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ARTICLE

DYNAMICS OF STUDENTS' ACTIVITY STATES IN THE PROCESS OF SOLVING MATHEMATICAL TASKS

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ABSTRACT

The mathematical task is a basic structural unit of teaching mathematics; moreover, the subject of teaching is developing students' ability to solve mathematical problems. It is important for teachers to understand what mental states accompany various types of students' activities in the learning process, including the solution of mathematical problems of various levels of difficulty. Mental states are triggered by external conditions and some person's attitude to the activity he is engaged in. We have conducted a study of the dynamics of mental states of 10th grade students in the process of solving problems based on both productive and reproductive activities. It showed different dynamics of positive and negative activity (practical) states. In the process of solving tasks of different levels of learning on the theme "Circles and polygons" there has been students' phased (after the analysis and after the solution of a task) self-analysis of their states. Students experiencing difficulties in solving problems based on productive activity showed the increased level of negative activity states, whereas after a task analysis on reproductive activity the level of positive activity states rose.

KEY WORDS
mathematical task, process of solving

INTRODUCTION

In the context of the rapidly changing information society, many countries face the problem of lowering the quality of mathematical background of students. The ability to solve mathematical problems is a key and necessary component of mathematical training. Understanding the basics of the process of solving mathematical problems in the framework of psychological and pedagogical researches has become a new stage in the development of modern training technologies.

The process of solving mathematical problems

The process of solving a mathematical problem involves a set of human actions aimed at solving it: from the first acquaintance with the statement of the problem to the design of the answer [1]. Under the concept of "problem solving" we will understand one of the stages of the process of solving the problem. There are various approaches to the selection of stages of solving a mathematical problem. Poya [2] distinguishes four stages of solving the problem: understanding of the proposed problem; analysis of the problem; synthesis, implementation of the found solution idea; verification and critical evaluation of the obtained solution.

Classification of the difficulty level of mathematical problems

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The concept of "the level of difficulty of a mathematical problem" is defined through a set of its objective and subjective components [3,4].

Understanding the level of difficulty of problems implies their different classifications [5,6]. V.P. Bespalko classifies problems by levels of achievement [Table 1] [7].

Table 1: The classification of tasks according to levels of achievement

N	Type of problems	Aim	Situation	Actions to solve the problem	Student's actions
1	«pupils'»	+	+	+	find out compliance
2	typical	+	+	±	apply a previously known algorithm
3	atypical	+	±	–	apply a previously unknown sequence of actions
4	creative	±	±	–	Carry out a research

Understanding the differences in dynamics and quality of mental states in the process of solving problems of different levels of difficulty will help to activate students' activity state in learning mathematics.

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Activity mental states in the process of solving mathematical problems

Many scientists studied problems of cognitive bases of mathematical preparation of students [8,9,10]. The theoretical basis of the psychological side of our research was the study of the interaction of mental states and cognitive processes in the context of general psychological mechanisms [11], as well as functional asymmetry of positive and negative mental states [12, 13]. A number of researches of cognitive bases of mathematical training of schoolchildren and students became interesting and important for us – they are researches of cognitive and metacognitive activity which are the basis of training in mathematics, also, studying of the leading processes of mathematical thinking [14,15] and induction by analogy as the main meta procedures of the solution of mathematical problems and development of instructions on its application in the learning process [16, 7].

Regularities of mutual transitions of cognitive states, temporal, gender-based and productive characteristics were studied by many researchers [17, 8]; private psychological concepts of cognition in mathematical education were developed and their empirical verification was carried out [18, 19].

One of the metacognitive states that accompany the process of solving the problem in mathematics is "the feeling of difficulty" of the solved problem and its impact on the productivity of the solution [2]. They showed the influence of negative mental states on academic progress in mathematics, for example, anxiety and the state of "hostility to mathematics" significantly worsen students' mathematical achievements [20].

Problem statement

The teacher's understanding of the reasons for the change of mental states of students in the process of solving mathematical problems of various levels of difficulty will make it possible to organize the educational activities of students more effectively; in particular, teachers will be able to use methodological and psychological techniques timely that promote the stimulation of positive activity states and levelling negative activity states.

Research questions

The study focuses on the analysis and synthesis of answers to the following methodological and psychological questions:

- Whether activity mental states are activated and what their dynamics is at the solution of the mathematical problems directed on reproductive or productive activity of pupils?
- Is there a link between students' success in solving mathematical problems that stimulate reproductive and productive activities?
- Do the dynamics and quality of mental states differ depending on the success in solving problems of different levels of difficulty?

