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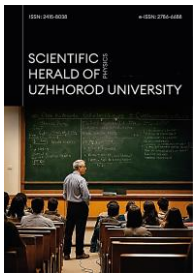

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Developing 21st century skills through PISA-based assessment-learning tasks

Yerkuat Nurgabylov*
Zhetysu University
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan

Zhalgas Akhmetov
Zhetysu University
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan

Sabyrkul Seitova
Zhetysu University
040009, 187A Zhansugurov Str., Taldykorgan, Republic of Kazakhstan

Abstract

Relevance. Currently, the textbooks used in educational schools in Kazakhstan largely lack tasks that require decision-making under conditions of uncertainty. The relevance of this study lies in addressing a significant gap in the educational curriculum of the Republic of Kazakhstan.

Purpose. The purpose of this study is to form and develop schoolchildren's decision-making skills in conditions of uncertainty, and 21st century skills, by drawing up model assessment and learning tasks and assignments for them.

Methodology. Diagnostic written work was carried out to identify the success of the developed method for constructing assessment and learning tasks, teaching schoolchildren to solve practice-oriented problems in the experimental (33 students) and control (32 students) classes.

Results. Monitoring showed that out of 33 students from the experimental class 22% did not score points corresponding to the mandatory threshold level (13 out of 26 points), 72% achieved an average level of learning (from 14 to 21 points), 6% achieved a high level of learning (from 22 to 26 points). In the control class, 68% of schoolchildren did not reach the mandatory threshold level, 29% reached the average level, 3% reached a high level of development of practice-oriented knowledge. To establish the success of the developed methodology for constructing assessment and training tasks for practical problems, a survey was conducted among mathematics teachers (17 people). The survey results showed that this approach allowed all 17 teachers to successfully create assessment and teaching tasks for selected educational tasks from a mathematics textbook.

Conclusions. Experimental studies confirm that teaching schoolchildren to solve practice-oriented problems and assessment tasks enhances their practice-oriented knowledge, including mathematical literacy, 21st-century thinking skills, and decision-making in uncertain conditions.

Keywords: decision making; thinking skills; mathematical reasoning; exam.

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*Corresponding author

Introduction

A feature of the Programme for International Student Assessment (PISA) study is that this study offers, to measure the learning of schoolchildren, the knowledge and skills that ensure the professional readiness of 15-year-old students to their practical activities. Therefore, the contents and recommendations of these studies are comprehensively used by many national educational systems of the world in order to reform the content of secondary education and improve the methods of teaching schoolchildren to solve practice-oriented problems.

With each cycle of the international PISA exam, the measured knowledge and competencies of schoolchildren, which they apply in their future practical activities, are improved and expanded. Thus, for the first time, the program concept of PISA-2021 included 21st century skills, such as: systematic, creative, critical thinking; research and study; initiative and perseverance; use of information; communication; reflection [1]. It is known that in the PISA study, the measurement of mathematical literacy of schoolchildren is implemented through the following assessment tools:

- context of problem situations;
- assessment tasks for problem situations, which contain components for assessing practice-oriented knowledge;
- mathematical reasoning, 21st century skills that students demonstrate as they complete assignments.

Mathematical reasoning includes the following competencies:

- understanding (recognition, reproduction);
- establishing a connection (establishing a variable value, connections between various concepts, objects, variables);
- reasoning (judgment, formulation, application of mathematical knowledge, interpretation of a solution, identification of patterns, generalization, abstraction).

The analysis showed that the main tool in the process of forming and developing mathematical literacy in schoolchildren is problems and assignments for them. It is through solving these types of problems that one can demonstrate the use of mathematical knowledge to understand real environmental phenomena and introduce students to methods for solving problems in science and practical activities. In this regard, in the international study PISA 2022, problematic decision-making tasks under conditions of data uncertainty were included for the first time. Since in any production process there are elements of uncertainty, which cause the emergence of problematic situations that cannot be resolved ambiguously. This situation complicates the decision-making process, finding the optimal solution in conditions of data uncertainty, which necessitate the use of appropriate methods. These methods make it possible, under certain conditions and restrictions, to make a suitable decision that is acceptable for practice.

N. Adelbayeva [2] was engaged in measuring such aspects as anxiety, fear of failure and self-efficacy of students in Kazakhstan. The conclusion revealed common and distinctive features between Kazakhstani schoolchildren in terms of these indicators of socio-emotional well-being and schoolgirls from other PISA participating countries. However, the study did not offer recommendations for improving the level of preparation of Kazakh students. N. Smanova and Sh. Tulegenov [3] analysed the results of Kazakh students in the international PISA study for different years 2009, 2012, 2015, 2018, based on which they found that Kazakhstan shows relatively low results in reading, mathematics and science literacy. The researchers substantiate this conclusion with the insufficient level of students' functional literacy measured by PISA. However, no tools have been disclosed to address these issues. B.A. Zhetpisbayeva et al. [4] pointed out that PISA testing involves measuring not the level of memorization of actual material by schoolchildren, but the effectiveness of applying their knowledge and skills in life situations. In the conclusion, it was proposed to use the method of subject-language integrated CLIL training as an effective approach to the formation of functional literacy of high school students in accordance with the requirements of PISA. The question of factors that can negatively affect the process of schoolchildren's training remained unsolved.

