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Solving Math Problems through the Principles of Scientific Creativity

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Abstract

Ongoing changes in mental and personal characteristics of the modern child initiate the updating of means and forms of education. And they, in their turn, update methodological techniques and approaches to the use of methods during the math class. The source of updating methodological techniques may be the principles used when solving scientific problems. Scientific creativity traditionally systematizes knowledge and skills for their use to a wide range of sciences. Therefore, the principles of scientific creativity have a lot in common with different subjects, showing the student the unity of approaches in working with knowledge. In this regard, the article is aimed at substantiating the principles of scientific creativity as effective methodological techniques for finding solutions to math problems and, on their basis, developing recommendations for conducting classes that prepare for final certification at school in mathematics. The leading research methods in this case are: observation of the methodological work of teachers of mathematics, conversations with teachers, analysis of guidance papers and questionnaires of teachers, statistical processing of research results. In 2018-2019 the experiment in which 19 mathematics teachers took part was conducted. Based on its results the authors of the article succeeded in: highlighting the principles of finding solutions to math problems based on the approaches used in scientific creativity; developing and implementing on the basis of these principles recommendations for conducting classes that prepare for final certification at school in mathematics. The effectiveness of using the principles of finding solutions to math problems was assessed. It allowed the authors to conclude that students have an increase in the speed of finding solutions to math problems by an average of 11%. Practical use of the proposed principles makes it possible to organize training for schoolchildren in solving math problems in traditional forms of teaching, but taking into account the particularities of the development of the modern schoolchild. Methodological recommendations developed by the authors can be used to teach students how to find solutions to math problems during classes that prepare for final certification at school in mathematics.

Keywords: methods of teaching mathematics, math problems, scientific creativity, search for problem solving, creative tasks

INTRODUCTION

The age-psychological characteristics of students are formed under the influence of internal and external environmental factors. They are the most discussed issue in the psychological and pedagogical literature. Ongoing changes in the mental and personal characteristics of the modern child affect the updating of school teachers' work models. The methodology of teaching school subjects corresponds to the peculiarities of perception and the logic of mastering knowledge by the modern child. In the organization of the cognitive activity of the modern child a special place is occupied by the development and use of creative abilities of the individual. The school subject helps this by creating an educational environment for the development of its

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Contribution to the literature

- In this study the principles of scientific creativity are highlighted, they allow to teach students how to find solutions to math problems: pre-action, continuity of control, pre-padded pillow, continuous action, completeness, and dynamism. The principles of teaching the search for math problem solving make it possible to compensate for the tendency towards reduction of the level of development of divergent thinking (creativity) among schoolchildren.
- The formed learning tasks based on the principles of scientific creativity allow mathematics teachers to use them in the classroom. Practical use of the proposed principles makes it possible to organize training for schoolchildren in solving math problems in traditional forms of teaching, but taking into account the peculiarities of development of the modern schoolchild.
- The methodological recommendations developed by the authors are unique in their contribution to existing studies in terms of illustrating the relationship between methods of scientific creativity and methodological techniques of the school teacher. The recommendations describe the set of principles of scientific creativity used at the level of methodological techniques, give examples and tips for their use, a set of math problems for independent work.

creative potential and the satisfaction of its needs for creative self-realization. We note that the average school age is a sensitive period for the development of creative abilities of the person. In this age period, creative skills are formed. Basically, the child's cognitive and intellectual spheres develop more actively (Cherdymova et al., 2018). Adolescents are characterized by cognitive activity, the emergence of new learning motives and an increase in knowledge. The indicated characteristics give the greatest effect when students are involved in scientific work. It traditionally systematizes knowledge and skills for their application to a wide range of sciences. Therefore, the principles of scientific creativity have a lot in common with different subjects. They demonstrate the student the unity of approaches when working with knowledge and allow systematizing them. The development of principles of scientific creativity in schoolchildren makes it possible to compensate for the existing tendency towards reduction of the level of development of divergent thinking (creativity) (Feldstein, 2010).

