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Methodological aspects of the development of functional literacy of schoolchildren in mathematics

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Abstract

Relevance. The pedagogical process should contribute to improving the functional literacy of students, including through mathematical skills. To accomplish this task, a methodology is needed that implements the effective construction of mathematics lessons.

Purpose. The purpose of the study is to consider ways to improve the functional literacy of schoolchildren in mathematics.

Methodology. To achieve this goal, the following methods were used: analysis, synthesis, hermeneutics, generalisation, concretisation, comparison, experiment, survey, and testing.

Results. The main results of the empirical research are the identification of problems faced by students when solving mathematical problems, and the selection of methods that contribute to improving functional literacy in mathematics lessons. The identified problems include: misunderstanding of mathematical terminology, problems of establishing the relationship between variables, problems in writing conclusions. To overcome these problems, students engaged in mathematics according to a methodology that includes: practice-oriented material, tasks for the classification of concepts, and also faced mathematical tasks in integrated lessons. Such training has led to the development of functional literacy. In addition, with the help of theoretical research, it was found that there is no single approach to the interpretation of the term “functional literacy”, and the fact that the term has changed since its introduction into everyday use. The meaning of the term reveals the criteria and parameters that are relevant for international monitoring checks. Moreover, when forming the original term “functional literacy”, current trends in modern life of society and human needs for effective social interaction are considered. Based on these criteria, tasks for international tests of the level of functional literacy are built.

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Conclusions. The practical value of the research is that the results can be used to develop the necessary methodologies in the construction of the pedagogical process, and in scientific activities to study the criteria of functional literacy.

Keywords: mathematics; development; interpretation; assignment; experiment; students.

Introduction

The topic of the development of functional literacy of schoolchildren with a focus on mathematical skills is very relevant, because a high command of basic mathematical knowledge is necessary for effective social interaction and solving their own life tasks. Therefore, it is important to pay attention to the creation of such a methodology that would allow translating mathematics from being an abstract science, for students, to a practically necessary and interesting science. The international monitoring study Programme for International Student Assessment (PISA), a test to assess the functional literacy of schoolchildren in different countries of the world, is conducted to determine the level of functional literacy of students. Based on the results of this international monitoring of functional literacy of the population of various countries in 2018, Kazakhstan ranks 68th out of 78 [1].

To improve the indicators of functional literacy of students, the country's leadership is modernising the education system, which once again proves the relevance and timeliness of this study. The problem of the study is that methodological aspects of the development of functional literacy of schoolchildren in mathematics with the help of empirical research have not been sufficiently investigated. The results of the reform of the education system of Kazakhstan are insufficiently highlighted, considering the methodological recommendations of monitoring organisations. The development of functional literacy in students is the subject of study of many world and Kazakh researchers, practical teachers, their papers contribute to the development of this topic and the reform of the education system of Kazakhstan. B.A. Zhaukenova considers the process of development of functional literacy of students with the help of mathematics lessons [2]. However, what exactly techniques, methods, and technologies of functional literacy development should be used to develop critical thinking when solving problems in mathematics remains unexamined.

S.Z. Nogaeva is engaged in revealing the importance of functional literacy as an advanced direction in the issues of improving the results of the education system of Kazakhstan, while not correlating the relationship of the four mathematical aspects of PISA research and methods of teaching mathematics to students [3]. U.A. Ospanova et al. analyse the activities of various international monitoring centres of functional literacy of the population of participating countries such as PIAAC, IALS, ALL and consider the results and criteria for their evaluation, although the question remains how to regulate the education system of Kazakhstan to increase the ratings of international research on functional literacy [4]. S.Kh. Baiguzhina considers the development of students' functional literacy in mathematics through the prism of the experience of the Japanese educational system, while the recommendations about the need to develop the basis of students' intellectual skills are insufficiently described in accordance with the experience of the Japanese educational system [5].

B.S. Karimova investigates the role of context-oriented tasks for the development of functional literacy of students in mathematics lessons, but there needs to be a clearer rationale for why students have difficulty with productive or contextualised tasks [6]. S.A. Imakova considers situational tasks as the main means to create a sufficient level of functional literacy of schoolchildren in mathematics lessons, while not revealing how this type of tasks will include all aspects of the content of test tasks that students will solve during international monitoring, such as: quantity (arithmetic), changes and dependencies (algebra), space and shape (geometry), uncertainty and data (statistics and probability) [7].

The purpose of this study is to develop a methodology for improving functional literacy in mathematics through empirical and theoretical research.

Materials and Methods

During this research, the methods of practical and theoretical cognition were used. To analyse the term "functional literacy", the method of hermeneutics was used to explore the principles of its interpretation. Theoretical research methods helped produce a holistic description of functional literacy, and to highlight this term in the context of mathematical knowledge. During the theoretical study, the meaning of the key term "functional literacy" was considered using methods of analysis and synthesis. The transformation of the term "functional literacy" was also considered, while methods such as classification and comparison were used, which allowed dividing the phenomenon under study into types of definitions depending on the time attribute. Generalisation and concretisation methods were used to write conclusions of theoretical research. To conduct an empirical study of functional literacy among seventh grade students, such methods as observation, comparison, experiment, survey, and testing were used. The empirical study of functional literacy of students in mathematics took place at the two economic entities, the Astana International School and the National School of Business and Engineering.

