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THE ROLE OF MATHEMATICAL TASKS IN THE DEVELOPMENT OF LOGICAL THINKING: SECONDARY SCHOOL PRACTICE AND THE EDUCATIONAL MODELS OF EUROPEAN COUNTRIES

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Summary: One of the principal objectives of contemporary education is not only the acquisition of factual knowledge but also the development of students' analytical thinking, logical reasoning, problem-solving, and creative thinking skills. Within this context, mathematics occupies a distinctive position in the educational process. Mathematical tasks serve as essential pedagogical instruments that foster logical thinking, enable students to identify cause-and-effect relationships, and strengthen their decision-making abilities. This article presents a comparative analysis of the impact of mathematical tasks used in secondary education on the development of students' logical thinking, drawing upon the advanced educational practices of Eastern and European countries. The mathematics education models implemented in Japan, Singapore, China, and South Korea are compared with the pedagogical approaches adopted in Finland, Estonia, Germany, and the Netherlands. The findings indicate that mathematical tasks designed to enhance logical reasoning significantly improve not only students' academic achievement but also their independent thinking, decision-making and creative problem-solving competencies. Furthermore, the study proposes methodological recommendations for adapting these successful international practices to the general education system of Azerbaijan.

Key words: logical thinking; mathematical tasks; secondary education; mathematical literacy; Eastern educational practices; European educational practices; problem-based learning; functional mathematical literacy.

MƏNTIQI TƏFƏKKÜRÜN INKIŞAFıNDA RIYAZI TAPŞıRıQLARıN ROLU: ORTA MƏKTƏB TƏCRÜBƏSI VƏ AVROPA ÖLKƏLƏRININ TƏHSIL MODELI

Xülasə: Müasir təhsil sistemində əsas məqsədlərdən biri yalnız faktiki biliklərin mənimsədilməsi deyil, həm də şagirdlərdə analitik düşüncə, məntiqi mühakimə, problem həll etmə və yaradıcı təfəkkür bacarıqlarının formalaşdırılmasıdır. Bu baxımdan riyaziyyat fənni xüsusi əhəmiyyət daşıyır. Riyazi tapşırıqlar şagirdlərin məntiqi təfəkküründü inkişaf etdirən, səbəb-nəticə əlaqələrini müəyyən etməyi öyrədən, qərar qəbul etmə bacarıqlarını möhkəmləndirən mühüm didaktik vasitələrdir. Bu məqalədə orta məktəblərdə istifadə olunan riyazi tapşırıqların şagirdlərin məntiqi təfəkküründə təsiri Şərq və Avropa ölkələrinin qabaqcıl təhsil təcrübəsi əsasında müqayisəli şəkildə araşdırılır. Yaponiya, Sinqapur, Çin və Cənubi Koreyada tətbiq olunan riyaziyyat tədrisi modelləri ilə Finlandiya, Estoniya, Almaniya və Niderlandın pedaqoji yanaşmaları müqayisə edilir. Tədqiqat göstərir ki, məntiqi təfəkkürü inkişaf etdirən riyazi tapşırıqlar şagirdlərin yalnız akademik nailiyyətlərini deyil, həm də onların qərarvermə, müstəqil düşünmə və yaradıcı fəaliyyət bacarıqlarını əhəmiyyətli dərəcədə artırır. Məqalədə Azərbaycan ümumtəhsil məktəblərində bu təcrübələrin tətbiqi istiqamətində metodik təkliflər də irəli sürülür.

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Açar sözlər: məntiqi təfəkkür, riyazi tapşırıqlar, orta məktəb, riyazi savadlılıq, Şərq təcrübəsi, Avropa təcrübəsi, problem əsaslı təlim, riyazi savadlılıq.

Introduction

In the era of globalization, one of the foremost responsibilities of educational systems is no longer limited to the transmission of knowledge; rather, it is to cultivate individuals who are capable of critical inquiry, independent decision-making, analytical reasoning, and adaptation to rapidly changing social and technological environments. The competency-based educational paradigm of the twenty-first century demonstrates that students' future professional success depends not on the quantity of memorized information but on their capacity for logical reasoning, analytical thinking, and effective problem solving. From this perspective, mathematics differs from other school subjects in that it represents not merely a body of theoretical knowledge but also a universal means of developing logical reasoning. Through mathematical tasks, students learn to compare phenomena, generalize information, identify causal relationships, formulate hypotheses, and justify the conclusions they reach. Consequently, contemporary educational theory increasingly recognizes mathematics as "the discipline that teaches thinking." The results of recent international large-scale assessment programmes demonstrate that countries achieving high educational performance do not primarily emphasize computational speed in mathematics instruction. Instead, they prioritize the development of mathematical reasoning and logical thinking skills. In particular, East Asian countries such as Japan, Singapore, China and South Korea have become internationally recognized leaders in this field (Ministry of Education, Singapore. (2021). In these education systems, mathematical tasks are carefully designed to encourage students to explore multiple solution strategies, justify their reasoning, and compare alternative approaches. Such practices systematically foster the development of logical thinking(European Commission. (2023). Similarly, the educational systems of several European countries—particularly Finland, Estonia, Germany, and the Netherlands—integrate mathematical tasks with authentic real-life situations. Their primary objective is to enable students to apply mathematical knowledge in everyday contexts, construct diverse solution strategies, and develop creative thinking abilities.