The indicated factors and characteristics lead to the increasing complexity of the work of the mathematics teacher. It should be noted that today modern approaches to updating the means and forms of teaching during school classes are being actively introduced. This conclusion can be made on the basis of observations of the organizational activities of mathematics teachers and conversations with them. At the same time, insufficient attention is paid to the consideration of didactic methods and techniques used by the teacher during classes. Updating methodological techniques and their application during mathematics classes allows using the accumulated educational and methodological potential in traditional forms of teaching, taking into account the characteristics of the development of the modern student. This requires reconsideration and updating of methodological techniques.

When considering the means by which students learn the concepts and methods of school mathematics, it is impossible to overestimate the educational task. It acts as the main didactic tool. The student is given most of the time during the class and when organizing independent work on the subject to solve problems. Therefore, the most systematically used methodological techniques can be considered when organizing collaborative activities of the student and the teacher during problem solving. In this process, it is especially difficult for the student to find the solution to the math problem. It was and remains the most "mysterious" stage for the student, although it is the search for the solution that provides the student with the opportunity to realize creative skills. In this regard, methodological techniques used at the stage of training to find the solution to the problem should create conditions for realization of creative potential. At the same time, they must take into account the age-psychological characteristics of students, including developing cognitive and intellectual spheres of the child.

The proposed approach to updating methodological techniques is to use the principles of scientific creativity in teaching to find solutions to math problems. For this study the following principles of scientific creativity can be distinguished: pre-action, continuity of control, pre-padded pillow, continuous action, completeness, and dynamism. They allow teaching how to find solutions to math problems.

Thus, changes in the psyche and personality of the modern child affect the updating of the models of the school teacher work. The methodology of teaching school subjects corresponds to the peculiarities of perception and the logic of mastering knowledge by the modern child. Middle school age is a sensitive period for the development of creative abilities of the person. Mastering the principles of scientific creativity by students allows organizing the realization of the child's creative potential in teaching mathematics. Therefore, the proposed approach to updating methodological techniques is to use the principles of scientific creativity when teaching to search solutions to math problems.

LITERATURE REVIEW

Researches in the scientific pedagogical, psychological and methodological literature on the issue of considering the principles of scientific creativity as effective methodological techniques for teaching how to find solutions to math problems are quite fragmented.

In the works of B. Bloom (1984), there is a phenomenon known as two-sigma (two curves of the normal distribution of student results), which consists in the fact that an ordinary student, trained individually according to an individual program, shows results 98% higher control group trained by standard methods. Individual learning is widely understood. For individualization one can consider learning objectives, educational approaches, didactic tools, teaching methods, and educational content. Any parameters may affect the student's learning effectiveness (Reimagining the Role of Technology in Education, 2017). In the works of B. Spitzer and J. Aronson (2015), it is noted that the effectiveness of teaching in class is also associated with the development of the student's personality and, for example, affects motivation and educational interest. Educational interest is a factor of reducing inequality in the level of education of students in class, including when working with the class where there are students with different levels of mathematical background. Didactic tools and methodological techniques are more effective when they take into account the personality of the student (Dover, Manwani & Munn, 2018; Durkin, Star & Rittle-Johnson, 2017). Most researchers are inclined to believe that using a system of didactic tools even for complex tasks can be effective (Payne et al., 2009; Akpinar, 2012).

Considering teaching methods in class, it is worth noting that practical problems and well-developed examples are well-known methodological techniques (Khairullina et al., 2019). Studies in mathematics and physics show that if students analyze examples instead of solving practical problems when studying new material, it may be useful for their subsequent work. Studies of examples require less cognitive load in comparison with decision making (Brisbin & Maranhao do Nascimento, 2019).

The issue of training problem solving is also investigated. Creative solutions are solutions that go beyond a set of well-known solutions. Traditionally, creativity is associated with the concepts of productivity and adaptability of the individual person, group, and organization, influenced by various factors. E.L. Santanen, R.O. Briggs, and G. De Vried (2003) in their studies evaluate the impact of a variety of incentives on the developing creative solutions. Scientists substantiate the cognitive network model of creativity, which offers a cognitive explanation of the mechanisms that cause creative decisions in the human mind.