The sample consisted of seventh grade students aged 13-14 years, the experiment took place without highlighting their gender. To collect data about the objects of the study, the method of observation and survey was used. The questions that were used during the survey are aimed at identifying difficulties in solving mathematical problems. And they included the following questions: "What difficulties arise during the reading and understanding of the text of the assignment?", "What difficulties arise when drawing up graphic drawings and their descriptions?", "What difficulties arise when using formulas for calculation?", "What difficulties arise when describing numerical tabular data?". These methods identified the problems that students experience when solving mathematical problems. The available theoretical assumptions regarding effective methods of improving functional literacy in mathematics were tested by experiment. The students were engaged in math lessons

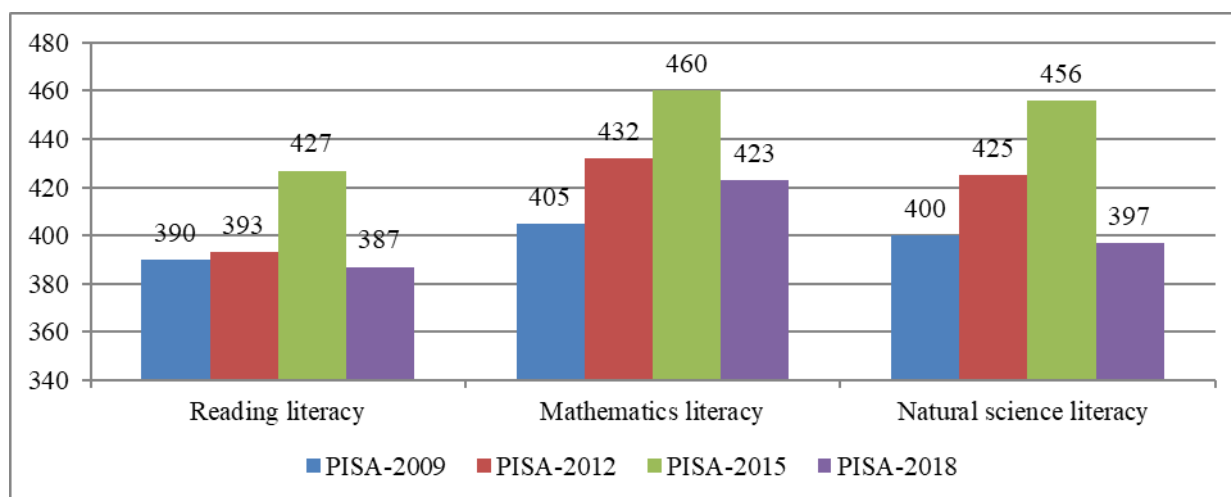
according to the chosen methods to consolidate the skills that turned out to be the lowest during the observation and survey.

In the experiment, the method of pedagogical control test was used in the preparation of tasks to establish the level of mathematical knowledge, in the context of functional literacy, considering the criteria of the PISA international monitoring. When interpreting the results of different stages of diagnosis, a comparison method was used, which provided information for subsequent calculations and interpretation. For direct calculations of the obtained primary data in the course of an empirical study, the means of mathematical and statistical analysis according to Pearson's chi-squared test were used. To interpret the results, comparison and measurement methods were used, which allowed comparing the data of the primary and final diagnostics. To describe the results of the study, graphical methods were used, which made it possible to visually display the results of an empirical study. A generalisation was used to write conclusions

based on the results of an empirical study, which allowed identifying all the important points of conducting an empirical study and structuring them.

Results

Strong subject knowledge of students does not guarantee their value for practical life. The ability to apply the acquired knowledge in life situations is called functional literacy. The existing PISA international functional literacy assessment system, which acts as an indicator of the quality of functional literacy received by students of 15 years of age. Each subsequent test changes focus. Previously, the focus was on reader literacy, this applies to the tests of 2000, 2009, and 2018. Since 2015, testing has been conducted online; Kazakhstan took part in this format in 2018. The assessment takes place according to reading, mathematical and natural science literacy (Figure 1). The PISA 2022 international monitoring is aimed at mathematical literacy and creative thinking [1].



In the PISA-2018 study, Kazakh schoolchildren demonstrated an average score in mathematics equal to 423, which allowed Kazakhstan to take 68th place in the

ranking among 78 countries participating in the study. The average score of the top 10 countries was 526 (Table 1).

Table 1. PISA-2018 results by participating countries

Country	Place	Average score		
		Mathematics	Natural science	Reading
China	1	591	590	555
Singapore	2	569	551	549
Hong Kong	3	551	517	524
USA	10	478	502	505
Kazakhstan	68	423	397	387
Azerbaijan	69	420	398	389

Source: created based on [7].

Moreover, the national report on the state and development of the education system of Kazakhstan indicates that college students show lower rates than students in schools, which means that the level of functional literacy in schools is higher [8]. It is necessary to develop a sustainable mechanism for the implementation of all tasks for the development of functional literacy among students. It should include not only updated methodological recommendations for teachers in the light of developing trends, but also sound theoretical methods,

approaches, and tools for the implementation of programmes for the development of functional literacy in Kazakh schools. Professional development programmes for teachers can be supplemented with tests to determine the competencies and level of functional literacy of teachers. As well as a unified electronic support system for teachers, recommendations for the introduction of new innovative pedagogical methods and approaches that exist and are developing in this field of education [9].

However, considering the data of the PISA assessment systems, it shows that students in Kazakhstan have insufficiently developed functional literacy. Therefore, the development of functional literacy should be one of the priorities of the education system of Kazakhstan. In the context of this study, an analysis of the concept of functional literacy should be made. According to V. Baigasheva and V. Avdonkin, functional literacy is the ability of a person to use reading and writing skills in the interaction with society (to issue a bank account, read instructions, fill out a questionnaire) [10]. That is, this is the level of literacy that gives a person the opportunity to enter into relationships with the external environment and adapt and function in it as quickly as possible. In contrast to literacy as a stable personality trait, functional literacy is a situational characteristic of the same personality. A.Y.

Sagimbayeva et al. suggest that functional literacy is the result of education that gives the skills and knowledge necessary for personal development, obtaining new knowledge and cultural achievements, mastering new techniques, successfully performing professional duties, organising family life, raising children, solving various life tasks [11].

