. Survey results at the beginning and after the experiment (Fig. 2).

<table>
<thead>
<tr>
<th>Formability Levels</th>
<th>At the beginning of the experiment</th>
<th>After the experiment</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Number of students</td>
<td>%</td>
</tr>
<tr>
<td>Low level</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>Average level</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>High level</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>


Figure 2. Survey results at the beginning were identical to the results of the first experiment stage

At the end of the experiment, the results were completely different. 82% of schoolchildren fully and correctly answered the theoretical questions of the questionnaire. 68% of schoolchildren responded positively to the question about their readiness to solve problematic tasks. However, along with theoretical training, the students lacked practical skills.

When organizing problem-oriented learning, students face the following difficulties: insufficient preparation of students for the perception of educational material in a problem-oriented presentation and lack of study time for solving problems of a problem-oriented nature.

The results of the control work indicate that the majority of schoolchildren have mastered a high level of formed individual skills included in research activities. Based on this, we can conclude that most of the participants in the experiment have mastered the general ability to perform research activities.

The analysis of tests and questionnaires allowed us to conclude that the training developed according to our methodology gives better results than the conventional method. After the learning experiment, most students began to understand the essence of problem-based learning, its elements and the essence of the task of solving problems. The experiment showed that students’ lessons in algebra and geometry became diverse in content due to the solution of various mathematical problems. It contributed to the activation of students’ activities and their positive motivation for learning activities carried out in the classroom and at home.

5.2 DISCUSSIONS

M. Rodionov notes the need to introduce a new type of education - problem-based. The author considers the statement of the problem to be one of the essential regularities in the assimilation of new knowledge. Without this initial stage of assimilation of the problem, the process of creative thinking does not begin. However, the method of this regularity lies in the fact that the assimilation of the problem develops the student’s thinking not because the teacher poses a problem but because the student solves it themselves (Rodionov et al., 2017). The author believes that in school practice, problem-based learning sometimes comes down to random posing of questions, the answers to which cause difficulties for students. However, traditional teaching does not exclude the consideration of such issues. The organization of problem-based learning implies a
qualitatively different interaction between the teacher and students and the specific construction of educational material. The latter is based on identifying the leading ideas of the course, their development and the role of the “human factor” in this process. The most crucial point of interaction between the teacher and students is the independent acquisition of knowledge, organized and led by the teacher. Students’ cognition is carried out as an academic, educational activity study.

J. Sitorus considers the three stages of the creative process from a general philosophical point of view since they are the basis of any creative activity. The first stage of creative activity is the stage of awareness, formation and formulation of the problem. The second stage is the stage of fundamental problem solving, during which the “key” to solving the problem must be found. The third stage is implementing a fundamental solution to the problem (Sitorus & Masrayati, 2016). The author considers the stages of creative activity, which are very similar to the stages of problem-based learning, so we conclude that the author considers problem-based learning as a kind of developmental learning.

The study of psychological, pedagogical and educational literature made it possible to state that the traditional teaching of mathematics in secondary schools is not entirely focused on the formation of students’ research skills since, in educational and methodological complexes for teachers and students, little attention is paid to the application and solution of problem-search problems in the lessons of algebra and geometry.

6 CONCLUSION

In the course of solving the tasks set, the following results and conclusions were obtained: The main blocks of students’ research skills necessary for the implementation of problem-based teaching of mathematics to students of a public education school are identified and substantiated. It is shown that the system of problem-search tasks is a means of forming these skills. The basic principles for constructing a system of tasks focused on the formation of each block and each skill that we have chosen are determined. A system of problem-search tasks in mathematics for schoolchildren has been developed. A method for forming selected skills based on the corresponding system of problem-search tasks in mathematics has been developed. It has been experimentally confirmed
that the proposed method improves the preparation of schoolchildren in mathematics. Thus, we can assume that all the tasks posed in the article have been solved.

ACKNOWLEDGEMENTS

We thank the mathematics teachers of secondary schools who provided support and assistance, based on which the search and experimental work have been carried out.
REFERENCES


Damyanov, I., & Tsankov, N. (2018). The role of infographics for the development of skills for cognitive modeling in education. International Journal of Emerging Technologies in Learning (Ijet), 13(01), 82. https://doi.org/10.3991/ijet.v13i01.7541


Rodríguez-Martín, Manuel, Diego Vergara, and Pablo Rodríguez-Gonzálvez. (2020) “Simulation of a Real Call for Research Projects as Activity to Acquire Research Skills: Perception Analysis of Teacher Candidates” Sustainability 12, no. 18: 7431. https://doi.org/10.3390/su12187431