Purpose of the Study

The research questions determine its purpose – on the basis of the dynamics of praxic states in the process of solving mathematical problems of various levels of difficulty it is necessary to assess the most favorable conditions for the construction of a system of mathematical problems aimed at improving the quality of activity states in the learning process.

Organization of experimental work with high school students to solve problems of different levels of difficulty with parallel psychological questioning

68 pupils of the 10th grades (16-17 years old) from one of the lyceums of Kazan (Russia) took part in the study. The sample presents students of various levels of training in mathematics (grade 10A, physical and mathematical profile; grade 10B, chemical and biological profile; grade 10C, humanitarian profile). In accordance with the educational program, for mathematical testing students were offered a system of problems on the complex topic of the course "Circles and polygons". The experimental work was organized in April 2017 in three stages: 1st day (56 students) – a conversation with a psychologist about the mental states of the person; 2nd and 3rd days (57 and 48 students, respectively) – the solution of 4 problems of different levels of difficulty.

METHODS

The purpose of mathematical testing of students was shifted, focused on the psychological side of the experiment to protect students from anxiety in solving mathematical problems. The study of students' praxic states was organized in isolation from the educational process and the teacher, who undoubtedly plays an

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important role in activating the mental states associated with the relations of students and teachers. All this made it possible to organize an experimental work.

Methods of diagnostics of mental states in the process of solving mathematical problems

The experiment was based on the method of diagnosis of mental states by A. O. Prokhorov [11]. In the group of positive activity states the author includes activation, vivacity, fun, admiration, attention, interest, joy, peace, happiness, satisfaction, pleasure, patience, mood (good), thoughtfulness, meditation. In the group of negative activity states-apathy, fatigue, fear, excitement, sadness, anger, difficulty, laziness, boredom, drowsiness, mood (bad).

On the first day of the study, each student was offered a list of mental states. Previously, students had a conversation about mental states, the need to establish and regulate them, and focusing on the list, they were proposed to fix for training their state in everyday life.

On other days, students were given the following questionnaire sheets: at first they were offered to fix their mental state at the beginning of the survey, then – two times in the course of solving each of the proposed mathematical problems. Thus, in one day of the research students specified nine times one or a complex of states which they felt at different stages of the solution of a problem.

Methods of organizing the process of solving mathematical problems of various difficulty levels

In the test, the concepts of "circle", "inscribed and central angles", "secant and chord of the circle", "trapezoid", "inscribed trapezoid", "inscribed triangle", "the location of the circles relative to each other" were actualized. There were 3 problems for the reproductive activity and one problem for the productive one.

RESULTS AND DISCUSSION

The results of the work carried out to solve problems of various levels of difficulty

2% of the students coped with the problems on the geometry of the productive level of acquisition, 72% of the students showed a good reproductive level of acquisition. Qualitative analysis of the work showed that most of the students do not have positive experience in solving problems of atypical and creative levels of acquisition.

Quality and dynamics of activity mental states in the process of solving problems

Let's pay attention to how students reacted to psychological testing. If mathematical problems were solved due to interest or habit, the assessment of mental states caused various emotional reactions. According to their reaction, students can be divided into three groups.

Group 1 – students who ignored the psychological aspect of the study. This manifested itself in the fact that they constantly recorded absolutely the same state. On the first day of the study there were four of 55 (7%) students on the first day, 6 of 46 students (13%) on the second day.

Group 2 – students who did not show the dynamics on the tasks of the reproductive level of acquisition, but reflected it on the tasks of the productive level of acquisition. On the first day of the study the number of such students was 7 (13%), on the second day – 5 (11%).

Group 3 – students who recorded a more diverse list of states in solving problems.

We will analyse what students' mental states accompanied the solution of problems of various levels of difficulty. Among 945 possible references of states all students mentioned more often: calmness (150 times), apathy (120), drowsiness (100), reflection (93), difficulty (83), boredom (83), attention (80), thoughtfulness (78). Note that apathy, drowsiness and boredom were often mentioned at the same time (in pairs or all together). The state of "difficulty" reached its highest values after the stage of analysis of problems for productive activities (see [Fig. 1]). (Stages of fixing mental states in the process of solving problems: 1.0 and 2.0 – before mathematical questioning, 1.1 – after the analysis of the 1st problem, 1.2 – after the solution and registration of the answer, 2.1 – after the analysis of the 2nd problem, etc.)).