Questions of creativity and creative problem solving are of interest to scientists from different fields of scientific knowledge. D.K. Allen and J.D. Young (2020) offer a kind of a multi-stage model of assessment and selection in the process of forming a complex creative solution to problems in the field of biotechnology. R. Galvin (2020) explores processes of finding a creative solution in the development of a technical product. The scientist evaluates the effect of communication elements and cognitive effects on the creative process. J. Lehmann and B. Gaskins (2019) study scientific creativity through the prism of artistic practice, emphasize the transformative function of creativity. Creativity is seen as an act of transformation that occupies the central place in the scientific activity.

The study of questions of problem solving when teaching can be singled out as a separate area of the research.

N.V. Hernandez and E. Freudenthal (2010), when analyzing methodological techniques on the example of engineering and mathematical education, note that in most cases traditional methods are used in teaching students, including remembering rules, solving controlled problems, following logical methods and patterns. The authors substantiate the need for creative involvement of students, which contributes to the development of inventiveness, analytical thinking, and increases internal educational motivation.

T.S. Mamontova (2020) notes that in accordance with the school educational standard the development of creativity is one of the main tasks of school education. In this regard, there is a need to revise the traditional methodology of teaching school subjects, taking into account the personal characteristics of the development of students. In her research, the scientist proves that the systematic use of tasks that require from students non-standard approaches to solving, imagination, imagination, divergent thinking helps to develop students' creativity. The reverse process is also noted: the use of assignments that require from students non-standard approaches to solving affects academic success in mathematics (Bishara, 2016).

Creative thinking is an integral element of mathematical education and contributes to the choice of optimal methods and means by which a previously unknown problem will be solved most productively. The process of finding a solution to a problem with the help of the creative approach is always unique, as it is based on individual abilities, inclinations and capabilities of the student, on his/her wealth of knowledge and personal experience (Kosheleva & Pavlova, 2017; Razuvayeva, 2014). N.A. Demchenkova and N.V. Razuvaeva (2014) substantiate the need to use heuristic methods when teaching mathematics to secondary school students. At the same time, the heuristic method is understood as a transforming action, the application of which allows one to find the main idea for solving a problem and reduce its solution to the use of already known algorithms (Mugallimova, 2006).

I. Setyana, T.A. Kusmayadi and I. Pramudya (2019) note that problem solving plays an important role in mathematics, which consists in understanding difficulties which students face in the formation of mathematical skills. This study showed how solving mathematical problems based on cognitive style affects the process of creative thinking. In general, the contextual learning strategy significantly affects conceptual understanding and ability to solve problems in mathematical subjects (Kalloo, Mohan & Kinshuk, 2017). It can be said about the impact of academic success in mathematics on the attitude to solving problems in mathematics (Mohd & Tengku Mahmood, 2011). V.V. Utyomov, A.R. Masalimova describe the method for modeling creative mathematical problems taking into account the difficulty levels of tasks in accordance with the system scale and requirements for setting tasks in primary school (Utemov & Masalimova, 2017).

C. Shen, D.B. Miele and M. Vasilyeva (2016) studied the relationship between academic thinking of college students and their insistence in solving complex mathematical problems. The research results showed that for certain types of mathematical problems, students' insistence can vary depending on academic thinking and previous experience of mathematical success or failure (Shen, Miele & Vasilyeva, 2016).

Thus, we can note the scientific interest in considering effective methodological techniques for finding solutions to math problems and for using scientific creativity methods for these purposes. However, the sources known to the authors describe the disparate results of using methods of scientific creativity or the description comes down to their use as methodological techniques used at school mathematics classes. At the same time, the principles of scientific creativity as methodological techniques can be used by mathematics teachers when teaching schoolchildren to solve math problems using traditional forms of teaching, taking into account the peculiarities of development of the modern schoolchild.

