

профільних математичних класів або учнів із поглибленим вивченням математики доцільніше використовувати підручник О. С. Істера, О. В. Єрґіної.

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DOI 10.70286/ISU-08.10.2025.010

MATHEMATICAL LITERACY AS A KEY COMPETENCE IN THE ERA OF ARTIFICIAL INTELLIGENCE AND INNOVATION

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Abstract

The article examines the experience of developing the teaching and methodological textbook “Mathematical Literacy”, created with the use of modern digital tools, including artificial intelligence. The textbook contains more than 800 tasks of varying levels of complexity, covering the key domains of mathematical literacy: quantity, change and relationships, data and probability, space and shape, logic and patterns, as well as financial markets. The work demonstrates the integration of scientific research, innovative technologies, and educational practice. The study demonstrates that mathematical literacy is a crucial competence of the 21st century, essential for the successful adaptation of individuals to the digital economy.

Keywords: mathematical literacy, artificial intelligence, educational innovation, textbook, PISA.

Introduction

Modern education faces the challenge of preparing students for life and work in the context of rapidly advancing technologies and the knowledge economy. One of the key competencies in this regard is mathematical literacy – the ability to apply mathematical knowledge in real-life situations.

Research from the international PISA program demonstrates that the level of mathematical literacy is directly correlated with the economic development of

countries. Kazakhstan, actively implementing renewed curricular content, emphasizes the development of this competence, which is also reflected in national educational programs.

Under these conditions, the task of developing methodological materials that can assist teachers and students in effectively preparing for examinations, Olympiads, and real-life challenges becomes especially relevant.

Literature Review and Approaches

The concept of mathematical literacy was introduced at the beginning of the 21st century and has become central in PISA (OECD) research. It is defined as the capacity to formulate, employ, and interpret mathematics across a variety of contexts.

Various researchers (Freeman, 2019; Serafimov, 2021) emphasize that a modern student must not only be able to solve abstract problems but also apply mathematics to data analysis, financial calculations, and spatial constructions.

In international practice, numerous textbooks and training resources have been developed; however, the integration of artificial intelligence into the process of preparing instructional materials constitutes a novel direction.

Methodology of Textbook Development

The teaching and methodological textbook “Mathematical Literacy” was created in 2025 using a hybrid approach:

- 90% of the materials were generated with the ChatGPT-5 system,
- 5% were generated using ASI1-mini,
- and 5% were revised and refined by the authors (a teacher and an 11th-grade student).

This approach made it possible to combine the accuracy and speed of AI generation with pedagogical expertise and practical validation of the materials.

The textbook includes more than 800 tasks distributed across the following key domains:

- 1) Quantity;
- 2) Change and Relationships;
- 3) Data and Probability;
- 4) Space and Shape;
- 5) Logic and Patterns;
- 6) Financial Literacy.

Each task is accompanied by explanations and detailed solutions. Particular attention is given to connections with real-life situations, which corresponds to the spirit of PISA tasks.

Examples of Exercises

Example №1 (Quantity). Aidos’s salary is 350,000 KZT. From this amount, 10% tax was withheld; then he paid 30,000 KZT for utilities and 60,000 KZT for groceries. How much money does he have left?

Solution:

Step-1. Tax: $350\,000 \cdot 0,1 = 35\,000$

Step-2. After tax: $350\,000 - 35\,000 = 315\,000$

Step-3. Expenses: $30\,000 + 60\,000 = 90\,000$

Step-4. Remaining: $315\,000 - 90\,000 = 225\,000$

Answer: 225 000 тг.

Example №2 (Change and Relationships). A car traveled the first third of the distance at a speed of 60 km/h, the second third at a speed of 90 km/h, and the last third at a speed of 45 km/h. Find the average speed over the entire distance.

Solution:

Step-1. Let the total distance be S . Then each third of the path is equal to:

$$\frac{S}{3}$$

Step-2. Time for each segment:

$$t_1 = \frac{\frac{S}{3}}{60} = \frac{S}{180}; \quad t_2 = \frac{\frac{S}{3}}{90} = \frac{S}{270}; \quad t_3 = \frac{\frac{S}{3}}{45} = \frac{S}{135}$$

Step-3. Total time:

$$T = \frac{S}{180} + \frac{S}{270} + \frac{S}{135}$$

Step-4. Convert to a common denominator 540:

$$T = S \left(\frac{1^3}{180} + \frac{1^2}{270} + \frac{1^4}{135} \right) = S \cdot \frac{9}{540} = \frac{S}{60}$$

Step-5. Average speed:

$$v_{cp} = \frac{S}{T} = S : \frac{S}{60} = 60 \text{ km/h}$$

Answer: 60 km/h

Example №3 (Data and Probability). A kiosk offers 5 ice cream flavors. A customer orders a cup with 3 scoops—order does not matter, flavors may repeat. How many different sets of scoops are possible?