On the first day before the solution of problems (stage 1.0) the ratio of states belonging to groups of positive activity states (PAS) and negative activity states (NAS) is approximately the same. In the course of solving the problems of reproductive level of acquisition (steps 1.1 – 3.2), most of the student's experience PAS, the lesser – NAS. Most of the children coped with the problems- they were satisfied with their work, and, indeed, 72% of the students successfully solved the problems of reproductive level. Small fluctuations of PAS and NAS began to change the direction of activity states in solving the third problem. In general, the problems are

familiar, similar problems were solved earlier by them, so there is no special dynamics of state changes. The situation changes as the students begin to analyze a problem that requires productive activity. If PAS increased after the analysis of the statements of the problems of the reproductive level of acquisition (stages 1.1, 2.1, 3.1), then after the analysis of the fourth problem there is an increase in NAS. After the solution, there is a further significant decrease in students' NAS.

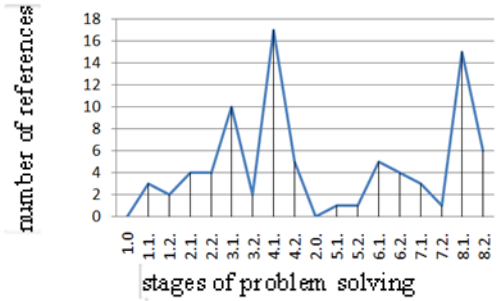

Fig. 1: Dynamics of change in the number of references of mental state "difficulty".

The mental state "calmness" reached its minimum exactly at the solution of problems of atypical and creative level of acquisition (see [Fig. 2]).

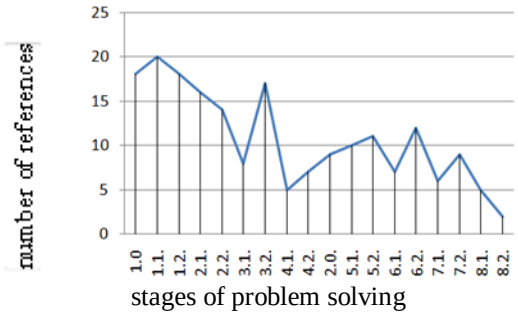

Fig. 2: Dynamics of changes in the number of references of mental state "calmness».

Mental states "apathy, drowsiness, boredom" reached the highest values at the beginning of the test, falling as the problems were solved.

We will arrange the states offered by students into groups and show the dynamics of changes in each group depending on the stage of solving problems (see [Fig. 3]).

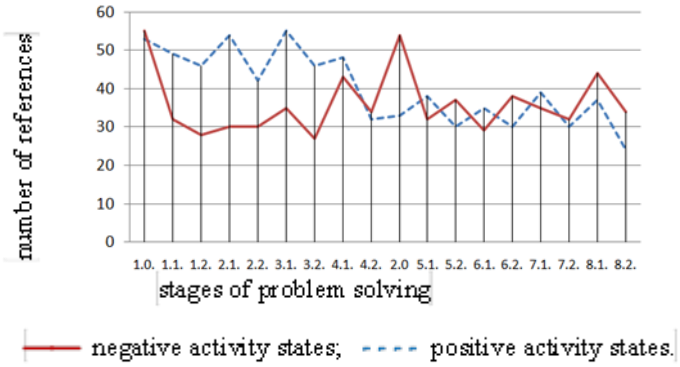

Fig. 3: Dynamics of positive and negative activity states in the process of solving mathematical problems.

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CONCLUSION

During the mathematical testing, it is concluded that the vast majority of students are not familiar with the tasks on the topic of "Circles and polygons" aimed at productive activity. Lack of such positive experience results in increase in both PAS and, to a greater extent, NAS.

Problems on reproductive activity do not demonstrate a great dynamics of activity states: the easier the problem is, the less dynamics we have. Furthermore, the quality and nature of the change in students' states do not depend on students' mathematical background. Conclusion: if the problem is familiar to students, he had the experience of solving it, it does not activate his praxic state.

Thus, the system of problems at mathematics classes should be maximally filled with tasks on productive activity as they raise the quality of pupils' mathematical preparation and stimulate dynamics of activity states, in particular, cognitive and volitional states.

The greatest activation of PAS occurs at the stage of task analysis when the student is not sure of the success of the solution, the decrease occurs after a successful ("seeming" successful) solution of the problem. [21].

Therefore, the system of problems should consist of tasks combined by a subject matter that seem within their powers, but cause difficulty. The solution of these problems should, on the one hand, be feasible, but contain new ideas. One should find other special methodological and psychological techniques that contribute to increase in the positive activity states.

CONFLICT OF INTEREST

There is no conflict of interest.

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