MATERIALS AND METHODS

Theoretical Basis of the Study

The theoretical basis of the study is the theoretical foundations of the principles of scientific creativity and their implementation in mathematics classes as effective methodological techniques of teaching how to find solutions to problems. In the educational literature the term "methodological technique" does not have one specific definition. A methodical technique is a multidimensional concept. This is a certain system of interconnected sequential actions of the teacher and the student, thanks to which the learning content is acquired. We can assume that the methodological technique in the mathematics class is the actions of the mathematics teacher aimed at creating conditions for students to solve a specific problem within the framework of the chosen methodological techniques.

When considering the question of training to find solutions to math problems, the methodological technique can be principles that allow the student to concentrate on the direction of the search for the solution to the problem. In the methodology of scientific knowledge, problems and scientific hypotheses, which after testing lead to the formation of scientific principles, are considered. The principles of knowledge are fundamental concepts that allow interpreting the content of laws and ideas. In this context the principles of scientific creativity can be considered as concepts that allow interpreting the content of laws and ideas inherent to creativity. Mastering the principles of scientific creativity is necessary for gaining creative thinking, for the formation of the person who has developed creative potential.

Thus, the use of principles of scientific creativity by the mathematics teacher in class to increase the effectiveness of learning can be considered as the teacher's use of methodological techniques, and the principles themselves can act as methodical techniques used during the mathematics class in combination with different teaching methods. As a result, the principles of scientific creativity update the existing system of methodological techniques for teaching mathematics.

In this study we dwell on the following six principles of scientific creativity, which allow teaching to find solutions to math problems:

- pre-action;
- continuity of control;
- pre-padded pillow;
- continuous action;
- completeness;
- dynamism.

These principles of teaching to search for solutions to math problems allow demonstrating to students the unity of approaches when working with knowledge in different subject areas.

Research Methods

To highlight the principles of scientific creativity that contribute to the effectiveness of training in finding solutions to math problems we used the following methods: observation of the methodological work of teachers of mathematics, conversations with teachers, analysis of guidance papers and questionnaires of teachers, statistical processing of the results of the pedagogical experiment.

Experimental Base of the Research

Testing, generalization and implementation of the research results were carried out on the basis of two comprehensive schools in the European part of Russia - innovative sites supervised by Vyatka State University, where the experimental study was carried out to assess the effectiveness of using the principles of scientific creativity during maths classes (2018-2019):

- by conducting experimental teaching of mathematics in 10-11 grades of secondary school by 19 teachers of mathematics using the chosen principles of scientific creativity: recommendations for conducting mathematics classes and preparing for final certification at school in mathematics (more than 370 students);

- by discussing methodological techniques at didactic seminars with mathematics teachers as a part of summing up the annual results of the work of innovative sites (50-60 participants);

- by discussing methodological techniques at didactic seminars with mathematics teachers as a part of summing up the annual results of the work of the innovative sites (50-60 participants);

- in the form of reports and speeches at scientific and methodological conferences of various levels, including international; publications in collections of scientific articles.

Research Stages

The research is carried out in four stages.

At the first stage, the state of the studied problem was revealed in the theory and practice of teaching schoolchildren mathematics in the secondary school. For this, the study and analysis of psychological, pedagogical and methodological literature on the problem was carried out (not only in mathematics, but also in related school disciplines); observation, discussions and analysis of the experience of mathematics teachers, methodologists in order to study the used methodological techniques when teaching how to search for solutions to math problems.

At the second stage, leading approaches to highlight the principles of finding solutions to math problems based on the approaches used in scientific creativity were developed; differentiation of the principles of scientific creativity was carried out. The results of the generalization were discussed during reports at conferences and seminars at various levels on the methodology of teaching mathematics.