Scientific Novelty

The scientific novelty of this study lies in its systematic and comparative examination of the role of mathematical tasks in the development of students' logical thinking within the context of secondary education in both Eastern and European countries. To the best of the author's knowledge, this is one of the first studies to synthesize and compare the pedagogical approaches employed in these educational systems with particular emphasis on their contribution to logical reasoning. The study reviews the impact of instructional approaches widely implemented in East Asian mathematics education, including problem-based learning, mathematical modelling, open-ended tasks, reflective assessment, and collaborative discussion, on the development of students' logical thinking skills. These approaches are subsequently compared with the pedagogical models adopted in several European education systems. Based on the findings of this comparative analysis, the study proposes a methodological framework that can be adapted to the national curriculum of Azerbaijan. The proposed model extends beyond the development of mathematical knowledge by promoting analytical thinking, logical reasoning, argumentation, decision-making, and problem-solving competencies through an integrated pedagogical approach.

Practical Significance of the Study

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The findings of this research have important practical implications for improving mathematics instruction in general secondary education, enriching curriculum content, and strengthening teachers' methodological competencies. The proposed methodological framework may assist mathematics teachers in designing daily lesson plans, selecting instructional tasks that foster logical thinking, and implementing formative assessment strategies more effectively. Furthermore, the findings may serve as a valuable scientific and methodological resource for teacher education programmes, professional development courses, the preparation of mathematics textbooks and teaching materials, and educational projects aimed at enhancing students' mathematical literacy. The study may also contribute to educational policy development by providing evidence-based recommendations for integrating internationally recognized instructional practices into the national mathematics curriculum.

Research Limitations

This research is primarily based on a comparative analysis of educational practices implemented in Eastern and European countries, together with a systematic review of the relevant international literature. Since no large-scale experimental implementation or long-term monitoring was conducted in Azerbaijani secondary schools, the practical effectiveness of the proposed methodological framework remains to be empirically verified under diverse educational conditions. Consequently, future empirical studies are required to evaluate its applicability and effectiveness in different school contexts. Furthermore, the scope of the present study is limited to secondary education. Other educational levels, including preschool, vocational, and higher education, were not investigated and therefore constitute promising directions for future research.

Twenty-first-century education requires students not merely to retain information but also to analyse, compare, synthesize, and apply knowledge in authentic contexts. Mathematics plays a central role in developing these higher-order cognitive competencies. As the language of logical reasoning, mathematics contributes directly to students' intellectual development. The educational strategies of the European Commission emphasize that mathematical literacy constitutes one of the essential foundations of economic growth, innovation, and sustainable social development. Consequently, mathematics instruction across many European educational systems increasingly focuses on solving authentic real-life problems, fostering critical thinking, and promoting independent decision-making. The concept of logical thinking refers to an individual's capacity to analyse information systematically, identify relationships among facts, draw valid conclusions, and make evidence-based decisions. According to Jean Piaget, during the school-age period children enter the stage of formal operational thinking, enabling them to develop abstract reasoning abilities (Piaget, 1972). Likewise, Lev Vygotsky argued that appropriately organized instructional activities expand learners' Zone of Proximal Development and facilitate the formation of logical cognitive operations (Vygotsky, 1978).

Theoretical Background

As a result of the impact of mathematical tasks on logical thinking, mathematical tasks develop the following skills:

1. Analytical thinking;
2. Comparison and generalization;
3. Determining cause-and-effect relationships;
4. Hypothesis-making;
5. Proof-making skills;
6. Searching for alternative solutions;
7. Critical evaluation.

Especially open-ended and multi-variant tasks allow students to develop different strategies and adopt a creative approach. In Finnish schools, mathematics is based on thinking, not memorization.

