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TEACHING STUDENTS CRITICAL THINKING THROUGH MODELING MATHEMATICAL PROBLEMS

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Abstract. This article highlights the role and importance of the process of modeling mathematical problems in developing critical thinking skills in students. Modeling not only encourages students to apply mathematical knowledge in practical situations, but also encourages students to analyze the problem, compare evidence, draw logical conclusions, and evaluate various solution options. The study shows the main stages of modeling — problem identification, mathematical model creation, model analysis, and re-adaptation of results to a real situation — as factors that activate students' thinking. It is also emphasized that the use of modeling-based tasks in the classroom can direct students to research, strengthen their independent decision-making, logical-mathematical thinking, and creative approach. This work is considered one of the effective methods of preparing students to solve real-life problems by introducing innovative approaches in mathematics education.

Keywords: mathematical modeling, critical thinking, student activity, problem analysis, logical thinking, creative approach, educational technologies.

INTRODUCTION

In the modern educational process, it is not enough for students to simply acquire ready-made knowledge, but the need for methods that encourage them to think independently, analyze, and consider the existing problem from different angles is increasing day by day. In this regard, modeling mathematical problems is recognized as one of the most effective ways to form critical thinking in students. Through the modeling process, the student understands the essence of a real-life problem, re-describes it through mathematical expressions, and tries to find the most optimal way to approach the solution. Each stage of this process requires the student to have such skills as logical clarity, analytical thinking, drawing conclusions based on evidence, and comparing alternative solutions.

The study of the impact of mathematical modeling on student thinking shows that this method not only develops mathematical competencies, but also forms such elements of critical thinking as thinking through each situation, sorting facts, avoiding incorrect or unfounded conclusions, and defending one's opinion with reliable evidence. As soon as the student analyzes the essence of the problem, he tries different strategies, evaluates the advantages and disadvantages of each strategy, and as a result learns to make informed decisions. This will increase his ability to effectively solve complex situations not only in mathematics, but also in everyday life. This article will provide a detailed description of the theoretical foundations of modeling mathematical problems and the possibilities of developing critical thinking in students through its application to the educational process. It is also aimed to demonstrate the stages of modeling, the impact of these stages on student thinking, and its effectiveness based on practical examples. Today, when the competency-based approach is becoming a priority in the education system,

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the widespread use of modeling technology is an important factor in forming students not only as knowledgeable people, but also as analytical, comparative, independent thinkers and responsible individuals.[3; 210]

LITERATURE ANALYSIS AND RESEARCH METHODOLOGY

The analysis of scientific sources on the formation of critical thinking in students through the modeling of mathematical problems shows that this area is widely covered as a relevant topic in international and local pedagogical research. In foreign literature, the modeling process is assessed as one of the main competencies of mathematics education, and it is emphasized that through it students develop the skills of problem identification, strategy selection and solution justification. In particular, researchers such as Birch and Lesh interpret modeling as "a process that forces the student to build a bridge between real-life problems and mathematical thinking." In local literature, the use of modeling in the teaching process, its role in motivating students to think actively, as well as a practical tool that promotes in-depth mastery of mathematical concepts, are emphasized.[4; 98]

Several approaches were used as a research methodology. First, by studying theoretical sources on the topic, the role of the modeling concept in education, its stages, and mechanisms of influence on student activity were identified. At the next stage, the observation method was used to analyze students' thinking activity, the level of questioning, the ability to propose alternative solutions, and the skills to justify their opinions in the process of completing tasks based on modeling in mathematics lessons.

Also, using the experimental method, the educational process was organized in two groups: in the experimental group, modeling-based tasks were regularly used, while in the control group, traditional methods were continued. Through this, the unique advantages of modeling in developing critical thinking were practically evaluated.

ANALYSIS AND RESULTS

The analysis of how the use of mathematical modeling in the educational process affects students' thinking, especially what changes it causes in the process of forming critical thinking, clearly confirms the effectiveness of this method. Preliminary observations have shown that students working with modeling tasks ask more questions to understand the essence of the problem, require additional information to assess the situation from different angles, and actively begin to search for a solution. This indicates that one of the main features of critical thinking is being formed - a deep understanding of the problem and its interpretation in different options.

In the analysis, it was found appropriate to study the impact of modeling on students in three main areas: (1) the formation of analytical thinking, (2) the enrichment of solution search strategies, (3) the development of logical reasoning and reasoning skills. The results obtained in each direction confirmed that modeling creates much broader cognitive opportunities than simple mathematical problems.