In the PISA study, the definition of functional literacy is based on understanding whether students' skills and knowledge are sufficient for full-fledged interaction in modern society, whether the base they have received is the basis for solving a wide range of everyday life tasks. The very definition of functional literacy has been introduced by UNESCO in 1957 and has been changing over time (Table 2).

Table 2. Changing the approach to defining the term “functional literacy” in the UNESCO organisation

Year of publication	Definition of functional literacy
1957	Level of literacy that makes possible the full-fledged activity of a person in a social environment
1965	Set of reading and writing skills for use in everyday life and solving everyday problems related to economic and social priorities
1975	Skills aimed at developing “critical thinking” that allows people to act in their world, transforming it
2006	Skills that allow improving the quality of life, making informed decisions, and continuing personal development in all areas that require literacy
2013	Ability to understand, evaluate, use written texts and interact with them to participate in society, achieve goals, and develop knowledge and potential
2016	Ability to take part in activities in a residential environment that require literacy and the use of reading, writing, and numeracy for personal and social development purposes

Source: created based on [4, 12].

As can be seen from the table, UNESCO's definition of functional literacy has changed, focusing on various aspects: the possibility of a full life, life priorities, types of thinking, the ability to make decisions, achieving goals, and achieving development. Notably, with the globalisation processes and technological development, the key set of skills necessary for life is changing, this can explain the changes in the approach to determining functional literacy. The original concept of literacy as simple reading and writing skills is no longer considered sufficient to meet the demands of the digital age and the needs of society [13]. That is, it can be stated that today the ability to read and write are necessary, while, as indicated above, this is not enough. It is also important for a person to have a sufficient level of critical thinking to assess the reliability of the source of information, and the skill to assimilate and apply the knowledge gained is necessary to create new skills thanks to reliable sources of information.

Z. Cencelj et al. suggest that the term functional literacy no longer reflects the essence of competence, since in the modern complex world each scientific direction has created a specific language and a specific way of structuring texts to represent knowledge about the world and its nature [14]. The consequence of this is that the school system must develop certain types of literacy, including scientific, technological, and engineering literacy within the framework of STEM literacy. That is, it can be concluded that the concept of functional literacy correlates not the quality of knowledge gained, but more the ability to choose sources of knowledge and apply in

everyday life the skills acquired through these sources of knowledge.

In the context of this study, the development of functional literacy of schoolchildren in mathematics is considered. B.A. Zhaukenova believes that when teaching mathematics, it is necessary to pay considerable attention to the work aimed at creating such functional literacy of students, which will contribute to the development of the skill of practical use of knowledge for a wide range of everyday and professional tasks from everyday life [2]. International assessment systems allow judging the level of students' math skills and understanding of the role of mathematics in the everyday world. Moreover, based on the results of the assessment, it is possible to judge whether a person will be able to use mathematical judgments and mathematics in general as a basis to realise their capabilities and, in a certain sense, meet the needs that take place and relevance for an active and creative civic position. In 2021, a procedure for monitoring the educational achievements of students in Kazakhstan was introduced, aimed at assessing the functional literacy of 4th and 9th grade students. This internal monitoring system is designed as a computer testing of students aimed at identifying the ability to apply knowledge and skills in life situations, logical and analytical thinking. According to the results of testing, methodological assistance is provided to institutions to improve indicators [8].

S.A. Imakova suggests that the low knowledge of mathematical literacy in PISA can be improved by implementing the following methodology: an integrated

approach to improving mathematical literacy and conscious involvement of all participants in training; all tasks that were in PISA, to introduce into school curricula, to develop similar tasks for the program of updated educational content; to improve children's computer skills and update the school's computer park [7]. School access to broadband Internet; reading books and improving reader literacy to elevate to the rank of ideology, to focus the attention of teachers on the importance of inter-subject integration of school disciplines of the natural-mathematical and humanitarian cycle; to increase the motivation of schoolchildren to study through the inclusion of practical classes aimed at developing skills for applying the acquired knowledge in life situations.

S. Baiguzhina introduces practical knowledge of mathematics in mathematics lessons through the development of students' ideas about numbers through visual and practical work, drawing up a reference lesson summary [5]. The teacher claims that the success of Japanese students in the international PISA monitoring is that these students work out a high level of basic mathematical knowledge, and their educational material is more saturated with illustrative materials and less loaded with a test. S.Z. Nogaeva suggests that in order to successfully pass the PISA functional literacy assessment, students of Kazakhstan should develop such competencies as: conceptualisation, application, analysis, and

interpretation [3]. The methodology of constructing mathematics lessons should be aimed at developing these particular competencies of students. The National Plan of Functional Literacy in Kazakhstan is a fundamentally updated teaching methodology and the content of education. Features of functional literacy: – this is the basic level for the development of reading and writing skills; – is aimed at solving everyday problems; – describes a person based on his behaviour in specific situations; – teaches to solve typical tasks [15-19].

Thus, it can be stated that improving the functional literacy of students in mathematics is a complex process that covers a new methodology of teaching, building lessons through changing curricula, teaching materials and the approach of the teachers themselves to learning. To conduct an empirical study, seventh grade students were selected at two economic entities □ Astana International School and the National School of Business and Engineering. The students were tested according to the criteria of the PISA international study in mathematics, namely: to form a situation in the language of mathematics; to apply mathematical concepts, facts and procedures, to interpret and evaluate mathematical results. The first stage of the study - is diagnostic. During this stage, respondents were given practical tasks consisting of four questions aimed at studying the level of functional literacy in mathematics (Table 3).