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Instead of giving students ready-made formulas, teachers encourage them to investigate the problem. Project-based and research-based tasks are widely used in lessons. Estonian experience Estonia has been one of the most successful countries in Europe according to PISA results in recent years. Here, mathematical tasks are related to everyday life, information technologies are widely used, and students discuss various solution strategies. Application of the Singapore method in Europe Singapore mathematics, which is applied in several European countries, is based on the Concrete–Pictorial–Abstract model(Estonian Ministry of Education and Research) This approach allows students to gradually master concepts and gain a deeper understanding of logical relationships. Germany In Germany, modeling tasks are widely used in mathematics lessons. Students solve real economic and social problems using mathematical methods, justify and present the results. The Netherlands According to the Realistic Mathematics Education (RME) approach, mathematics is associated with life events. Students first analyze a real situation, then solve it by converting it into a mathematical model. PISA assessment and logical thinking The PISA assessment conducted by the OECD shows that in high-performing countries, problem-based learning, open-ended questions, discussion, research tasks and etc. cooperative activities prevail in mathematics lessons (OECD. (2023). These approaches increase the level of logical reasoning and functional mathematical literacy of students. As for the methods that can be applied in secondary school, teachers can use the following methods to develop logical thinking:

1. problem-based learning;
2. research-based tasks;
3. mathematical games;
4. logic competitions;
5. debate elements;
6. STEAM projects;
7. interactive tasks through digital platforms;
8. group problem solving.

Tasks that develop logical thinking are:

1. logical sequence tasks;
2. combinatorics problems;
3. probability problems;
4. strategy games;
5. problems requiring proof;
6. non-standard problems;
7. research-type tasks;
8. everyday life problems.

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Application possibilities in Azerbaijani schools The curriculum reforms implemented in the Republic of Azerbaijan also consider competency-based learning a priority. Increasing the number of logical tasks, PISA-type tasks, projects and research-oriented activities in mathematics lessons can increase students' functional literacy. The widespread use of problem-based learning methods in teachers' professional development programs will be an important step in this direction. In this regard, the comparative study of Eastern and European experience is of great scientific and practical importance for improving the teaching of mathematics in Azerbaijani secondary schools. Logical thinking expresses a person's ability to systematize, analyze, compare, generalize information and draw substantiated conclusions. In psychology, this concept is considered the highest form of cognitive processes and is evaluated as one of the main indicators of students' intellectual development. Representatives of developmental psychology note that school age is the most favorable period for the formation of logical operations. At this stage, students begin to understand complex logical relationships by moving from concrete concepts to abstract thinking. Mathematical activity is one of the most effective tools that accelerates this transition. From a pedagogical point of view, the development of logical thinking depends on the teaching methods applied by the teacher and the nature of the tasks used. Although traditional training based on the application of ready-made algorithms strengthens the reproductive activity of students, it does not sufficiently allow for the development of their analytical and creative thinking skills. On the contrary, problem-based, research-oriented and open-ended mathematical tasks involve the student in active cognitive activity, encourage him to explore alternative solutions and develop the ability to make independent judgments. In modern didactics, it is accepted that mathematical thinking is not only the ability to perform calculations, but also the ability to build logical proofs, put forward hypotheses, justify the results and apply them in various situations. Therefore, the content of mathematical tasks should serve not only the mastery of formulas, but also the development of logical operations. This principle occupies a special place in the education systems of Eastern countries. In Japanese and Singaporean schools, teachers evaluate the logical reasoning by which students arrived at that answer, rather than finding the correct answer. This approach leads to the deepening of mathematical thinking and the formation of reflective thinking in students. Thus, the development of logical thinking is not a random process, but a complex cognitive process formed as a result of mathematical tasks prepared on a scientific basis, modern pedagogical technologies and a systematic learning environment. In this regard, the selection and structure of mathematical tasks used in secondary school should be considered one of the key factors in the intellectual development of students.

Future research directions

In future studies, it is considered appropriate to study the results of the experimental application of mathematical tasks that develop logical thinking in Azerbaijani schools, conduct comparative analyses across different age groups, and investigate the impact of artificial intelligence technologies on the development of mathematical thinking in a digital educational environment. At the same time, the development of adaptation models of successful experiences of Eastern countries in accordance with the characteristics of the national curriculum, the assessment of the impact of the systematic application of PISA and TIMSS-type tasks on students' mathematical literacy, as well as the empirical study of the relationship between the level of methodological preparation of mathematics teachers and students' logical thinking indicators can be considered promising areas for future scientific research in this direction (OECD. (2023). PISA 2022 Results (Volume I):

Conclusion

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Mathematical tasks are one of the most effective pedagogical tools in the development of students' logical thinking. The experience of European countries shows that connecting mathematics with life, applying open-ended problems, research and project-based activities significantly develop students' analytical and creative thinking skills. The systematic application of these approaches in Azerbaijani schools will also serve to improve the quality of education, achieve more successful results in international assessments, and form competitive human capital.