Simultaneously with the second stage, the third stage is implemented, during which the experiment was carried out, in which 19 mathematics teachers from two schools of the European part of Russia were involved, the schools are innovative sites supervised by Vyatka State University. The teachers were invited to use the principles of scientific creativity during their classes. After it the survey was conducted and the results were analyzed.

At the fourth stage the generalization of experience and the assessment of the effectiveness of using the principles of scientific creativity when searching for solutions to math problems were carried out. The principles of scientific creativity are described as methodological techniques for their use by mathematics teachers based on the results of their phased implementation in the teaching practice of studying school mathematics.

RESULTS

As a result of summarizing the methodological techniques used by 19 mathematics teachers in teaching how to find solutions to problems, and conversations with these teachers, we applied six principles of scientific creativity: pre-action, continuity of control, pre-padded pillow, continuous action, completeness, and dynamism. We present each of them further.

The Principle of Pre-Action

After the first reading of the conditions of the problem, it is not worth immediately using the familiar method of solving the problem. If a pattern is seen, then the amount of further actions when solving the problem can be reduced. So, for example, it is possible to clarify the definition, the form of presentation of the result of solving the problem, etc. The obtained information can reduce the uncertainty arising when solving the problem, or suggest new ways to solve it.

The formulation of the principle: to analyze the problem preliminary so that it helps in solving the problem without unnecessary time costs or directing to the most effective solution.

Example № 1

Solve the equation: $\sqrt{\frac{2-x}{x-1}} - 7\sqrt{\frac{x-1}{2-x}} = 6.$

The solution

Let’s not hurry to square both sides of the equation, but make a replacement.

Let $\sqrt{\frac{2-x}{x-1}} = t$ then

$$t - \frac{7}{t} = 6, t > 0 \Leftrightarrow \begin{cases} t > 0 \\ t^2 - 6t - 7 = 0 \end{cases} \Leftrightarrow \begin{cases} t > 0 \\ \left[\begin{array}{l} t = -1, \\ t = 7 \end{array} \right. \end{cases} \Leftrightarrow t = 7.$$

Thus,

$$\sqrt{\frac{2-x}{x-1}} = 7 \Leftrightarrow \frac{2-x}{x-1} = 49 \Leftrightarrow \begin{cases} x \neq 1, \\ 2 - x = 49(x-1) \end{cases} \Leftrightarrow x = \frac{51}{50}.$$

The answer: $\left\{\frac{51}{50}\right\}$.

The Principle of Continuity of Control

When searching for a solution to a problem, a solution that is similar in content to the problem from the past experience is automatically chosen. But if there are small changes in the content of the problem, then an automatical solution can lead us to the wrong solution, giving the opportunity to make a number of mistakes. These mistakes can be made at a subconscious level, and to find them is difficult. Therefore, self-control of each step of the solution and control of the resulting solution at the end are necessary.

The formulation of the principle: when solving a problem, carry out work on checking correctness continuously, including at the end of the solution.

Example № 2

Solve the equation: $\left(2\sin x+\sqrt{3}\right)\cdot\sqrt{\cos x}=0$.

The solution

We use the principle of continuity of control and indicate that the left side of the equation makes sense when $\cos x\geq 0$.

So

If $\cos x=0$, then $x=\frac{\pi}{2}+\pi k, k\in\mathbb{Z}$.

If $\cos x>0$, then $2\sin x+\sqrt{3}=0$, next $\sin x=-\frac{\sqrt{3}}{2}$, from which $x=-\frac{\pi}{3}+2\pi k, k\in\mathbb{Z}$.

The answer: $\left\{\frac{\pi}{2}+\pi k, -\frac{\pi}{3}+2\pi k: k\in\mathbb{Z}\right\}$.

The Principle of Pre-Padded Pillow

When solving this problem, the person who solves it sometimes puts forward proposals, the validity of which he/she subsequently checks. The more assumptions he/she has to make, the more time consuming it becomes to find the solution to the problem. Therefore, it is important to refute the assumption before verifying the false assumption.

The formulation of the principle: if, when solving a problem, it will be necessary to take an action, some preparatory measures must be taken before it is completed.