K.A. Zhumagulova et al. [5] formulated their own recommendations regarding the use of PISA for the formation of functional natural and scientific literacy of students in Kazakhstan. In the conclusion, it was stated that such an approach can be used to determine the priority directions for the development of natural science education; development of new educational programs and methods; evaluation of the effectiveness of modern educational reforms. At the same time, it was not determined how and on the basis of which principles the proposed recommendations will be implemented. The researchers studied the structure of the PISA test, on the basis of which the researcher developed technological maps (step-by-step problem-solving algorithms) that should be used to prepare students in Kazakhstan for the PISA tests. The study did not reveal the priority of acquiring 21st century skills for students and the specifics of their application in their daily life in today's conditions.

However, there are almost no tasks for decision-making under conditions of uncertainty in the textbooks used in educational schools of the Republic of Kazakhstan. It is a priori clear that in order to form and develop students' decision-making skills under conditions of uncertainty, it is necessary to train schoolchildren in mathematics lessons to solve practice-oriented problems and assignments for them, in the context of PISA studies. In this regard, there was a need to develop a methodology for compiling assessment-learning assignments for practice-oriented tasks on decision making under conditions of uncertainty, and a methodology for teaching schoolchildren to perform these tasks and assignments.

Literature Review

Many published scientific studies are focused on identifying problems that hinder the successful formation and development of functional literacy in schoolchildren. For example, S. Yalcin [6] revealed low functional literacy among teachers at many universities involved in the process of training future teachers. M. Hasselhorn [7] notes that a third of all children enrolled in primary school in Germany do not have sufficient academic skills, which indicates violations of the concept of primary education. C.M. Krause et al. [8] explored the problems of developing

a positive attitude among schoolchildren towards practical mathematics, improving the integration of interdisciplinary disciplines with the tasks of everyday practice, and establishing interpersonal relationships in a team.

Many countries around the world pay special attention to the successful completion of secondary education; it prepares students for a future career and admission to colleges and universities. At the same time, special attention is paid to teaching schoolchildren mathematical literacy. In this regard, in the last decade, many articles have been published on the results of the international PISA examinations. Out of these, the publication of M. Salas-Velasco et al. [9] can be highlighted, who analysed the results of the international PISA exams and emphasized that most countries more or less included topics on mathematical and financial literacy in their educational programs. Leading scientific centres and communities in Europe, America, and Asia propose to include interdisciplinary courses in secondary education programs that would contribute to the development of functional literacy in schoolchildren and are focused on successfully teaching them mathematical literacy [10].

In recent years, researchers have paid more attention to the psychological and pedagogical foundations of teaching schoolchildren mathematical literacy and the development of 21st century skills. For example, H.H. Bi [11] and Y. Belfali [12] offer a new understanding of student learning, that identifies the main goals of a mathematics teacher's efforts to improve students' mathematics achievement in the context of PISA studies. The studies of H. Retnawati and N.F. Wulandari [13], J. Jailani et al. [14] describe the dynamics of successful development of mathematical literacy in students in direct dependence on the established school level and on their class affiliation. The article by R. Lavi et al. [15] examine the problems of choosing effective teaching methods for schoolchildren from the perspective of developing mathematical literacy and 21st century skills. M. Saarela and T. Kärkkäinen [16], emphasizing the accessibility of the results of the international PISA exams, note that scientific and pedagogical research aimed at developing mathematical literacy and 21st century skills are unfortunately very small.

The work of B.S. Haug and S.M. Mork [17] examined the views of mathematics teachers on the effectiveness of using thinking skills in their teaching activities and professional development. D. Nurgabyl et al. [18] proposed an algorithm for compiling differential models of environmental phenomena, a methodology for the formation and development of interdisciplinary knowledge. In another article, D. Nurgabyl et al. [19] explored the problems of formation and development of mathematical literacy in the context of international studies PISA. Many studies are devoted to the study of the mental processes through which decision-making is realized, the characteristics of decision-making depending on the types and environment of learning, the relationship between individual ability and decision-making skill. For example, I. Bulog et al. [20], X. Yu et al. [21] studied the individual characteristics of students in the process of making various decisions in relation to their psychological characteristics.

W.X. Zhang and Y.S. Hsu [22] proposed a learning module that contributed to the involvement of students in the process of collaborative learning to make a collective decision. N.F.S. Dijkstra et al. [23] analysed and established the relationship between individual entrepreneurial ability and decision-making skill under uncertainty using the Columbia Card Task. E.S. Kim et al. [24] concluded, that decision-making inference is implemented through various cognitive and neurolinguistic processes. Moreover, the participation of these processes in decision-making judgments depends on the certain and uncertain conditions through which the decision is made. Some studies are aimed at establishing, measuring decision-making abilities. For example, J. Schiebener et al. [25] developed a model universal logistic task to determine the decision-making ability of study participants.

Thus, on the basis of this review and the conducted experimental study, authors conclude that the success of preparing schoolchildren for practical activities in adult life, in particular, depends on the formation of schoolchildren's decision-making skills in conditions of uncertainty, the development of 21st century skills that are underestimated and not offered in school mathematics textbooks.