The conducted research shows that in the modern education system, mathematical tasks are not only a didactic tool serving to instill mathematical knowledge and skills in students, but also one of the main mechanisms for the formation of their logical thinking, analytical judgment, critical thinking ability, and creative problem-solving skills. The logical structure of mathematics encourages students to compare facts, determine cause-and-effect relationships, make generalizations, put forward hypotheses, and justify these hypotheses with scientific arguments. In this regard, the content and methodological structure of mathematical tasks should be considered one of the main factors determining the quality of the educational process. A comparative analysis of the study shows that the main goal of teaching mathematics in the education systems of Eastern countries - especially Japan, Singapore, China and South Korea - is not to teach students ready-made algorithms, but to develop their skills in mathematical reasoning, searching for alternative solutions, substantiating their arguments and drawing logical conclusions (Asian Development Bank (2021). Approaches such as problem-based learning, open-ended tasks, collective discussion, mathematical modeling and reflective assessment applied in these countries serve to form a high level of cognitive activity in students. That is why these countries are constantly at the forefront in international assessments in terms of mathematical literacy and logical thinking indicators. The experience of European countries also proves that the integration of mathematics with real-life situations, the application of project and research-based tasks, student-oriented and competency-based learning models play an important role in the development of logical thinking. However, comparative analysis shows that in the educational models of Eastern countries, more attention is paid to the systematic development of mathematical reasoning, the organization of the thinking process at each stage of the lesson, and the student's justification of his own solution strategy. These features are one of the main aspects that distinguish their educational model. Although the curriculum reforms implemented in Azerbaijani secondary schools have identified the development of logical thinking and functional literacy as a priority direction, the dominance of reproductive tasks in mathematics lessons still prevents the full realization of the analytical and creative thinking potential of students. Therefore, it is considered necessary to update the content of mathematical tasks, adapt them to the requirements of international assessment programs, expand problem-based and research-oriented activities, and strengthen the professional development of teachers in this direction. Based on the research, it can be concluded that the application of successful elements of the mathematical education model of Eastern countries in Azerbaijani schools, especially tasks based on mathematical reasoning, open problems, modeling activities, reflective assessment and collaborative problem solving, taking into account the requirements of the national curriculum, can significantly contribute to the development of students' logical thinking, improving mathematical literacy and achieving higher results in international assessments. The selection and purposeful organization of mathematical tasks on a scientific basis not only increases the efficiency of teaching mathematics, but also serves to form the intellectual potential of society, to educate a new generation that thinks innovatively, can make scientifically justified decisions and adapts to global challenges. Therefore, the development of a didactic model of mathematical tasks aimed at the development of logical thinking and its systematic application in secondary schools should be considered one of the most relevant directions of modern pedagogy. The

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integration of this model into the national education system will make a significant contribution to the priority goals of Azerbaijan's education strategy, the development of students' 21st century competencies, and increasing the country's competitiveness in the international education space. From a methodological perspective, the following specific steps are considered appropriate for Azerbaijani schools:

1. At least 2–3 open-ended, multiple-solution mathematical tasks should be prepared for each teaching topic and presented to students for discussion and justified presentation at the appropriate stage of the lesson.
2. The stages of "understanding the problem", "choosing a solution strategy", "justifying the solution" and "verifying the result" should be separately noted in the lesson plan, and the expected activities and time allocation for each stage should be determined.
3. At least one group work and one pair discussion should be organized in each lesson, and students should be required to present at least two different solutions to the same task.
4. At least one real-life task related to the Azerbaijani context and relevant to daily life should be prepared and applied on the topics of percentage, measurement, ratio, probability and graph analysis.
5. An in-school methodological seminar should be held for teachers at least twice a year on the topic of preparing, evaluating and applying PISA and TIMSS-type tasks in the lesson.
6. At least one formative assessment tool such as an observation sheet, short reflection question or exit ticket should be applied in each lesson, and the results should be registered at the end of the lesson.
7. At least two different difficulty levels of task packages should be prepared for weak and strong students in each subject, and the implementation of differentiated tasks should be monitored during the lesson.
8. At least one lesson observation and one mutual experience exchange should be organized for mathematics teachers every quarter, and exemplary lesson materials should be systematized in the school's methodological bank.
9. In each lesson, students should be required to explain the solution orally and justify it in writing, and the level of logical consistency and justification should be taken into account in the assessment, in addition to the correct answer.
10. At the end of each quarter, a short diagnostic test should be conducted to determine the indicators of mathematical judgment and logical thinking of students, and the results should be analyzed comparatively.

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