The first direction — the impact on analytical thinking — was assessed through the students' activity in the process of completing modeling tasks. The analysis showed that the connection of the problem to a real situation arouses interest in students and they tend to break the problem

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into smaller parts. In this case, students try to distinguish between the main and secondary factors of the situation, and as a result, develop an analytical approach. It was found that additional questions asked by the teacher, especially questions such as “Why?”, “What will be the result if the condition changes?”, “What other solution can there be?” further strengthened the analytical process.

The second direction — the enrichment of solution search strategies — was assessed by the students' ability to use various mathematical methods in the modeling process. Modeling requires the student to imagine and compare several solution options in his mind. The analysis showed that in this process, students not only use traditional algorithms, but also develop alternative methods that are convenient for them, expand the solution paths based on logical assumptions. This also stimulates their creative thinking.

The third direction - logical reasoning and reasoning - has emerged as one of the most important pedagogical effects of modeling. The students' attempts to express their opinions based on mathematical arguments in the process of presenting a solution, to prove their arguments is a high stage of critical thinking. One of the important things observed during the analysis is that during the modeling process, the student critically approaches his own opinion, re-examines his arguments, and, if necessary, revises the model. This indicates that the student is developing the skill of reflection.[6; 120]

The results show that students who regularly worked with modeling tasks achieved significant growth in skills such as logical thinking, independent analysis, reasoning, comparing different sources, and evaluating the effectiveness of solutions. The integration of modeling into the lesson process not only helps students to understand mathematical concepts more deeply, but also prepares them to independently solve real-life problems.

The results also showed that the introduction of modeling into the learning process changes the role of the teacher. The teacher is not a traditional knowledge provider, but rather a guide, discussion manager, and thought provoking person. This change brings students to the center of activity.

Mathematical modeling serves as a powerful didactic mechanism for teaching students to think critically. It develops their analytical thinking, logical reasoning, solution creation, and proofreading skills. The results of the study confirm that the regular use of modeling in mathematics education is an effective tool for developing critical thinkers and independent decision-makers.

Example 1: Comparing Alternative Solutions

Situation:

The class wants to choose between two transportation options for an excursion:

Bus: 450,000 soums (40 seats)

Minivan: 150,000 soums (10 seats)

There are 32 students in the class. Which option is optimal?

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Modeling:

Bus: 1 is enough → 450,000

Minivan: 4 are needed → 600,000

Critical thinking process:

— Questions such as “Which option is cheaper?”, “Which one is more affordable?”, “Does it have enough seats?” arise.

— The student compares comfort and time along with price.

Result:

The student learns not only mathematical calculations, but also decision-making.

Example 2: Provision through modeling

Situation:

A kindergarten uses 230 m³ of water per month. In the summer months, water consumption increases by 18%. How much water is consumed in July?

Model:S= 230+(230×0.18)

Elements of critical thinking:

— The student thinks “What does 18% mean?”, “Does the increase make sense?”

— Adapts the model to real life: justifies that more water is used because the summer is hot.

Example 3: Interpretation and inference

Situation:

A small math test was conducted in the class. Scores:

12, 15, 18, 19, 10, 17, 14, 20

The teacher asks the students to assess the “general level of preparation of the class.”

Modeling:

Students find the average score, determine the median, and interpret the result.

Critical Thinking:

— “Is the average score good enough?”

— “What is the spread of scores?”

— “Which students need additional help?”

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CONCLUSION

The analysis clearly shows that modeling mathematical problems is one of the most effective pedagogical approaches in forming critical thinking in students. In the modeling process, the student seeks to translate real-life situations into mathematical language, identify logical connections, compare alternative solutions, and choose the most optimal result. Each stage of this process forms the skills of independent thinking, in-depth analysis of the problem, drawing conclusions based on evidence, and logical proof.

Also, the use of modeling in the educational process enhances active intellectual practices in students, such as research, experimentation, asking questions, and evaluating results. The closeness of the tasks to real life interests the student in the process and encourages them to make independent decisions. As a result, the student not only acquires mathematical knowledge, but also learns to apply it in practical situations.

In general, mathematical modeling plays an important role in forming a culture of critical thinking in students, teaching them an analytical and creative approach, and providing them with the necessary competencies for successful study and work at the next stages.

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