Materials and Methods

In October 2022 in Zhetysu district of the Republic of Kazakhstan, a survey of secondary school mathematics teachers (37 people) was conducted in order to establish the attitude of teachers to solving practical-oriented problems, as well as to the formation and development of 21st century skills and mathematical literacy in schoolchildren with the help of solving practical-oriented problems.

Based on the analysis of the results of the teacher survey, it was established that all respondents have a positive attitude towards solving practice-oriented tasks in the context of PISA assessment tasks. In addition, about 71% of teachers are negative about the formation and development of schoolchildren's mathematical literacy. They justified their negative attitude by the fact that in the process of solving practice-oriented problems, schoolchildren's mathematical literacy is naturally formed and developed. It was found that more than 80% of math teachers admitted that they could not identify the tasks and assignments that would help students develop 21st century thinking skills. At the same time, they emphasize that students' critical thinking, reflection skills, and evaluations develop when discussing problem-solving algorithms. As for the skills of systemic thinking, they are improved with the help of modular learning technology and intermediate or final assessment of students' educational achievements.

Then an analysis of the content of mathematics textbooks (grades 5-9) was carried out, as a result of which it was found that the share of practical problems is more than 30% of the total number of exercises studied by schoolchildren in mathematics lessons. In this case, these educational tasks are mainly aimed at the formation of mathematical concepts, statements and the development of computing skills among students. At the same time, tasks formulated in the form of problem situations, as well as those aimed at the formation and development of mathematical literacy, are used less. In these textbooks, almost no tasks are aimed at the formation of 21st century

thinking skills among the mandatory tasks. In addition, there are no exercises involving the acquisition of decision-making skills in conditions of uncertainty. Thus, there was a need to develop methods for constructing assessment and learning tasks aimed at developing 21st century thinking skills and decision-making skills under conditions of uncertainty.

The PISA study, the stages of problem solving, the student's cognitive activity manifested at each stage of problem solving, the standard program from the school mathematics course, intended for teaching schoolchildren, became the methodological basis for the compilation of systems of assessment and learning tasks for practically-oriented tasks.

Results

The Republic of Kazakhstan has constantly taken part in measuring the quality of school education under the international PISA program since 2009. In 2018, according to the results of the PISA study, schoolchildren of the Republic of Kazakhstan showed the worst result in terms of educational level for the entire period of participation in the PISA exams (69th place out of 79 participating states) and decreased by 37 points compared to 2015.

In 2022, the average score of schoolchildren in Organisation for Economic Co-operation and Development countries in the PISA-2022 international exams in mathematical literacy decreased significantly (by 16 points), and a slight positive increase (by 1 point) was shown by schoolchildren in the Republic of Kazakhstan. Such negative dynamics were clearly manifested by the low level of development of interdisciplinary knowledge and thinking skills among schoolchildren in the process of solving practice-oriented problems [26]. This problem in Kazakhstani schools is directly related to the traditional learning process, in which teachers' pay almost no attention to the processes of formation and development of mathematical literacy and 21st century skills. The efforts of mathematics teachers in most cases are aimed at teaching schoolchildren fundamental mathematical knowledge and solving traditional mathematical problems.

In textbooks, educational and methodological materials on mathematics, used in schools of the Republic of Kazakhstan, assessment-learning assignments to practice-oriented problems, aimed at the formation and development of practice-oriented knowledge among students, are clearly insufficient. In this context, the authors refer to practice-oriented knowledge as the development of mathematical literacy and 21st century skills. Accordingly, the authors will suggest a methodology for creating assessment-learning assignments specifically designed for practice-oriented tasks. Firstly, the study showed that assessment-learning assignments for practice-oriented tasks can be successful in the formation and development of students' practice-oriented knowledge and skills only if the following requirements are used as the basis for the preparation of assessment-learning assignments, arising from the basic principles of teaching, confirmed by teaching experience:

- systematicity and consistency;
- availability;
- clarity and visuality;
- interdisciplinarity and scientific character;
- consciousness, activity, independence.

Secondly, the methodology for compiling assessment-learning assignments for practice-oriented tasks is implemented through the use of the entire algorithm for solving a practice-oriented problem. Next, the methodology for compiling assessment-learning assignments will be shown for practice-oriented tasks using the example of compiling assessment and training tasks for practice-oriented tasks on decision making under conditions of uncertainty. To form and develop decision-making skills in schoolchildren, authors will compose assessment-learning tasks using the following algorithm of actions:

1. A problem situation is formulated (a task is drawn up) with definite or uncertain data, an introductory object is compiled, which allows to visualize the problem, and stimulates schoolchildren's cognitive activity.
2. Assessment and training tasks are constructed, based on the algorithm for solving the problem.
3. The requirement for completing each assessment-learning assignment is formulated (for example, answers with justified comments are required).
4. Based on possible decision options, the optimal decision is made.
5. Information for discussion is formulated.

First consider a practical problem that has a specific, defined solution, which will be determined by considering and comparing all the data.

Task 1 "Calculation": the head cook of a small cafeteria, based on the financial capabilities of the cafeteria and the projected number of visitors, made a preliminary calculation for preparing meat goulash from lamb (Table 1).

