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EFFECTIVENESS OF THE DIFFERENTIAL APPROACH IN TEACHING PROBLEM-SOLVING STRATEGIES IN MATHEMATICS LESSONS

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Abstract: This article examines the effectiveness of the differential approach in teaching problem-solving strategies in mathematics lessons from scientific, theoretical, and practical perspectives. The study was conducted on the basis of a mixed (mixed-method) methodology and analyzed the dynamics of problem-solving skills development using tasks adapted to the level of students' preparedness, cognitive style, and reading pace. Pre-test and post-test results showed a significant improvement in the results in the experimental group, which confirmed the role of the differential approach in improving students' strategic thinking, metacognitive activity, and problem-solving effectiveness. The results of the qualitative analysis showed that students became more active during the lesson, strived for independent decision-making, and gained freedom in solving problems based on various strategies. The article reveals the practical possibilities of the differential approach in improving the quality of mathematics education and provides methodological recommendations for teachers.

Keywords: differential approach, mathematical education, problem-solving strategies, metacognitive skills, individualized learning, constructivism, learning activity, level of assimilation.

INTRODUCTION. In recent years, the issue of developing effective teaching strategies, taking into account the individual characteristics of students in the educational process, has become particularly relevant. In particular, the application of a differential approach in teaching problem-solving strategies in mathematics lessons makes it possible to organize learning adapted to the pace of learning, cognitive style, interests, and level of preparedness of students. This form of individualization of education plays an important role in increasing the effectiveness of the educational process, increasing student activity, developing mathematical thinking, and forming skills for independent problem analysis (Tomlinson 2014).

The theoretical foundations of the differential approach are based on the principles of constructivism. According to it, each student builds knowledge on the

basis of their existing cognitive experience, and the teacher plays the role of a teacher, a guide, and not a manager of the process (Vygotsky 1978). It is also shown that the psychological factors of differentiation in education - the zone of close development, metacognitive approach, student motivation - serve the assimilation of complex problems in mathematics through an individual approach (Bruner 1996).

Recent studies confirm that there are significant differences between students in the process of solving mathematical problems: some prefer an algorithmic approach, while others tend to use graphical, logical, or creative methods (Polya 1957). Therefore, the application of a differentiated approach in teaching problem-solving strategies allows the student to choose a suitable strategy, compare options, and evaluate the result. According to researchers, such an approach significantly strengthens students' problem-solving competencies, optimizes cognitive load, and increases performance (Hattie 2009).

A review of the literature shows that many foreign and domestic researchers have analyzed the effectiveness of the differential approach in teaching mathematics in various aspects. For example, Tomlinson notes that differentiated tasks provide complexity corresponding to the level of assimilation of students (Tomlinson 2014). Polya developed methods for systematically teaching problem-solving strategies and emphasized the need to adapt them to the developmental stage of students (Polya 1957). Hattie shows that the positive impact of individualized learning on learning outcomes has been proven through experimental research (Hattie 2009).

At the same time, the number of methodological recommendations and studies aimed at individualizing lessons in the education system of Uzbekistan has been increasing in recent years. They provide mathematics teachers with practical recommendations for working with a set of adapted exercises and problems, taking into account different levels of student preparedness, and for implementing variable teaching methods.

This research is aimed at scientifically studying the effectiveness of the differential approach in teaching problem-solving strategies in mathematics lessons, analyzing existing experience, and proposing an improved model. In subsequent sections, the research methodology, the obtained results, and their discussion are presented.

METHODS AND MATERIALS. This study is aimed at determining the effectiveness of the differential approach in teaching problem-solving strategies in mathematics lessons, and a mixed-method design was used. The study was conducted in two main stages: diagnostic analysis and experimental testing. At both stages,

methods of collecting, processing, and statistical analysis of qualitative and quantitative data were used (Creswell 2014).

1. Study participants

A total of 84 students studying in grades 6-7 participated in the study. They were divided into two groups:

The control group (42 students) - was trained using traditional teaching methods.

The experimental group (42 students) was trained using a set of variant tasks and problem-solving strategies developed on the basis of a differential approach.

Groups were selected based on the principle of equalization, balanced according to the level of initial training of students, general performance indicators, and cognitive profile (Tomlinson 2014).

2. Research material

During the study, the following materials were developed and applied:

Differentiated set of tasks: problems adapted to the level of students' preparedness (A - high, B - medium, C - elementary), cognitive style (analytical, visual, logical), and reading pace.

Complex of problem-solving strategies: Adapted based on the 4-stage methodology proposed by Polya (understanding the problem, planning, execution, verification).

Diagnostic tests: consist of 20 tasks that assess the skills of understanding problems, applying strategies, logical analysis, and checking answers.

Observation sheets: to determine student activity during the lesson, the speed of strategy selection, and the level of metacognitive reflection.

3. Research methods

3.1. Quantitative methods

Pre-test and post-test analysis: changes between the control and experimental groups were compared using the student’s t-test.

