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DEVELOPING MATHEMATICAL LITERACY IN CHEMISTRY EDUCATION BASED ON A COMPETENCY-BASED APPROACH

Annotation

This article examines the essence of the concept of mathematical literacy and its role and importance in the modern education system from both theoretical and practical perspectives. Particular attention is paid to the analysis of tasks developed within the framework of the international assessment programme PISA, which are aimed at assessing students' mathematical literacy. The article highlights the importance of mathematics in PISA-based tasks that focus on analysing real-life situations, solving practical problems, and developing logical and critical thinking skills. In addition, the content, structure, and features of tasks designed to develop mathematical literacy are demonstrated through examples within a competency-based approach. The results of the study confirm that the development of mathematical literacy is an important factor in improving students' functional knowledge and skills and in preparing them to solve real-life problems.

Keywords: mathematical literacy, quality of education, PISA, competency-based approach, real-life situations, problem solving.

KOMPETENSIYAGA ASOSLANGAN YONDASHUV ASOSIDA KIMYO TA'LIMIDA MATEMATIK SAVODXONLIKNI RIVOJLANTIRISH

Annotatsiya

Ushbu maqolada matematik savodxonlik tushunchasining mohiyati hamda uning zamonaviy ta'lim tizimidagi o'rni va ahamiyati nazariy va amaliy jihatdan tahlil qilinadi. Xususan, o'quvchilarning matematik savodxonligini baholashga qaratilgan PISA xalqaro baholash dasturi doirasida ishlab chiqilgan topshiriqlarni tahlil qilishga alohida e'tibor qaratilgan. Maqolada real hayotiy vaziyatlarni tahlil qilish, amaliy muammolarni hal etish hamda mantiqiy va tanqidiy fikrlash ko'nikmalarini rivojlantirishga yo'naltirilgan PISA asosidagi topshiriqlarda matematikaning tutgan o'rni yoritib berilgan. Shuningdek, kompetensiyaga asoslangan yondashuv doirasida matematik savodxonlikni rivojlantirishga qaratilgan topshiriqlarning mazmuni, tuzilmasi va o'ziga xos xususiyatlari misollar orqali ko'rsatib berilgan. Tadqiqot natijalari matematik savodxonlikni rivojlantirish o'quvchilarning funksional bilim va ko'nikmalarini oshirish hamda ularni real hayotiy muammolarni hal etishga tayyorlashda muhim omil ekanligini tasdiqlaydi.

Kalit so'zlar: matematik savodxonlik, ta'lim sifati, PISA, kompetensiyaga asoslangan yondashuv, real hayotiy vaziyatlar, muammolarni hal etish.

РАЗВИТИЕ МАТЕМАТИЧЕСКОЙ ГРАМОТНОСТИ В ХИМИЧЕСКОМ ОБРАЗОВАНИИ НА ОСНОВЕ КОМПЕТЕНТНОСТНОГО ПОДХОДА

Аннотация

В данной статье рассматривается сущность понятия математической грамотности, а также её роль и значение в современной системе образования с теоретической и практической точек зрения. Особое внимание уделяется анализу заданий, разработанных в рамках международной программы оценивания PISA, направленных на оценку математической грамотности учащихся. В статье подчёркивается значение математики в заданиях, основанных на PISA, которые ориентированы на анализ реальных жизненных ситуаций, решение практических задач и развитие логического и критического мышления. Кроме того, в рамках компетентного подхода на примерах демонстрируются содержание, структура и особенности заданий, направленных на развитие математической грамотности. Результаты исследования подтверждают, что развитие математической грамотности является важным фактором повышения функциональных знаний и навыков учащихся, а также их подготовки к решению реальных жизненных проблем.

Ключевые слова: математическая грамотность, качество образования, PISA, компетентный подход, реальные жизненные ситуации, решение проблем.