Table 1. Calculation for preparing lamb meat goulash in a small cafeteria

Days of the week	Monday	Tuesday	Wednesday	Thursday	Friday
Mass of fresh meat	5 kg		8 kg		10 kg
Cooked meat weight	3 kg	3.6 kg	4.8 kg	2.4 kg	6 kg
Number of servings		24		16	

The search for unknown elements in this table is based on data analysis. Analysis and deductive reasoning make it possible to determine a general algorithm for solving a given problem. The identified algorithm for solving the problem allows to formulate assessment-learning assignments to this task. Completing these assignments allows to find the desired solution to the problem (Table 2).

Table 2. Assessment-learning assignments to this task

Assignment	Answer	Assessment
How much fresh meat do you need to take on Tuesday and Thursday to prepare lamb goulash? Provide answers with reasonable comments	6 kg and 4 kg	For correct completion of this task, it is proposed to give a maximum of 2 points
Determine the weight of meat allocated for one serving of meat goulash	0.15 kg	For correct completion of this task, it is proposed to give a maximum of 2 points
Fill the table	-	For correct completion of this task, it is proposed to give a maximum of 1 point
(Information for discussion). Determine what part of its weight lamb loses during cooking? Provide an answer with a reasonable comment	40%	For correct completion of this task, it is proposed to give a maximum of 2 points

Characteristics of the task (problem situation) "Calculation":

1. Area of mathematical content: semi-definite data, decision-making on the purchase of fresh meat on Tuesday and Thursday.
2. Context: social.
3. Cognitive activity: reproduction, tabular presentation, establishing connections between objects, systematization of knowledge, mathematical reasoning, deductive, inductive, computational thinking, generalization.
4. The maximum total number of points assigned for the correct solution of problem 1 is 7 points.

Thus, in the process of completing assignments 1-4 to task 1, thinking skills allowed schoolchildren to guess general patterns in several particular cases. At the same time, they develop deductive, inductive, computational thinking, and develop the skills of finding a percentage by a number and a number by a percentage. Observation, comparison, and inductive thinking are accompanied by the development in students of such important thinking skills as generalization and abstraction. Namely, they abstract from specific numerical expressions and reveal a hidden general pattern: "When cooked, sheep meat loses 40% of its original weight". A decision-making problem under conditions of uncertainty of some elements of the production cycle can be considered. In the solving process, it is preferable to not consider all options, but rather only those options that can be deemed more suitable, while discarding the unsuitable ones.

Task 2 "Delivery of vegetables": the vegetable depot received an order from a supermarket for the delivery of 11 tons of vegetables. The vegetable depot has vehicles with a carrying capacity of 3 tons and 1 ton. The director of the vegetable depot's fleet needs to select the optimal composition of trucks to fulfil the order. Based on the entire algorithm for solving this problem, assessment-learning assignments to this task are constructed. Assignment 1 to task 2: select various combinations of trucks to complete the order. Solution: the number of trucks with carrying capacities of 1 and 3 tons required to fulfil the order can be expressed through variables x and y. Thus, the following equations can be obtained (1):

$$1x + 3y = 11. \quad (1)$$

The search for solutions to this equation is based on the analysis of uncertain data. Completing this task, through deductive reasoning and analysis of the problem situation, allows to establish all kinds of truck compositions. According to the meaning of the problem situation, it is required to find all possible positive integer solutions to equation. So, according to the meaning of the problem, $x>0$. Then 11-3y>0, or $y < 3\frac{2}{3}$. Therefore, the variable y can only take the values y=1;2;3. Then from formula 1, authors obtain the corresponding values of the variable x=8;5;2. From here, the composition of trucks for fulfilling the order is determined in the form of the following pairs: (8;1); (5;2); (2;3), where the first coordinate indicates the number of vehicles with a carrying capacity of 1 ton, and the second indicates the number of vehicles with a carrying capacity of 3 tons. Answer: (8;1); (5;2); (2;3). For correct completion of this task, it is proposed to give a maximum of 3 points.

Assignment 2 to task 2: it is known that gasoline consumption from the vegetable depot to the supermarket and back for each brand of truck is 5 and 10.5 litters, respectively. Select the most optimal composition of trucks to complete the order, considering that the total gasoline consumption to complete the order should not exceed 45 litters. The search for solutions to this task is based on the use of the known, specific data. Solution: using inductive reasoning, have found the values of the objective function that determines the total gasoline consumption, authors obtain:

$$8 * 5 + 1 * 10.5 = 55.5, \quad (2)$$

$$5 * 5 + 2 * 10.5 = 46, \quad (3)$$

$$2 * 5 + 3 * 10.5 = 41.5. \quad (4)$$

It follows that the fleet director will use 2 vehicles with a carrying capacity of 1 ton and 3 vehicles with a carrying capacity of 3 tons, which make up the optimal composition of trucks, to fulfil the order. Answer: (2;3) – optimal composition of trucks. For correct completion of this task, it is proposed to give a maximum of 2 points.

Characteristics of the task (problem situation) "Delivery of vegetables":

1. Area of mathematical content: uncertainty and data, change and relationships, decision-making on choosing the optimal composition of trucks to fulfil an order.
2. Context: social.
3. Cognitive activity: reproduction, establishing connections between objects, formulation, systematization

of knowledge, mathematical reasoning, deductive, inductive, computational thinking, generalization.