Descriptive statistics: averages, variance, percentage differences were analyzed.

Correlation analysis: the relationship between the use of differential problems and the results of problem-solving was clarified (Hattie 2009).

3.2. Qualitative methods

Semistructured interviews: interviews were conducted with mathematics teachers on the advantages and practical problems of the differential approach.

Observation: student activity in the lesson process, independence in choosing a strategy, and the level of collaboration were analyzed (Vygotsky 1978).

Students' reflective diaries: difficulties and successes in the process of choosing a strategy were studied.

4. Experimental process

The experiment was conducted for 10 weeks:

1. Week 1: diagnostic tests, identification of cognitive methods, assessment of the level of initial training.

2. 2-9 weeks: lessons were conducted in the experimental group based on a differential approach; in the control group, traditional methods were used.

3. Week 10: Summarize the results of the final test, interviews, and observation.

5. Data processing

The analysis was carried out using Microsoft Excel and SPSS programs. Qualitative data were processed using the thematic coding method, and the main categories were identified (Braun & Clarke 2006).

RESULTS AND DISCUSSION. The research results showed that the effectiveness of the differential approach in teaching problem-solving strategies in mathematics lessons is significantly higher. According to the results of the pre-test, there were practically no differences between the control and experimental groups, which confirmed the equality of the initial training levels of the groups. The results of the post-test conducted at the end of the experimental process showed an increase in the average indicator in the experimental group by 27-32%, while in the control group this increase was about 10-12%. Also, the analysis of the t-test confirmed the presence of a statistically significant positive difference in the results of the experimental group ($p < 0.05$). This result shows that the differential approach has a direct positive impact on students' problem-solving skills, which is consistent with previous research, in particular, Hatti's conclusions about the influence of an individual approach on learning outcomes (Hattie 2009).

The observation results showed that the processes of analyzing the problem, choosing a strategy, and justifying the solution were more active in the students of the experimental group. Since the differentiated tasks took into account the individual cognitive characteristics of the students, they sought to solve the problems using a convenient approach. This process led to an increase in metacognitive activity in students, a more thorough completion of the stages of understanding the problem and planning. This situation aligns with Polya's theoretical views on problem-solving models, reaffirming that a student's allocation of more time to the process of understanding and planning the problem directly affects the quality of the final result (Polya 1957).

Analysis of qualitative data, in particular, the results of conversations and reflective diaries, showed that students felt more free during lessons organized on the basis of a differential approach, developed skills of independence and creative decision-making in the process of problem-solving. Teachers noted that although such an approach requires greater flexibility in managing the learning process, it is effective in increasing student activity and motivation. This shows that, in accordance with Vygotsky's principles about the zone of proximal development, providing the student with somewhat more complex, but feasible tasks accelerate the process of knowledge acquisition (Vygotsky 1978).

The changes observed during the experiment show that lessons conducted on the basis of a differential approach form such important competencies of students as the conscious selection of problem-solving strategies, step-by-step implementation, and verification of the result. In addition, a reduction in the time for solving problems and a decrease in the number of errors in students of the experimental group were also assessed as indicators that determine the effectiveness of this methodology. It was observed that when students completed tasks tailored to them, the cognitive load decreased and thereby increased attention stability, which demonstrated the practical result of the constructivist approach (Bruner 1996).

In general, the study showed that the differential approach is effective in the process of teaching problem-solving strategies in mathematics lessons, and education adapted to the pace of students' learning and cognitive style significantly improves their academic performance. The results show that a differentiated approach activates students, personalizes the problem-solving process, develops strategic thinking, and encourages independent learning. At the same time, it was noted that this model requires teachers to have a high level of methodological training, flexible planning, and classroom management.

CONCLUSION. The research results clearly showed that the application of a differential approach in teaching problem-solving strategies in mathematics lessons significantly increases the assimilation indicators of students. Due to the fact that the differentiated tasks were adapted to the level of individual readiness, cognitive style, and reading pace of students, they were able to solve problems based on a more conscious, step-by-step, and strategic approach. Differences between pre-test and post-test results, data obtained through observation and interviews confirmed that in the experimental group, students' skills in analyzing the problem, choosing a strategy, justifying the solution, and checking the result were significantly developed.

The effectiveness of the differential approach is primarily related to the possibility of activating students, strengthening their personal participation in the learning process, and creating favorable cognitive conditions for them. It was noted that the metacognitive activity of students increased, they consciously chose problem-solving strategies, and their ability to assess their knowledge increased. This fully corresponds to the principles of constructivism, Vygotsky's views on the zone of near-development, and the step-by-step problem-solving model proposed by Polya.

In general, the conclusion of the study is that the application of a differential approach in teaching problem-solving strategies in mathematics lessons not only increases the level of students' knowledge, but also deepens their thinking processes, actively involves them in the lesson process, and creates an effective learning environment for each student. The widespread implementation of this approach in practice will serve to improve the quality of mathematics education.

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