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Quality Accordingly PISA: from Math Teachers' Continuing Education to Students' Mathematical Literacy

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Abstract

The article reveals the problem of education quality improvement, which acquires an important social significance nowadays. The priorities of education quality in Russia are formulated by the President Vladimir Putin who emphasizes that education quality is a system-forming and dominant factor in the social development of the individual, society and state.

Analyzing philosophical, social and pedagogical approaches to the notion "quality of education", it is revealed that this phenomenon determines the conditions and effectiveness of educational process in society. Education, corresponding to the needs of society is considered in the context of a comparative study of PISA general education quality, emphasizing that the results of PISA correlate with the economic and social development of the country. We suggest practical ways to improve the significance of Russian general education system quality in the definition of 15-year-olds mathematical literacy based on the identification of math students' problems. The levels of mathematical literacy achievements and their special characteristics are given in the table of the indicators.

As a practical significance of the research results presented in this paper, is the Program "Formation of practical mathematical literacy of schoolchildren", used in the process of math teachers training and aimed at improving their professional competence to form schoolchildren mathematical literacy.

The article represents the training manual "Life as a mathematical plot" to master the formation of students mathematical competence in grades 7-8. It is directed to making the transition from abstract mathematical tasks to solving practical social problems.

Keywords: PISA, quality of education, mathematical literacy, math teacher, mathematical competence, mathematical problem.

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Introduction

Russian State Educational Policy of the 21st Century is based on the ideological platform “Accessibility - Quality - Efficiency”, in connection with which the quality of education acts as the most important system-forming and dominant factor in the social development of the individual, society and state. On the background of fundamental changes in the economic, political, cultural life of the country, which are aimed at the formation of new economic and social structures and mechanisms that significantly change the content of the requirements for the quality of Russian education (Skudareva, 2015).

The President of the Russian Federation expressed his ideas on the essential state of educational policy of the 21st century on January 30, 2018 :

“... Education issues are extremely important, ... It is impossible to achieve the development of technologies of future without qualitative education, and Russia should be one step ahead in this sphere” (Latuhina, 2018).

In his annual Address to the Federal Assembly on March 1, 2018 V.V. Putin said: “We will continue active work to develop our general education but at all levels. At the same time, I emphasize: a modern, high-quality education should be accessible to every child. Equal educational opportunities are a powerful resource for the development of the country and ensuring social justice ” (Latuhina, 2018).

Close attention to the quality of education was also mentioned in the Decree of the President of the Russian Federation of May 7, 2018 (2018) where the President set up the goal: “... When developing the national project in the field of education, proceed from the fact that in 2024 it is necessary to achieve the following goals and targets: ensuring global competitiveness of the Russian education, the Russian Federation entering the ten leading countries in the world on the terms of general education quality”.

The normative quality of education is fixed in the Federal Law on Education (Government of the Russian Federation, 2012) and the Federal State Education Standards for Secondary General Education (2012) as a complex characteristics of educational activities and students training, expressing the degree of their compliance with federal state educational standards, federal state requirements and (or) the needs of the individual or legal entity in whose interests the educational activity is carried out, including the degree of the planned results in the educational program achievements (Skudareva, 2015).

It seems to us relevant and possible to discuss the problems of education quality, identify its theoretical aspects, note its applied value and analyze the practical experience of university education in improving the quality of education.

Literature Referencies

It is essential to define the theoretical foundations of the concept “quality”. “Quality” as a philosophical category is a combination of all essential, relatively stable properties and characteristics of an object or a subject. The doctrine of quality has gone the way from the qualitativism of Aristotle to the modern qualitative paradigm. Systemic changes in the nature of quality were already made in Aristotelian teaching: an attempt to classify qualities, the principle of integrity, the concept of a hierarchical structure of material objects quality were developed. Hegel investigated the category of quality rather broadly, in the aggregate of the concepts “quantity”, “limit”, “certainty”, “property”, “measure”, etc. Hegel approved the primacy of quality over quantity. The doctrine of quality was further developed in Marxist philosophy. K. Marx showed that the products of human labor, also acquire systemic, social qualities that reflect their inclusion in the system of social relations (Maykova, 2015). Subetto (2017) identifies many aspects in the definition of quality: property, structurality, dynamism, certainty.