Introduction. In the 21st century, the main task of the education system is not to encourage memorisation of knowledge, but to teach learners how to apply it in real life and to solve real-world problems. One of such essential skills is mathematical literacy. The concept of mathematical literacy has been introduced into modern education within the framework of a competency-based approach and refers to a learner's ability to understand mathematical knowledge in various real-life

contexts, use this knowledge, and make informed decisions based on it[2].

According to OECD (Organisation for Economic Co-operation and Development), within the framework of the international PISA (Programme for International Student Assessment) studies, mathematical literacy is defined as follows: "Mathematical literacy is an individual's ability to apply mathematics to solve real-life problems, to draw

conclusions based on mathematical reasoning, and to express these conclusions in a clear and understandable form"[1]. According to this definition, literacy involves not only performing calculations, but also analysis, reasoning, justification, argumentation, and model construction in real-life contexts. The term mathematical literacy was first introduced in pedagogical research in the second half of the 20th century, particularly in the 1980s. However, its widespread international use began in 2000 through the PISA studies. From that year onward, mathematical literacy was established as a key indicator of the quality of general education. In 2003, 2012, and 2022, PISA identified mathematical literacy as a priority domain. During these cycles, methodological approaches were updated, and students' skills in working with digital and graphical information were also included as assessment criteria [3].

Literature review. The issue of mathematical literacy has been widely studied in recent years as an important scientific problem in both international and national educational research [4]. In particular, various approaches have been proposed regarding the content of mathematical literacy, its components, and its significance in the educational process. A systematic analysis of the definitions and conceptual perspectives presented by researchers helps to clarify the modern interpretation of this concept[5]. Through the components presented below, learners do not merely memorise mathematical knowledge; instead, they gradually develop the ability to understand it conceptually, analyse it critically, and apply it effectively in real-life situations. These components contribute to the formation of independent thinking, problem-solving-oriented approaches, and informed decision-making competencies in learners[6].

Table 1

Main Components of Mathematical Literacy (According to the PISA Framework)

Component	Description
Formulation	Understanding the problem and transforming it into a mathematical model
Application	Using computational, geometric, or algebraic methods
Interpretation	Analysing and interpreting the result in relation to real-life contexts

In PISA tasks, mathematical literacy is assessed based on the following contexts:

- Personal (budgeting, shopping, health, time management)
- Occupational (wages, production, efficiency)
- Societal (traffic flow, population statistics, election results)

- Scientific (experimental results, graphical analysis, environmental data)

Through these contexts, knowledge is linked to real-life situations, and learners' competencies are assessed. PISA studies evaluate students' levels of mathematical literacy across six proficiency levels:[7]

Table 2

Level	Description
Level 1	Basic calculations and application of fundamental concepts
Levels 2-3	Moderate-level graphical analysis and model construction
Level 4-5	Solving extended problems and applying analytical thinking
Level 6	Developing complex models and making decisions under conditions of uncertainty

- Advantages of assessing mathematical literacy:
- Prepares learners for real-life situations
 - Develops independent thinking and decision-making skills
 - Fosters critical thinking, reasoning, and justification skills
 - Promotes a culture of working with numerical and digital data
 - Strengthens interdisciplinary connections (with biology, economics, and geography)

Mathematical literacy in contemporary education does not merely refer to the ability to handle numbers, but rather to the capacity to apply them meaningfully in real-life contexts[8]. Through international assessments such as PISA, this competence has become an important indicator of educational quality. By developing mathematical literacy, we cultivate not only knowledgeable individuals, but also a generation capable of solving real-world problems[9].

Table 3

Subject	Example	Expression in Mathematical Literacy
Chemistry	Calculating the mass of 1 mole of a substance or determining solution concentration	Using proportions, percentages, and algebraic formulas
Physics	Calculating physical quantities such as power, force, and energy	Applying formulas and understanding unit conversions
Biology	Analysing graphs showing population growth	Drawing conclusions based on graphs and evaluating statistical trends
Geography	Analysing graphs related to climate change	Working with quantitative data presented in diagrams and maps

Mathematical literacy is an integral part of learning the natural sciences. It enables learners to develop scientific thinking, a critical approach, and the ability to make decisions based on numerical evidence. By fostering mathematical literacy in the teaching of natural sciences, we educate not only knowledgeable individuals, but also analytical, creative learners who are capable of solving modern-day problems[10].