Example № 3

Three different natural numbers are the lengths of the sides of the obtuse triangle. Can the ratio of the larger of these numbers to the smaller of them be equal $\frac{8}{7}$?

The solution

The principle advises us to take preparatory measures before searching for the solution. We define that the triangle is obtuse, then the sum of the squares of the lengths of its smaller sides is less than the square of the larger side. We get that if the big side is $8x$, and the smaller side is$7x$, then the average side is at least $7x$, but $(7x)^2+(7x)^2>(8x)^2$. So, the answer: cannot.

The Principle of Continuous Action

When solving problems, we resort to the signals that are used for further conclusions. If our signal was initially false, then subsequent conclusions can give false judgments. So, unreasonable judgments are not used when solving problems, and the course of solving is built continuously on the basis of logically sound transitions.

The formulation of the principle: when solving a problem, a continuous logical sequence of sound judgments is built.

Example № 4

Two players take turns. Before the start of the game, they have two peas. The move consists in passing to the opponent any natural number of peas. It is not allowed to pass such a quantity of peas that someone has already transferred in this game. Anyone who cannot make the next move according to the rules is considered a loser. Who will win this game: a beginner or his/her opponent no matter how the partner plays?

The solution

We use the principle and construct a chain of logically sound judgments.

The first player will either give the second two peas (the second will give him one, and the first will have no moves), or he/she will give one. In this case, the second player can give him/her two peas, get three back, give four and win. One way or another, the second player wins.

The Principle of Completeness

When searching for a solution to a problem, one must be sure that all possible cases of a solution are considered. To do this, you need to correctly determine the basis for choosing alternatives to the solution or check their absence.

The formulation of the principle: when solving a problem, it is necessary to check all possible solution alternatives.

Example № 5

Solve the inequality: $(x^2-3.6x+3.24)(x-1.5)\leq 0$.

The solution

We reconstruct the expression and, making sure that all the alternatives are considered, we write down the solution:

$$(x-1.8)^2(x-1.5)\leq 0\Leftrightarrow\left[\begin{array}{l}x=1.8,\\ x\leq 1.5.\end{array}\right.$$

The answer: $(-\infty;1.5]\cup\{1,8\}$.

The Principle of Dynamism

When searching for a solution to a problem after comprehending the proposed condition, we consider the approach within which we can find a solution to this problem. The approach itself has its own constituent

Table 1. The results of the reflective questioning teacher survey

Types of proposed probplems	The average assessment of the time spent by the student on the search for solutions to math problems, according to the teacher, in minutes without using the principles of scientific creativity	The average assessment of the time spent by the student on the search for solutions to math problems, according to the teacher, in minutes when using the principles of scientific creativity
Equations	4	3.1
The stereometric problem	8.7	8
Inequalities	5.1	4.3
The planimetric problem	7.9	7.5
Financial maths	5.9	5.1
Average values	6.32	5.6

elements and solution methods. After the methods used in theory, are applied to solve this problem. This transition from the problem to the approach and back to the problem can be multiple.

The formulation of the principle: when solving a problem, the approach and the methods used to solve it must be selected so as to be optimal at each stage of solving this problem.

Example № 6

45 people enter the 1st grades: 20 boys and 25 girls. They were divided into two classes: in the first class there should be 22 people, and in the second - 23. After distribution, the percentage of girls in each class was calculated and the numbers obtained were added up. What should be the distribution of classes so that the amount received is the largest?

The solution

Instead of the total percentage, we choose the following approach to the solution: we will consider the total percentage of girls. In this approach, the numbers differ 100 times and reach their maximum simultaneously. Each girl in the class of 22 people makes up $\frac{1}{22}$ the total number of students in this class, and in the class of 23 people -$\frac{1}{23}$ of the total number of students. So, if you swap a girl from the larger class and a boy from the smaller one, the total percentage of girls will increase. Thus, the maximum is achieved when all such rearrangements are made, that is, when the smaller class consists entirely of girls, and in the larger class there are 3 girls and 20 boys

Thus, the considered methodological techniques, built on the principles of scientific creativity, can be used by mathematics teachers in teaching the search for solutions to problems.