4. The maximum total number of points assigned for the correct solution of problem 2 is 5 points.

Task 3 "Trade courier": the trade courier is located at A_1. He must deliver the ordered pizzas from point A_1 to points A_2, A_3, A_4 and return back to point A_1. The trade courier needs to choose the most optimal closed route (in terms of the shortest distance to visit all delivery points, timely delivery of pizzas).

Introductory text to task 3: the operating principle of navigators in smartphones is based on an algorithm for finding the optimal solution to the trade courier problem, where the delivery points are intersections. Assignment 1 to task 3: the courier is located at A_1. He must deliver the ordered pizzas from point A_1 to points A_2, A_3, A_4 and he knows $|A_{ij}|$ – the distance between the A_i-th and A_j-th points, where $i, j = \overline{1.4}$ (Table 3). Indicate all possible routes for pizza delivery to the specified points, determine the number of routes. Provide answers with reasonable comments.

Table 3. Table of distances x_{ij} between delivery points

	A_1	A_2	A_3	A_4
A_1	0	2.08	1.54	1.82
A_2	2.08	0	1.29	0.98
A_3	1.54	1.29	0	2.45
A_4	1.82	0.98	2.45	0

This content assignment is an assignment on uncertainty. Using comparison and analysis, as well as deductive, inductive, computational thinking, and combinatorial knowledge, authors determine all possible pizza delivery routes.

Solution. The number of possible routes is defined as the number of all permutations of three elements $A_2A_3A_4$ and it is equal to 3!=6, where:

$$A_1A_2A_3A_4A_1;\ A_1A_2A_4A_3A_1;\ A_1A_3A_2A_4A_1;\ A_1A_3A_4A_2A_1;\ A_1A_4A_3A_2A_1;\ A_1A_4A_2A_3A_1. \quad (5)$$

For correct completion of this task, it is proposed to give a maximum of 3 points.

Assignment 2 to task 3: determine routes that differ only in the direction of traversing the points. Provide answers with reasonable comments. When completing this task, schoolchildren operate with semi-definite data, a spatial representation of this task, and apply the principle that the distance between two points does not depend on the direction of movement. Solution: comparing the routes $A_1A_2A_3A_4A_1$ and $A_1A_4A_3A_2A_1$; $A_1A_2A_4A_3A_1$ and $A_1A_3A_4A_2A_1$; $A_1A_3A_2A_4A_1$ and $A_1A_4A_2A_3A_1$ authors make sure that these routes are equal in pairs along the entire length of the route, but differ in the direction of bypassing the pizza delivery points:

$$M_1 = |A_1A_2| + |A_2A_3| + |A_3A_4| + |A_4A_1| = |A_1A_4| + |A_4A_3| + |A_3A_2| + |A_2A_1|, \quad (6)$$

$$M_2 = |A_1A_2| + |A_2A_4| + |A_4A_3| + |A_3A_1| = |A_1A_3| + |A_3A_4| + |A_4A_2| + |A_2A_1|, \quad (7)$$

$$M_3 = |A_1A_3| + |A_3A_2| + |A_2A_4| + |A_4A_1| = |A_1A_4| + |A_4A_2| + |A_2A_3| + |A_3A_1|. \quad (8)$$

For correct completion of this task, it is proposed to give a maximum of 2 points.

Assignment 3 to task 3: choose the shortest closed route connecting all delivery points. Provide answers with reasonable comments. Solution: using the found formulas that determine the lengths of the routes M_1, M_2, M_3 as well as the data in Table 2, authors obtain:

$$M_1 = 2.08 + 1.29 + 2.45 + 1.82 = 7.64, \quad (9)$$

$$M_2 = 2.08 + 0.98 + 2.45 + 1.54 = 7.05, \quad (10)$$

$$M_3 = 1.54 + 1.29 + 0.98 + 1.82 = 5.63. \quad (11)$$

Comparing the received data, the merchant courier decides that routes $A_1A_3A_2A_4A_1$ and $A_1A_4A_2A_3A_1$ are the shortest. For correct completion of this task, it is proposed to give a maximum of 2 points.

Assignment 4 to task 3: in order to fulfil orders, the courier left pizzeria A_1 at exactly 11:55 with an average speed of 40 km/h. Which route would the courier choose, taking into account the pizza delivery time (Table 4)?

Table 4. Courier's route selection based on pizza delivery time

Pizza delivery addresses	**Order acceptances time**	**Pizza delivery time**
A_2	11:20	12:06
A_3	11:25	12:11
A_4	11:35	12:21

Solution. Routes $A_1A_3A_2A_4A_1$ and $A_1A_4A_2A_3A_1$ are the shortest. Obviously, when choosing route $A_1A_4A_2A_3$, the order delivery time to points A_2 and A_3 may be disrupted. In this regard, consider the route $A_1A_3A_2$. The order delivery time to point A_2 along the route $A_1A_3A_2$ consists of travel time and order delivery time (approximately 5 minutes). Then, using the data in Table 2, authors find that the order delivery time to point A_2 will be equal to:

$$T_2 = \frac{(1.54+1.29)}{40} * 60 + 5 \approx 9.2 \text{ min}. \quad (12)$$

Therefore, the order will be delivered to point A_2 along the route $A_1A_3A_2$ on time at 12:05, and to point A_3 the pizza will be delivered earlier than the scheduled delivery time of the order. Thus, the courier decides that the closed route $A_1A_3A_2A_4A_1$ is the most optimal. For correct

completion of this task, it is proposed to give a maximum of 3 points.