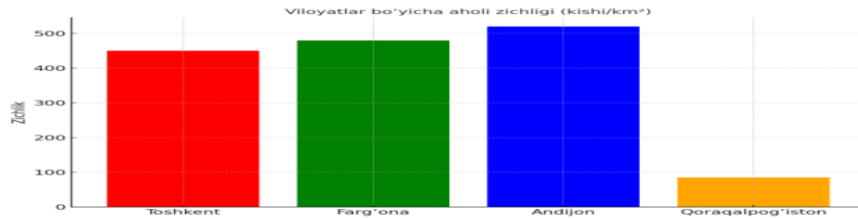
Analysis and results. In this section, tasks aimed at developing and assessing mathematical literacy are analysed.

These tasks are designed based on the methodology of the international assessment programme PISA and are intended to identify students' ability to apply mathematical knowledge in real-life and interdisciplinary contexts. In constructing the tasks, the goal is to ensure the step-by-step development of learners' competencies such as understanding a problem, creating a mathematical model, performing calculations, and analysing the results. Below, sample tasks related to mathematical literacy in the natural sciences are presented.

Task 1. A solar panel produces 1.2 kJ of energy per hour. If there are 8 hours of sunlight during the day, how much energy will be produced-?

Task description: Using basic mathematical skills to calculate the efficiency of a solar panel.	Solution: $1.2 \text{ kJ} \times 8 \text{ hours} = 9.6 \text{ kJ}$	Competency: Mathematical modelling and analysis of physical indicators.
Cognitive process: Application and evaluation	Context: Personal	Cognitive level: Level 2
Task format: Calculation		
Task 2. A car travels 100 km in 2 hours. Calculate the average speed and the fuel consumption if the car travels 12 km per 1 litre of fuel.		
Task description: Physical-mathematical calculation based on motion and fuel efficiency.	Solution: Speed = $100 \text{ km} \div 2 \text{ h} = 50 \text{ km/h}$ Fuel consumption = $100 \text{ km} \div 12 \text{ km/l} = 8.33 \text{ litres}$	Competency: Making decisions based on a physical model
Cognitive process: Application and evaluation	Context: Personal	Cognitive level: Levels 2–3
Task format: Calculation and written explanation		

Task 3. Based on the population density graph, identify the most densely populated area and explain the reasons for this.



Task description: Comparing population density across regions using a graph and providing explanations.

Solution: The highest population density is observed in Andijon region, due to a large population and a relatively small land area.

Competency: Statistical analysis and geographical interpretation

Cognitive process: Understanding and interpretation

Context: Social

Cognitive level: Level 3

Task format: Written task based on a diagram

Conclusion. In conclusion, mathematical literacy plays a crucial role in modern education by developing not only students' mathematical knowledge but also their ability to apply this knowledge in real-life and interdisciplinary contexts. The analysis of the tasks demonstrates that a mathematical literacy

- oriented approach gradually fosters students' skills in understanding problems, constructing mathematical models, performing calculations, analysing results, and drawing well-reasoned conclusions[11]. Through tasks integrated with the natural sciences, the development of mathematical literacy enhances students' scientific thinking, critical reasoning, and evidence-based decision-making competencies. At the same time, such tasks prepare learners to address real-world problems, understand interdisciplinary connections, and apply knowledge in practice. Therefore, the systematic integration of tasks aimed at developing mathematical literacy into the educational process is a key factor in improving the quality of education, strengthening students' functional literacy, and nurturing individuals who are competitive, analytical, creative, and capable of solving contemporary challenges.

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