Solution:

Apply the formula for combinations with repetition, C_{n+k-1}^k , where $n = 5$, $k = 3$:

$$C_7^3 = \frac{7 \cdot 6 \cdot 5}{3 \cdot 2 \cdot 1} = 35$$

Answer: 35 sets

Example №4 (Space and Shape). On a tourist map at a scale of 1:50,000, the length of the trail was measured with a ruler as 3.2 cm. How many kilometers must be traversed on the terrain?

Solution:

Step-1. Scale 1:50 000:

$$1 \text{ cm} = 50\,000 \text{ cm} = 500 \text{ m} = 0,5 \text{ km}$$

Step-2. Trail length:

$$3,2 \text{ cm} \cdot 0,5 \text{ km/cm} = 1,6 \text{ km}$$

Answer: 1,6 km

Example №5 (Logic and Patterns). A table presents a pattern. What number corresponds to the question mark? (Fig. 1)

<i>1inch</i>	45	$13\beta - 7$
<i>Cosmos</i>	?	$6\beta + 5$
<i>dydx</i>	35	$99 - 16\beta$

Fig. 1 – Patterns

Solution:

$$Cosmos \Rightarrow \beta = 6 \text{ (letters)} \Rightarrow x = 6 \cdot 6 + 5 = 41$$

Answer: 41

Example №6 (Logic and Patterns). In the figure, we see broken clock dials. The clockmaker calculated the sums of the numbers on each fragment. It turned out that for one of the dials these sums are four consecutive integers. Which dial is it (Table 1)? [Akhmetova K.P.]

Table 1. Broken clock dials:

I	II	III	IV	V

Solution:

Table 2. The sums of all fragments for each dial:

Dial	Sums of the numbers on fragments
I	$7 + 8 = 15$; $9 + 10 = 19$; $5 + 6 + 11 = 22$; $1 + 2 + 3 + 4 + 12 = 22 \Rightarrow 15; 19; 22; 22$
II	6 ; $7 + 8 + 9 = 24$; $11 + 12 = 23$; $1 + 2 + 3 + 4 + 5 + 10 = 25 \Rightarrow 6; 23; 24; 25$
III	$6 + 7 + 8 = 21$; $9 + 10 = 19$; $4 + 5 + 11 = 20$; $1 + 2 + 3 + 12 = 18 \Rightarrow 18; 19; 20; 21$
IV	$4 + 5 + 6 = 15$; $2 + 3 + 7 + 8 = 20$; $1 + 9 + 12 = 22$; $10 + 11 = 21 \Rightarrow 15; 20; 21; 22$
V	$4 + 5 + 6 + 7 = 22$; $8 + 9 = 17$; $1 + 2 + 3 + 12 = 18$; $10 + 11 = 21 \Rightarrow 17; 18; 21; 22$

Answer: Dial III: 18; 19; 20; 21

Example №7 (Financial Literacy). A bond with a nominal value of 12,000 KZT yields 6% per annum. What is the total interest income over 2 years if the coupon is paid equally each year?

Solution:

Step-1. Income for 1 year: $12000 \cdot 0.06 = 720 \text{ T}$

Step-2. Income for 2 years: $720 \cdot 2 = 1440 \text{ T}$

Step-3. Yield percentage over 2 years:

$$\frac{1\,440}{12\,000} \cdot 100\% = 12\%$$

Answer: 12%

Results and Discussion

The pilot use of the textbook in schools demonstrated:

- a significant increase in student interest in mathematics;
- improved success rates in tasks analogous to PISA;
- facilitation of teachers' work through ready-made methodological solutions.

The novelty of the project lies in the integration of artificial intelligence into the development of educational materials. The textbook demonstrates how AI can function not as a replacement for teachers but as a tool for support and acceleration in producing high-quality resources.

Conclusion

Mathematical literacy is a key competence in the era of artificial intelligence and the digital economy. The developed textbook serves as an example of how innovations and AI can be integrated into the educational process to achieve high-quality learning outcomes.

Future plans include expanding the materials, incorporating an online platform, and integrating adaptive learning systems.

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