Characteristics of the task (problem situation) "Trade courier":

1. Mathematical content: uncertainty and data, decision making.
2. Context: social.
3. Cognitive activity: judgment, inference, formulation, decision making.
4. The maximum number of total points assigned for the correct solution of problem 3 is 10 points

Task 4 "Academic achievements": there are 33 students in the class. They are randomly divided into 3 groups of 11 students. Based on the results of ongoing monitoring of student progress, the mathematics teacher proposed comparing the final educational achievements of the three groups (Table 5).

Table 5. Results of current monitoring of student progress

Assessments	**2**	**3**	**4**	**5**
Number of 1st group assessments	1	6	2	2
Number of 2st group assessments	0	7	3	1
Number of 3st group assessments	3	6	1	1

Analysis of this table gives a clear idea of how the characteristic varies in the totality of data. But they are not enough to fully characterize the sample without the use of generalizing numerical characteristics. In this regard, authors come to the following assignments.

Assignment 1 to task 4: based on the results of ongoing monitoring of student progress, you will identify and compare the final educational achievements of the three groups (Table 5). Solution: the usual method for solving such a problem is to find the arithmetic mean, or the same thing, to find the average grade, which is based on the assumption that the higher the arithmetic mean, the better the educational achievements of the corresponding group. So, authors get:

$$\bar{x}_1 = \frac{2*1+3*6+4*2+5*2}{11} = \frac{38}{11} = 3.45, \quad (13)$$

$$\bar{x}_2 = \frac{2*0+3*7+4*3+5*1}{11} = \frac{38}{11} = 3.45, \quad (14)$$

$$\bar{x}_3 = \frac{2*3+3*6+4*1+5*1}{11} = \frac{33}{11} = 3. \quad (15)$$

Comparing these values, authors conclude that the final average scores of educational achievements in the first two groups are higher, identical and equal to 3.45. For correct completion of this task, it is proposed to give a maximum of 3 points. Analysing the distributions of assessments of groups whose averages are the same, authors notice that for one of them the assessment values can be scattered in a narrow range around the average, and for the other, in a wide range. Therefore, in such cases, the educational achievements of both groups may differ significantly. In this regard, authors can formulate assignment 2 to task 4.

Assignment 2 to task 4: based on the results of ongoing monitoring of student progress, you will determine more sustainable educational achievements in the groups under consideration (Table 4). Solution: sustainable educational achievement of students expresses the characteristic of deviation from the arithmetic mean and has a cognitive meaning. In this regard, authors will apply the dispersion, which determines the average square of the deviation of the assessment values from the arithmetic mean. Thus:

$$S_1^2 = \frac{1}{10}[1(2-3.45)^2 + 6(3-3.45)^2 + 2(4-3.45)^2 + 2(5-3.45)^2] = 0.87, \quad (16)$$

$$S_2^2 = \frac{1}{10}[0(2-3.45)^2 + 7(3-3.45)^2 + 3(4-3.45)^2 + 1(5-3.45)^2] = 0.47, \quad (17)$$

$$S_3^2 = \frac{1}{10}[3(2-3.45)^2 + 6(3-3.45)^2 + 1(4-3.45)^2 + 1(5-3.45)^2] = 1.02. \quad (18)$$

Comparing these values, schoolchildren decide that the students of the second group has more stable educational achievements, in contrast to students of another group. For correct completion of this task, it is proposed to give a maximum of 3 points.

Characteristics of the task (problem situation) "Academic achievements":

1. Mathematical content: uncertainty and data, decision making.
2. Context: personal.
3. Cognitive activity: judgment, inference, formulation, decision making.
4. The maximum total number of points assigned for the correct solution of problem 4 is 6 points.

The content of tasks for practice-oriented of tasks satisfies the above requirements, namely: the principles of systematicity and consistency, accessibility, visuality, interdisciplinarity and independence. Assessment-learning assignments, compiled by using the entire algorithm for solving the original problem and analysing the distribution of the sample, are aimed at developing the development of practice-oriented knowledge and decision-making skills. Teaching schoolchildren to solve assessment-learning assignments for practice-oriented problems will be successful if only the methodology for teaching schoolchildren to solve these problems is correctly selected (or developed). The context of the tasks and the assessment-learning assignments for them are mainly aimed at using the problem-based learning method (PBL).

Since the implementation of PBL begins with the construction or selection of problem situations that form the basis of this teaching method. The PBL method is aimed at the formation and development of practice-oriented knowledge and skills, and the abilities of schoolchildren for independent creative activity. In turn, the content of the developed tasks and assignments to them are focused on taking advantage of the advantages of independent completion of tasks. In this regard, such tasks should be completed by students in pairs. Obviously, this approach develops students' mathematical reasoning, critical thinking, reflection, and communication skills.