Table 3. Characteristics of tasks for the diagnosis of functional literacy in mathematics

Structural components	Assessment scope
Mathematical conditions	Knowledge of terms and command words, careful reading, writing definitions, possession of logical phrases
Story	Careful reading, practice of checking conclusions, interpretation
Visual intermediaries	Analysis of various manifestations of concepts, drawing conclusions, conclusions
Pattern	Practising different levels of mathematical proof, patterns

Analysing the responses of students after the diagnosis of functional literacy in mathematics, it can be stated that

the percentage of basic skills was distributed rather unevenly (Figure 2).

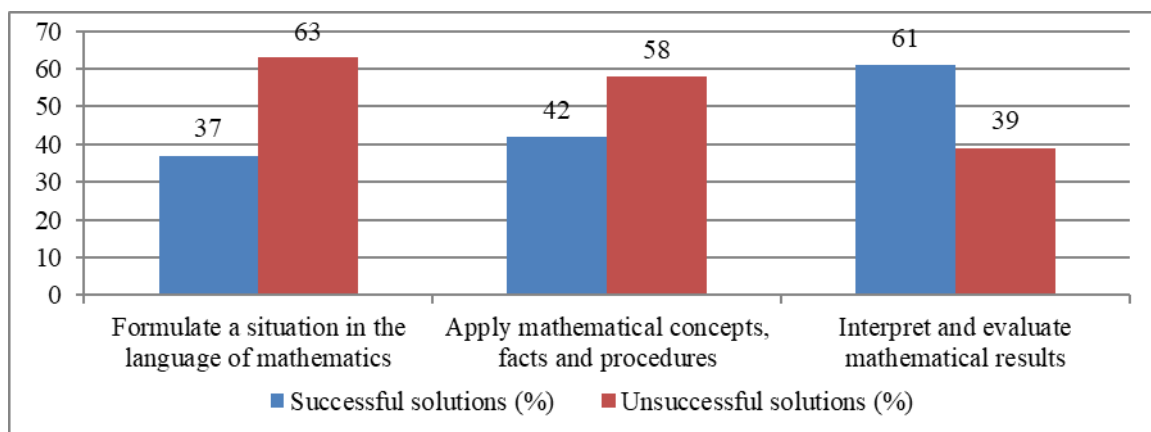


Figure 2. The level of developed skills of functional literacy in mathematics according to PISA criteria

Figure 2 shows that respondents demonstrated more skills during the interpretation and evaluation of mathematical results. The second stage of the empirical study was a survey of respondents who gave incorrect

answers about the difficulties that arise in the process of completing practical tasks in mathematics. The results are shown in Table 4.

Table 4. Student survey results

No.	Question	Respondents' answers
1	What difficulties arise in the course of reading and understanding the text of the assignment?	A large number of unknown terms – 63%

2	What difficulties arise when drawing up graphic drawings and their descriptions?	Not knowing the technique of constructing graphic drawings and describing the conclusion – 42%
3	What difficulties arise when using formulas for calculation?	Misunderstanding of the relationship between variables – 58%
4	What difficulties arise when describing numerical tabular data?	Difficulties in comparing the most significant indicators to describe their impact – 39%

Table 4 shows that most of the respondents' problems are related to mathematical terminology, inability to identify relationships between variables that can be presented in various forms (verbal, graphic), difficulties in drawing conclusions when describing the solution of the

problem. In order to overcome the difficulties of students and improve their functional literacy with the help of mathematics, skills that need correction with the help of mathematical tasks were selected (Table 5).

Table 5. Methods of improving skills in mathematics with the help of mathematical problems

Ability	Type of mathematical problems	Acquired skills
Formulation of the situation in the language of mathematics	Tasks for creating models of problem solving. Tasks that create the need to analyse different types of data: tables, diagrams, figures. Tasks for the classification of concepts.	Ease of interpretation of mathematical terminology. The ability to analyse data recorded in different formats, combine them into groups, explain why they belong to a group, and formulate common features for each group.
Apply mathematical concepts, facts, and procedures	Practice-oriented tasks. Activities that develop inter-subject relations (project and research work).	The ability to analyse and summarise issues when drawing conclusions and describing the solution to the problem.

Thus, the development of functional literacy in mathematics of students can be developed using a methodology that includes: practice-oriented material, tasks for the classification of concepts integrated lessons that will consider the same object from different sides and

from the perspective of different subjects. The results of the study showed that the use of these methods allowed to increase the functional literacy in mathematics of students (Table 6).

Table 6. Comparative analysis of the results of diagnostics of functional literacy of students in mathematics

Evaluation criteria	Successful		Unsuccessful	
	Primary diagnostics	Final diagnosis	Primary diagnostics	Final diagnosis
Form a situation in the language of mathematics	37%	43%	63%	57%
Apply mathematical concepts, facts, and procedures	42%	54%	58%	46%
Interpret and evaluate mathematical results	61%	70%	39%	30%

With identified problems, in the process of interviewing respondents, with the use of mathematical terminology, inability to identify relationships between variables that can be presented in different forms (verbal, graphical), difficulties in drawing conclusions when describing the solution of the problem. Math lessons were conducted using tasks: creating models for solving a problem, classifying concepts, practice-oriented tasks,

design and research work. The influence of new methodologies in the construction of mathematics lessons on the development of functional literacy was determined using Pearson's chi-squared test (χ^2). The test was performed six times to calculate the average value. The results were evaluated as "successful" or "unsuccessful" (Table 7).

Table 7. The results of the mathematical and statistical analysis of the results of the study according to the Pearson chi-squared test (χ^2)

No.	Indicators	Values
1	χ^2	2
2	$\chi^2 (0.05;5)$	11.07
3	p-value	0.06
4	χ^2 test	0.84

To analyse the data, it was expected that the level of difficulties faced by students when using terms in the text, formulating rules and definitions decreased compared to

the level at the beginning of the study (40%), and the reliability of these expectations was verified using the chi-squared test (Table 7). It follows from the table below that,

since the value of the variable p does not significantly exceed the established significance level (0.05), the assumption of reducing difficulties in solving problems was confirmed. This allowed registering positive changes according to the above criteria of functional literacy in comparison with the first diagnostic stage of the empirical study. The final diagnosis was carried out based on criteria and indicators. During the re-diagnosis, tasks similar to the first stage of the experiment were used.