Recently, the category of “quality” in pedagogics is the most used for the analysis and interpretation of various phenomena in pedagogical reality. It seems appropriate to differentiate the notions of “quality of knowledge” and “quality of education”. In the first case, a systematic review of students' knowledge quality and the ways of its improvement were implied by many practitioners and scholars. The scientific approach of Shamova and Davydenko (1993) formulates that the most rational in the system of qualities not only the quality of students' knowledge but the development of the student's personality.

In connection with the humanization of education in pedagogy, there has been a distinct transition from the consideration of "the quality of knowledge" to "the quality of education". According to Slastenin (2009) humanistic paradigm, there is a tendency towards a dominant consideration of education quality in the unity of its two sides – procedural and resulting.

Slastenin (2009), carrying out a philosophical and phenomenological analysis of the education quality, defines this concept as a set of education properties, which allowed to solve the problems of training, education and personal development, as one of the most important education quality characteristics.

The quality of education according to Adamsky (2009), is the level of success, socialization of a citizen, as well as the level of conditions for mastering the educational program of school. The results providing a high level of quality are academic knowledge, social and other competencies, plus social experience acquired by students while realising school educational program. This concept becomes not only pedagogical, but also economic, and more precisely, organizational and financial.

The “quality of education” was formulated as the education system characteristic reflecting the degree of compliance of real educational results, achieved with regulatory requirements, social and personal expectations (Lomakina, 2016).

Ilyenkova (2006) defines the quality of education as the demand for acquired knowledge in specific conditions of their application to achieve a specific goal and improve the quality of life.

According to Zheleznova (2008), “quality of education” is a social category and can be defined as the totality of the education properties that meets the modern requirements of pedagogical theory, practice and is able to satisfy the educational needs of the individual, society and state.

The presented scientific points of view confirm the difference in the descriptions and definitions of the term quality of education, each of which contains specific features and differences noted above, and reflect its main characterological features: “education and personality” by Slavenin (2009), “social and other competencies plus social experience” by Adamsky, “correspondence of educational results to social and personal expectations” by Lomakina (2016). Ilyenkova (2006) considers the demand for acquired knowledge to achieve a specific goal and improve the quality of life as a key criterion of “quality of education”.

However, Waldman (2015, p.109) argues that “... unfortunately (or fortunately), there is no single and simple answer to the question: “What is the quality of education?” – “Quality is a dynamic and ever-changing concept”. The quality of education shows how well the student achieves success in each of the following areas: realization of his full potential, ability to live and work with dignity, improvement of his own life quality, adoption of informed decisions and ongoing education: a concrete answer to the question “What is the quality of education?” will depend on who asks this question, and what are his views on the goals of education”. The choice of a particular goal or its interpretation also depends on a particular social group that has its own understanding of the quality of education:

- for students, "quality" is his marks, attractiveness of the subject and instructions content, or usefulness of school education to get work;
- for parents, "quality" is preserving certain values, contribution to family traditions, guarantees of employment;
- for school, "quality" is its graduates success, the results shown by the students when taking national exams and tests;
- for the local community, "quality" is the local community values, the rating of the school at

national exams, well educated and trained graduates;

- for the country, "quality" is the formation of national consensus, the preservation or rethinking of national history, and the achievement of competitiveness in the global economy;
- at the international level, "quality" is an opportunity to ensure peaceful coexistence and contact with the world community" (Waldman, 2015).

Purpose and objectives of the study

The purpose of the study is to assess the ability of students to use the knowledge and experience acquired at school to solve a wide range of life tasks in various fields of human activity, communication and social relations.