For the developed problems, of particular importance is not obtaining an answer, but the process of finding a solution, processing input information into output information through mathematical reasoning. Therefore, a final stage of cognitive work on similar assessment and learning tasks is necessary. This final stage is a discussion with the whole class about the results of students' tasks and the algorithm for solving problems in general, using cognitive, activity-based methods of discussion. When discussing, it is necessary to pay attention to the stages of solving the problem, to mathematical reasoning (understanding, formulation, application of mathematics, interpretation of the solution, decision making).

Experimental studies have confirmed that such an approach to teaching schoolchildren to solve practice-oriented problems is effective. Additionally, assessment-learning assignments contribute to the formation and development of schoolchildren's mathematical literacy. This approach also enhances 21st-century thinking skills and decision-making skills under conditions of uncertainty.

Discussion

In scientific doctrine, the issue of using the PISA approach in teaching schoolchildren and helping them to develop modern skills of the 21st century is being actively investigated. In this regard, there are positions aimed at supporting tasks based on PISA and, on the contrary, those researchers who are categorically against them. An example of representatives of the last category is the study of S. Grey and P. Morris [27], which critically analyse the PISA approach to assessing creativity as one of the key skills of the 21st century. This study also examined this relationship, namely that in the PISA 2021 cycle, creative thinking was included as a new assessment domain alongside reading, mathematics and science.

Thus, common among studies is an approach to defining creative thinking, which involves the ability to put forward non-trivial ideas that depart from conventional conclusions and create something non-standard and original. It has been criticized that PISA seeks to assess creativity by calculating the probability of random associations using computer simulations. In this regard, it is appropriate to question the appropriateness of such an approach for measuring the complex and multifaceted phenomenon of creativity. S. Grey and P. Morris also pointed out that PISA tries to reduce creativity to a narrow instrumental understanding for the purpose of international comparison and ranking of countries. Thus, a common conclusion among the studies is that the conceptualization of creativity can have a negative impact on educational policy and teaching practice.

U.A. Deta et al. [28] managed to uncover and explore specific 21st century skills that PISA assesses and which are becoming increasingly important in today's world. The researchers highlighted critical thinking, creativity, communication, cooperation and civic responsibility. During the conduct of this study, it was also established that this international study, which is coordinated by the Organization for Economic Cooperation and Development (OECD), allows to establish the level of effectiveness of information analysis, judgment making, and problem solving among students. At the same time, it should be emphasized that with the help of tasks formed on the basis of PISA, it is possible to reveal the level of development of students' abilities to generate new ideas, use non-standard methods, as well as ingenuity. All these are components of creativity skills, which are mandatory for students developing in the conditions of globalization. Also, in the research process, the feasibility of conducting a qualitative assessment of the skills of clear and concise expression of thoughts among students, which is also possible with the help of PISA tasks, was emphasized. A common finding among the studies is that PISA can effectively assess the 21st century skills of students in different countries, namely active listening, quality cooperation, teamwork, mutual respect, and responsibility for one's actions.

In the study by E. Auld et al. [29] the combination of PISA methods used to assess students' knowledge and skills was explored. In particular, multiple-choice tests and tasks were emphasized. As for the first category, it is one of the most common methods used to assess students' knowledge in reading, mathematics, and science. Accordingly, PISA tests have several levels of difficulty to cover a wide range of student abilities. With the help of tasks, it is possible to assess the ability of students to apply their knowledge and skills to solve real problems, while they can be open, closed or multiple choice.

Also, some PISA tasks require students to use a computer. During the research, special attention was paid to the survey, since this approach allows to assess the students' attitude to learning, their goals and their vision for the future. Equally important are school questionnaires, as they provide information on school policies and practices and help researchers understand how school-level factors affect student outcomes. Thus, both studies reached similar conclusions that PISA uses a combination of different methods to obtain a more holistic view of students' knowledge and skills. This helps researchers to gain better understanding on how students in different countries are preparing for life and work in the 21st century.

N.E. Susilowati et al. [30] have been researching how PISA results can be used at international, national and regional levels. During this study, attention was also paid to this issue, in particular, it was established that OECD uses PISA results to compare the education systems of OECD member countries. In addition, PISA is also used to monitor countries' progress in achieving the United Nations Sustainable Development Goals. As for the national level, both studies emphasized that Ministries of Education of countries use PISA results to assess the effectiveness of their education systems and identify priority areas of work. Thus, a common approach is that PISA results are used to develop policies and programs aimed at improving student outcomes. In the analysis at the regional level, it was found that schools can use PISA results to evaluate their performance and compare themselves with other schools. In addition, teachers can use PISA results to identify their students' strengths and weaknesses and plan lessons. What the studies have in common is the conclusion that PISA results are a valuable tool that can help countries improve their education systems and prepare their students for success in today's world.

PISA results depend on a variety of factors, which are often divided into two main categories, namely those related to students and schools. The research of the first category was carried out by S. Sjøberg and E. Jenkins [31], who found that PISA studies showed that students with higher socio-economic status tend to have better results. During this research, it was also emphasized that students, who are more motivated to study, are characterized by higher results. Also common between the approaches is the isolation of such a factor as the family environment, since students who grow up in families where education is valued, as a rule, have better academic performance. Both studies found that prior education is a determining factor, as students who have better preparation in primary and secondary school absorb new learning information faster and more effectively.