Figure 3 shows that the results of an empirical study on the development of functional literacy of students in mathematics with the help of new methodologies have a tendency to improve on all three criteria. Thus, comparing the results of the diagnostic stages of an empirical experiment, students more easily formulate conclusions using mathematical terms, can interpret information from different sources (text, graphic). That is, students can analyse, understand and evaluate the task in front of them.

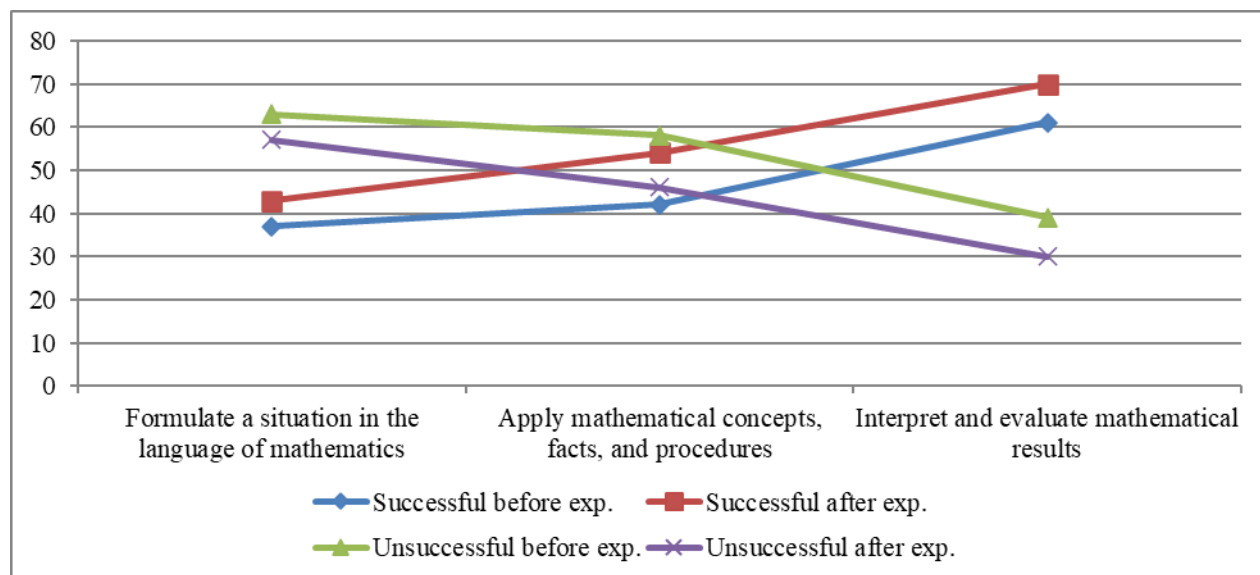


Figure 3. Comparison of the level of functional literacy of students in mathematics according to PISA criteria at the first and final stages of an empirical study

Based on the results of the experiment, it can be stated that the methodology of building a lesson using: tasks for creating models of problem-solving; tasks that create the need to analyse different types of data: tables, diagrams, drawings; tasks for the classification of concepts; practice-oriented tasks; activities that develop subject-to-subject relationships there have been significant changes in the selected criteria of functional literacy.

Discussion

According to the data obtained by A. Syafitri et al., the problem-based learning (PBL) approach had a positive effect on students' mathematical literacy abilities [16]. This is confirmed by the results of this study, where practice-oriented tasks were used. I.R. Khaesarani and R. Ananda are engaged in the study of functional literacy in mathematics in Indonesia [17]. According to the results of the PISA, Indonesia ranked 72nd out of 78 participating countries, so scientists also recommend developing students' mathematical knowledge through the introduction of methodologies based on higher-order thinking □ this is the skill of solving mathematical problems as problems that link new and old experiences. The student's ability to connect several related concepts is important, operating with them and changing them at the same time using them to obtain new solutions. What this study confirms in the context of the use of types of mathematical problems that will affect the development of key parameters of functional literacy of students in mathematics, they are also aimed at encouraging students to use old and new methods of solving problems [20-24].

N. Nurhanurwati, in their research on functional literacy in the context of mathematical science, came to the conclusion that mathematics teachers should conduct training by involving students in solving real-life problems that students may face, that is, those that exist in the real world [18]. Thus, students' ability to formulate, apply, and reason will develop. At the same time, students will be using their thinking to solve problems. This is also confirmed by this study, which found that students are more thoughtful about solving practice-oriented tasks [25; 26]. S. Cruz and D. Vargas offer an Open High School Program (OHSP) for Filipino students [19]. These schools aim to motivate students to attend classes and thereby improve their functional literacy. Scientists have come to the conclusion that if the quality of education is improved by applying a policy aimed at ensuring that school instruction is student-oriented, then the results of the level of functional literacy will increase. This study also shows that formal learning of mathematics leads to difficulties for students.

D. Verner and N. Blunch conducted research in West Africa, where they confirmed the importance and significance of functional literacy for a person's professional and social life, studies have shown that functional literacy is a prerequisite for entering the labour market and the level of financial return depends on the level of functional literacy [20]. The research by D. Surwanti and I. Hikmah has established that functional literacy of students in relation to simple instructions can be developed through practice and habituation [21]. Habituation should be directly related to everyday life, and also requires sustained practice not only in the classroom,

but also outside the classroom, so that it becomes a habit and they can live well in society [27-30]. This is confirmed by this study in terms of the application of practice-oriented tasks and the implementation of inter-subject projects to improve the level of functional literacy.