Reflexive Analysis of the use of Boxed Training Solutions

In order to assess the effectiveness of using the principles of scientific creativity as methodological techniques for teaching how to find solutions to math problems, in 2018-2019, 19 maths teachers of 10-11 grades of two comprehensive schools in the European part of Russia were involved - the schools are innovative sites supervised by Vyatka State University. Teachers were invited to use the proposed principles of scientific creativity during their classes. Later a questionnaire was proposed for self-esteem. The teachers answered the reflexive question: “Estimate in minutes the average time spent on finding solutions to math problems by a student without using the proposed principles of scientific creativity and when using these principles.” The summarized results in minutes are presented in Table 1.

It should be noted that the results of the analysis of teachers’ answers show a decrease of 11% in time spent by students when searching for solutions to math problems. Additionally, the hypothesis about the equality of universe means according to Student’s t-test. The calculations showed that the experimental value of the criterion T fell into the critical region T ≥ tkp; therefore, the universe means of the two samples are not equal. Thus, it can be argued that the use of the principles of scientific creativity is effective in teaching to search for solutions to math problems.

DISCUSSIONS

In the course of the study, the principles of finding solutions to math problems based on the approaches used in scientific creativity are highlighted: preliminary action, continuity of control, pre-padded pillow, continuous action, completeness, dynamism. The description of the principles of scientific creativity as methodological techniques allows their use by mathematics teachers. Practical application of the proposed principles makes it possible to organize training of schoolchildren in solving math problems in traditional forms of teaching, but taking into account the peculiarities of development of the modern schoolchild.

Experimental teaching mathematics was carried out in 10-11 grades of the secondary school by 19 teachers of mathematics using the chosen principles of scientific creativity. Methodological instructions for giving mathematics classes using the principles of scientific creativity were used.

The assessment of the effectiveness of using the principles of searching for solutions to math problems on the basis of two comprehensive schools in the European part of Russia was made - the schools are innovative sites supervised by Vyatka State University.

The results of the analysis of the questionnaire of teachers show an increase in students' speed of finding solutions to math problems by an average of 11%.

This approach made it possible to update the methodological techniques used during the mathematics class. They allow using the accumulated educational and methodological potential in traditional forms of education, taking into account the characteristics of development of the modern student. The source of updating methodological techniques is the principles used in solving scientific problems. So, the discussed aspect is the choice of the volume of use of methods of scientific creativity during mathematics lessons. On the one hand, scientific creativity systematizes knowledge and skills for their application to a wide range of sciences, showing the student the unity of approaches when working with knowledge. On the other hand, the limited lesson time does not allow backing out of the subject matter and studying traditional approaches to solving problems.

CONCLUSION

Thus, the significant result of the research is the theoretical justification of the principles of scientific creativity as effective methodological techniques for teaching to find solutions to math problems. The description of the principles of scientific creativity that can be used in mathematics lessons allows organizing schoolchildren to solve math problems using traditional forms of learning, but taking into account the features of development of the modern student.

On the whole, the following six principles of scientific creativity can be outlined, which allow teaching to search for solutions to math problems: pre-action, continuity of control, pre-fitted pillow, continuous action, completeness and dynamism. These principles of teaching to search for solutions to math problems allow the student to demonstrate the unity of approaches in working with knowledge in different subject areas. Based on the principles of scientific creativity, school math problems have been developed that allow teachers to form students' ability to use these principles. To organize the preparation of schoolchildren for final certification in mathematics, methodological recommendations have been developed aimed at training to search for solutions to problems. It should be noted that at the same time students spend less time searching for solutions to math problems. Also we can indicate that the use of the principles of scientific creativity allows possible to compensate for the tendency towards reduction of the level of development of divergent thinking (creativity) among schoolchildren.

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