A. Pokropek et al. [32] revealed factors related to schools, one of which is the quality of the teaching staff. Accordingly, PISA studies have shown that the quality of teaching is one of the most important factors influencing student performance. In addition, this study found that students who attend schools with favourable school climates tend to perform better. A common finding is the role of resources possessed by schools, since educational centres with greater resources are characterized by higher results. The impact of school policy should be emphasized separately, as rules regarding homework and assessment can affect student results. In both studies, it was emphasized that countries with a higher level of economic development tend to have higher PISA score. It has also been emphasized that cultural factors such as attitudes towards education and the role of teachers can have a direct impact on students' results.

Based on the above, it can be established that researchers' approaches to the application of PISA are heterogeneous, which indicates the presence of both advantages and disadvantages in this approach. At the same time, it should be emphasized that PISA aims to take into account all the listed factors when interpreting the results in order to investigate the prerequisites for the appearance of differences between the performance of students in different countries.

Conclusions

An analysis of research has shown that pedagogical research devoted to the development of mathematical literacy in schoolchildren is extremely small. Authors argue that this article helps to eliminate those gaps in this problem that relate to the problems of the formation and development of practice-oriented knowledge, 21st century skills, and decision-making skills.

An analysis of textbooks used in schools in the Republic of Kazakhstan showed that educational tasks by type of presentation of context are generally not designed for the formation and development of schoolchildren's practice-oriented knowledge, 21st century skills, and decision-making skills. It can be noted that assignments to problem situations, compiled by international PISA experts, not only provide a means of measuring mathematical literacy development, but also contribute to a consistent, comprehensive study of the task. In order to eliminate this problem, namely with the help of model examples mathematics teachers should be trained in the preparation of assessment-learning assignments to practical problems, aimed at the formation and development of practice-oriented knowledge, 21st century skills, and decision-making skills under conditions of uncertainty.

Experimental work has shown that the constructed assignments to practice-oriented tasks, the proposed methodology for teaching schoolchildren, cognitive and activity-based discussions of the results of assignments by schoolchildren allow schoolchildren to develop practice-oriented knowledge, 21st century skills, and decision-making under conditions of uncertainty. Analysis of the results of schoolchildren's written assessments confirmed that increasing the development of decision-making skills in conditions of uncertainty, and, in general, the development of mathematical literacy of schoolchildren can be successfully achieved through the integration of interdisciplinary knowledge, mathematical reasoning and the thinking skills 21st century.

The results of the final survey of mathematics teachers determined that the proposed algorithm for constructing assessment-learning assignments for problem situations helps to increase methodological preparedness, expand practice-oriented knowledge of mathematics teachers, and improve the quality of the content of educational and methodological materials. The proposed algorithm for constructing tasks for problem situations can be successfully used in writing textbooks and teaching aids of the new generation, aimed at developing mathematical literacy and thinking skills of the 21st century.

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Conflict of Interest

The authors declare no conflict of interests.

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Розвиток навичок 21-го століття за допомогою навчальних завдань на основі PISA

Єркуат Нургабилов
Університет Жетису
040009, вул. Жансугурова, 187А, Талдикорган, Республіка Казахстан

Жалгас Ахметов
Університет Жетису
040009, вул. Жансугурова, 187А, Талдикорган, Республіка Казахстан

Сабиркуль Сеїтова
Університет Жетису
040009, вул. Жансугурова, 187А, Талдикорган, Республіка Казахстан

Анотація

Актуальність. Зараз у підручниках, які використовуються в школах Казахстану, значною мірою відсутні завдання, які вимагають прийняття рішень в умовах невизначеності. Актуальність даного дослідження полягає в усуненні істотної прогалини в освітній програмі Республіки Казахстан.

Мета. Метою даного дослідження є формування та розвиток у школярів навичок прийняття рішень в умовах невизначеності та навичок 21 століття шляхом складання модельного оцінювання та навчальних завдань і вправ для них.

Методологія. Для виявлення успішності розробленої методики побудови оцінювально-навчальних завдань та навчання школярів розв'язуванню практико-орієнтованих задач проведено діагностичну письмову роботу в експериментальних (33 учні) та контрольних (32 учні) класах.

Результати. Моніторинг показав, що з 33 учнів експериментального класу 22% не набрали балів, що відповідають обов'язковому пороговому рівню (13 з 26 балів), 72% досягли середнього рівня навченості (від 14 до 21 бала), 6% досягли високий рівень навченості (від 22 до 26 балів). У контрольному класі 68% школярів не досягли обов'язкового порогового рівня, 29% – досягли середнього рівня, 3% – високого рівня розвитку практико-орієнтованих знань. Для встановлення успішності розробленої методики побудови оцінювальних і тренувальних завдань для практичних вправ було проведено анкетування вчителів математики (17 осіб). Результати опитування показали, що такий підхід дозволив усім 17 учителям успішно створити завдання для оцінювання та навчання для обраних навчальних завдань із підручника математики.

Висновки. Експериментальні дослідження підтвердили, що навчання школярів розв'язувати практико-орієнтовані задачі та оцінювальні завдання покращує їхні практико-орієнтовані знання, зокрема математичну грамотність, навички мислення 21 століття та прийняття рішень у невизначених умовах.

Ключові слова: прийняття рішень; навички мислення; математичне мислення; екзамен.