A.Y. Sagimbayeva et al. concluded that in the process of improving the functional literacy of students, it is necessary to change the pedagogical approach to a more loyal one, then the teacher turns from a harsh judge into a caring assistant and adviser [11]. The conflict zone disappears between the teacher and the student and the probability increases that the acquired knowledge will become skills [31]. This study also determines that the improvement of functional literacy should be accompanied not only by the introduction of a new methodology but also by a change in the pedagogical approach. Z. Cencelj et al. conducted a study of functional literacy in schools and found that a transition from understanding functional literacy as a monolithic competence to the so-called functional literacy in subject areas is necessary [22]. Functional literacy in certain subject areas can only be the result of interdisciplinary cooperation between a native language teacher and a subject teacher or teachers, while the latter bears the share of responsibility [32-35]. This also reflects this study in the context of the need for a new methodology of the educational process.

The theoretical analysis allowed considering the definition of functional literacy, which is designated by the international organisation UNESCO. It can be said that the principles of interpretation of the definition have changed in accordance with the relevance of various aspects of public life. In earlier periods, the emphasis was on the possibilities of a full-fledged human life, which give the skills of writing, reading and counting [36]. Further, the concept expanded and covered life priorities, different types of thinking that can enable a person to develop in the conditions of technological development and the strengthening of globalisation processes [37; 38]. This is a natural process, because for modern life, reading, counting, and writing skills are not enough, it is necessary to have critical thinking to assess the situation, develop skills that will contribute to improving the quality of life and unlocking potential. All these aspects currently reflect the meaning of the term “functional literacy” [23]. That is, it can be concluded that the concept of functional literacy correlates not the quality of knowledge gained, but more the ability to choose sources of knowledge and apply in everyday life the skills acquired through these sources of knowledge. Notably, the improvement of the functional literacy of students in mathematics is a complex process that covers a new methodology of teaching, building lessons through changing curricula, creating new teaching materials, and changing teachers’ approach to learning [39-42].

Empirical research has revealed the problems of students that are associated with mathematical terminology, inability to identify relationships between variables, difficulties in comparing different forms of data, difficulties in writing conclusions. This set of problems can be corrected by changing the methodology of constructing mathematics lessons. The new methodology should include practice-oriented tasks, tasks with the need to classify concepts [24; 43]. It is also important to conduct

integrated lessons that will allow using mathematical skills in the study of other subjects and fields of science. The level of difficulties faced by students when using terms in the text, formulating rules and definitions decreased compared to the level of the beginning of the study (40%), and the reliability of these expectations was verified using the chi-squared test. It follows from the mathematical and statistical calculations made that, since the value of the variable p does not significantly exceed the established significance level (0.05), the assumption of reducing difficulties in solving problems was confirmed. This allowed registering positive changes according to the above criteria of functional literacy in comparison with the first diagnostic stage of the empirical study. On the basis of the selected criteria and indicators, the final diagnosis was carried out. During the re-diagnosis, tasks similar to the first stage of the experiment were used.

The results of an empirical study on the development of functional literacy of students in mathematics with the help of new methodologies have a tendency to improve on all three criteria. Thus, comparing the results of the diagnostic stages of an empirical experiment, students more easily formulate conclusions using mathematical terms, can interpret information from different sources (text, graphic). That is, students can analyse, understand and evaluate the task in front of them. Based on the results of the experiment, it can be stated that the methodology of building a lesson with the use of new tasks has confirmed its effectiveness. Among them were: tasks for creating models of problem solving; tasks that create the need to analyse different types of data: tables, diagrams, figures; tasks for the classification of concepts; practice-oriented tasks; activities that develop subject-to-subject relationships. At the end of the empirical study, students had significant changes in the selected criteria of functional literacy.

Conclusions

This study analysed approaches to defining functional literacy, in general and in the context of mathematics skills. It was found that there is no single interpretation of the definition of functional literacy, but this is characteristic of the theoretical foundations of the social sciences. This term in papers and normative documentation of international organisations has changed with the understanding of the needs of modern man, the development of technology and the acceleration of globalisation processes. At the same time, the focus shifted from literacy and understanding of texts as basic human knowledge to skills that should ensure effective human interaction for public and personal purposes. Notably, the improvement of the functional literacy of students in mathematics is a complex process that covers a new methodology of teaching, building lessons through changing curricula, creating new teaching materials, and changing teachers’ approach to learning.

In the course of an empirical study, it was revealed that most of the problems of students are related to mathematical terminology, the inability to identify relationships between variables that can be presented in various forms (verbal, graphic), difficulties in drawing conclusions when describing the solution of a problem. The solution to these problems and the development of functional literacy in mathematics of students can be

developed using a methodology that includes: practice-oriented material, tasks for the classification of concepts, integrated lessons that will consider the same object from different sides and from the perspective of different sciences. International research and monitoring stimulate the development of functional literacy in many countries, including Kazakhstan. Based on the recommendations prescribed after the PISA-2018 monitoring, reformation procedures for changing the teaching system in schools are being developed. The methodology of building lessons should include tasks that will contribute to the

development of the student's critical thinking. Such tasks are not done by example from the textbook, but only have hints to construct the correct solution.

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None.

Conflict of Interest

None.

References

- [1] Education in Eastern Europe and Central Asia: Findings from PISA. 2021. <https://www.oecd.org/countries/georgia/education-in-eastern-europe-and-central-asia-ebceb179-en.htm>
- [2] Zhaukenova BA. Formation of mathematical literacy of students in the process of teaching mathematics. *Ped Sci Pract.* 2016;1(11):62-67.
- [3] Nogaeva SZ. Functional literacy is the main direction of improving the quality of education. *Sci Time.* 2022;5:27-31.
- [4] Ospanova UA, Kulakhmetova AR, Shalina AN. International comparative and country studies (PIAAC, IALS, ALL) on the assessment of basic functional literacy skills. *Bull L.N. Gumilyov Eurasian Nation Uni.* 2023;1(142):222-234.
- [5] Baiguzhina SKh. Development of functional literacy of students in mathematics lessons: Using the experience of the Japanese school. *Ped Sci Pract.* 2016;3(13):94-97.
- [6] Karimova BS, Zhetpeisova NO, Kypshakbai NK. The role of context-based tasks in the development of functional literacy of schoolchildren. *Bull Sci Educ.* 2021;8(111):60-67.
- [7] Imakova SA. Situational tasks as a means of developing the functional literacy of schoolchildren in mathematics lessons. 2021. <http://www.gbilim.kz/index.php/me-tep/79-situatsionnye-zadachi-kak-sredstvo-formirovaniya-funktsionalnoj-gramotnosti-shkolnikov-na-urokakh-matematiki>
- [8] National report on the state and development of the education system of the Republic of Kazakhstan for 30 years of independence and 2021. 2023. <https://www.gov.kz/memleket/entities/edu/documents/details/407389?lang=ru>
- [9] Hanley N, Ospanova UA, Baimakhanbetov MA. Development of functional literacy in secondary education: Thematic discourse analysis. *Bull Al-Farabi Kazakh Nation Uni.* 2022;70(1):16-30.
- [10] Baigasheva V, Avdonkin V. Formation of functional literacy of students in the classroom as the basis for the development of creative personality. 2022. <https://ojs.ukrlogos.in.ua/index.php/interconf/article/view/18350>
- [11] Sagimbayeva AY, Avdarsol S, Yerekeshova M, Baiganova AM, Kuanysh D. Assessment of functional literacy of students in computer science based on the criteria-based approach. *Cypriot J Educ Sci.* 2022;17(4):1227-1243.
- [12] Vágvolgyi R, Coldea A, Dresler T, Schrader J, Nuerk HC. A review about functional illiteracy: Definition, cognitive, linguistic, and numerical aspects. *Front Psychol.* 2016;7:1617.
- [13] Nurgiyantoro B, Lestiyarini B, Rahayu DH. Mapping junior high school students' functional literacy competence. *J Cakrawa Pendidik.* 2020;39(3):560-572.
- [14] Cencelj Z, Aberšek B, Flogie A, Aberšek MK. Metacognitive model for developing science, technology and engineering functional literacy. *J Baltic Sci Educ.* 2020;19(2):220-233.
- [15] Taskynbayeva K, Ybyrayeva K. Improving students' creative research skills via integrating functional literacy. *InterConf.* 2023;143:126-131.
- [16] Syafitri A, Huda N, Haryanto. Problem-based learning model: It's effect on mathematical literacy ability based on students' visual verbal ability. *Al-Jabar: J Pendidik Matem.* 2021;12(2):427-436.
- [17] Khaesarani IR, Ananda R. Students' mathematical literacy skills in solving higher-order thinking problems. *Al-Jabar: J Pendidik Matem.* 2022;13(1):81-99.
- [18] Nurhanurwati N, Caswita C, Bharata H, Widyastuti W. The analysis of junior high school students' mathematical literacy: Field study in Bandar Lampung. *Al-Jabar: Pendidik Matem.* 2022;13(1):199-209.
- [19] Cruz S, Vargas D. Open High School Program (OHSP): Efficacy in its implementation. 2021. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3800933
- [20] Verner D, Blunch NH. Is functional literacy a prerequisite for entering the labor market? An analysis of the determinants of adult literacy and earnings in Ghana. 2000. <https://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-2410>
- [21] Surwanti D, Hikmah I. Improving students' awareness of functional literacy. *Eng Lang Teach Educ J.* 2019;2(2):79-89.
- [22] Cencelj Z, Kordigel Aberšek M, Aberšek B, Flogie A. Role and meaning of functional science, technological and engineering literacy in problem-based learning. *J Baltic Sci Educ.* 2019;18:132-146.
- [23] Abylkassymova AE, Kappasova SE, Zhadraveva LU. Development of mathematical literacy of schoolchildren through discourses. *Bull Abai Kazakh Nation Ped Uni.* 2022;3(79):110-117.

- [24] Konstantinov NN, Semenov AL. Productive education in the mathematical school. *Chebys Collec.* 2021;22(1):413-446.
- [25] Kudabayeva K, Kosmuratova R, Bazargaliyev Y, Sartayeva A, Kereyeva N. Effects of metformin on lymphocyte DNA damage in obese individuals among Kazakh population. *Diabet Metabol Syndr: Clinic Res Rev.* 2022;16(8):102569.
- [26] Kudabayeva KI, Bazargaliyev YS, Batenobna K, Agzamova RT. Peculiarities of chronic gastritis in diabetes mellitus type 2. *Eur J Phys Health Educ.* 2014;6:1-5.
- [27] Tokysheva G, Makangali K, Uzakov Y, Kakimov M, Vostrikova N, Baiysbayeva M, Mashanova N. The potential of goat meat as a nutrition source for schoolchildren. *Potravinar Slovak J Food Sci.* 2022;16:398-410.
- [28] Marzhan D, Maxat D, Akbota A, Moldabek K, Rabiga K, Rysbayeva G. The development of computational skills of visually impaired children of primary classes. *Cypr J Educ Sci.* 2022;17(2):451-463.
- [29] Jawabreh O, Qader AA, Salah J, Al Mashrafi K, AL Fahmawee EAD, Ali BJA. Fractional Calculus Analysis of Tourism Mathematical Model. *Progr Fract Different Applic.* 2023;9:1-11.
- [30] Kenesbayev SM, Salgarayeva GI, Makhmetova AA, Idrisov SN, Sabit B. Management of information software systems in the corrective work with children with disabilities. *Espacios.* 2017;38(46):34.
- [31] Nukusbekova G, Toguzbayeva D, Hashimli R, Oguz H, Taukeleva S. Reflux Symptom Index: Translation to the Kazakh Language and Validation. *J Voice.* 2022. doi: 10.1016/j.jvoice.2022.07.004
- [32] Suatbayeva R, Toguzbayeva D, Taukeleva S, Mukanova Z, Sadykov M. Speech perception and parameters of speech audiometry after hearing aid: Systematic review and meta-analysis. *Electr J Gen Med.* 2024;21(1):em563.
- [33] Vasenko VV, Kovtun NI, Krasiuk LV. Algorithmization of subject-transformative activities of younger schoolchildren during design and technology classes. *Scient Societ.* 2023;1(3):16-25. doi: 10.31470/2786-6327/2023/3/16-25
- [34] Maltsev DV. Efficiency of a High-dose Intravenous Immunoglobulin Therapy in Children with Autism Spectrum Disorders Associated with Genetic Deficiency of Folate Cycle Enzymes. *J Glob Pharm Technol.* 2019;11(5):597-609.
- [35] Maltsev D, Natrus L. The effectiveness of infliximab in autism spectrum disorders associated with folate cycle genetic deficiency. *Psych, Psychother Clinic Psychol.* 2020;11(3):583-594.
- [36] Maltsev D. High-dose intravenous immunoglobulin therapy efficiency in children with autism spectrum disorders associated with genetic deficiency of folate cycle enzymes. *Psych, Psychother Clinic Psychol.* 2016;7(2):207-224.
- [37] Salah J, Ur Rehman H, Al-Buwaiqi I. The Non-Trivial Zeros of The Riemann Zeta Function through Taylor Series Expansion and Incomplete Gamma Function. *Mathem Statist.* 2022;10(2):410-418.
- [38] Salah JY. Properties of the modified caputo's derivative operator for certain analytic functions. *Int J Pure Appl Mathem.* 2016;109(3):665-671.
- [39] Kasyanenko O. Directions of ICT use in Ukrainian educational institutions in the educational process with children with special educational needs: A literature review. *Sci Bull Mukachevo State Univer. Ser "Ped Psychol."* 2023;9(3):17-26. doi: 10.52534/msu-pp3.2023.17
- [40] Kudabaeva KI, Koshmaganbetova GK, Bazargaliyev YS, Baspakova AM. Assessment of the iodine status in the population in western Kazakhstan according to data of urinary iodine concentrations. *Gig Sanit.* 2016;95(3):251-254.
- [41] Kudabaeva KI, Yermukhanova LS, Koshmaganbetova GK, Bazargaliyev YS, Baspakova AM, Kaldybaev KK, Kaldybaeva AT. Estimation of the thyroid gland volume by means of ultrasonography among school children in Aktobe Area, Kazakhstan. *Res J Pharm, Biol Chem Sci.* 2015;6(2):87-93.
- [42] Salah J, Al Hashmi M, Rehman HU, Al Mashrafi K. Modified Mathematical Models in Biology by the Means of Caputo Derivative of a Function with Respect to Another Exponential Function. *Mathem Statist.* 2022;10(6):1194-1205.
- [43] Baidalinova BA, Gabdulhaeva BB, Zhakupov MK, Darzhuman GK, Kabieva SZ. Vocational training of students when studying biological disciplines. *Life Sci J.* 2014;11(SPEC.ISS.1):245-248.

Методичні аспекти розвитку функціональної грамотності школярів у процесі навчання математики

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Анотація

Актуальність. Педагогічний процес повинен сприяти підвищенню функціональної грамотності студентів, у тому числі за допомогою математичних навичок. Для виконання цього завдання необхідна методика, що реалізує ефективну побудову уроків математики.

Мета. Метою дослідження є розгляд шляхів підвищення функціональної грамотності школярів на уроках математики.

Методологія. Для досягнення поставленої мети використано такі методи: аналіз, синтез, герменевтика, узагальнення, конкретизація, порівняння, експеримент, анкетування, тестування.

Результати. Основними результатами емпіричного дослідження є виявлення проблем, з якими стикаються учні під час розв'язування математичних задач, та підбір методів, що сприяють підвищенню функціональної грамотності на уроках математики. Серед виявлених проблем: нерозуміння математичної термінології, проблеми встановлення зв'язку між змінними, проблеми з написанням висновків. Для подолання цих проблем учні займалися математикою за методикою, яка включає: практико-орієнтований матеріал, завдання на класифікацію понять, а також стикалися з математичними задачами на інтегрованих уроках. Таке навчання призвело до розвитку функціональної грамотності. Крім того, за допомогою теоретичного дослідження було виявлено, що не існує єдиного підходу до трактування терміну «функціональна грамотність», а також те, що термін зазнав змін з моменту його введення в повсякденний вжиток. Зміст терміну розкриває критерії та параметри, які є релевантними для міжнародних моніторингових перевірок. Крім того, при формуванні оригінального терміну «функціональна грамотність» враховано актуальні тенденції сучасного життя суспільства та потреби людини в ефективній соціальній взаємодії. На основі цих критеріїв побудовано завдання для міжнародних тестів рівня функціональної грамотності.

Висновки. Практична цінність дослідження полягає в тому, що результати можуть бути використані для розробки необхідних методик при побудові педагогічного процесу, а також у науковій діяльності для дослідження критеріїв функціональної грамотності.

Ключові слова: математика; розвиток; інтерпретація; завдання; експеримент; студенти.