Methodology

Emphasizing the state and public component in the formulation of the last two thesis and conducting a brief theoretical study of "quality of education"concept, it seems possible and relevant to consider this phenomenon in the context of a comparative study of PISA general education quality, determining the mathematical literacy of 15-year-olds based on the example of "The Center of professional skills improvement of teachers" experience in GGTU (Orehovo-Zuevo, MR)" Teacher of the future.

The main method is the method of cotextual analysis and the diagnostic methods of interrogation and questioning, which allowed to identify the difficulties encountered by the Russian student while solving practice-oriented mathematical problem. Diagnostic results are presented in a contextual analysis of the situation.

Results

PISA is an international program for assessing the functional literacy of 15-year-old students in the fields of reading, science, mathematics, etc. It is one of the largest international large-scale monitoring research in the field of education. PISA has been carried out since 2000 by the Organization for Economic Cooperation and Development (OECD) and is becoming increasingly widespread: 32 countries- in the first cycle, there were 78 in 2018.

Every three years PISA allows to evaluate not only the literacy of students, but also the dynamics of contextual indicators of national general education system, correlated with the economic and social development of the country. Therefore, the results of this study are of great importance for the educational

policy of many countries.

The average weighted result of Russia in the group of international studies, and the place of the Russian Federation among the ten leading countries is determined through the coverage of preschool education and early development programs in the OECD ranking; results in the International Monitoring Study of the Quality of School Mathematics and Science Education TIMSS (Eng. TIMSS - Trends in Mathematics and Science Study) (Grades 4 and 8); results in the International program for the assessment of PISA students educational achievements in mathematical, reading and science literacy; graduation rate for general education programs in the OECD ranking. The table below shows the data on the assessment of student educational achievements (PISA) in Russia for the period 2000-2015. They are very disappointing.

Table 1. Results of the International Student Educational Achievement Program (PISA) of the Russian Federation

Research area / year	2000	2003	2006	2009	2012	2015
Math literacy	22	29	34	38	34	23
Reading literacy	27	32	39	43	42	26

Since 2019, the national project "Education" has become the supporting structure for modern Russian educational policy, in its essence - a response to the May decree of Vladimir Putin (Kuz'min, 2018).

The increase in the average weighted result of the Russian Federation should be provided by the contribution to the federal project "Teacher of the Future", one of ten national projects "Education", the aim of which is to ensure the global competitiveness of homeland education and Russia entering the ten top countries of the world general education quality.

Global trends in education dictate the need to build an educational ecosystem of the 21st century in Russia, which must be constantly renewed, providing students with new educational opportunities. The educational process in such an ecosystem is supported by new educational renovated technologies focused on practice and sociocultural situation changing. The educational ecosystem is based on the values of modern civilization, and its effective functioning should be ensured by modern pedagogy.

The most important element of the educational ecosystem is a teacher who possesses important professional competencies, owns relevant educational technologies and is involved in the active process of functioning and development of this ecosystem.

The Center for Teachers Professional Development of GGTU "Teacher of the Future", started the implementation of the Program "Formation of Practical Mathematical Literacy of Schoolchildren" aiming to improve their professional competence in solving and working out educational tasks for the development of students mathematical literacy.

Mathematical literacy is the individual's ability to formulate, apply, and interpret mathematics in a variety of contexts. It includes mathematical reasoning, the use of mathematical concepts, procedures, facts and means to describe, explain and predict phenomena. It helps people understand the role of mathematics in the world, make well-founded conclusions and decisions that are necessary for a constructive, active and reflective citizen.

One of the main challenges of the 21st century to modern education is the need for the formation of functional (including mathematical) literacy of all students, regardless the level of study and their further educational and professional plans. Table 2 describes the levels of students mathematical literacy and correlation between higher levels of teacher's mastery in the professional mathematical competence and the achievement of higher levels of learners mathematical literacy.

Table 2. Math literacy levels

Level	Level description	What students who have achieved a given level of math literacy can demonstrate
6.	The ability to think independently, analyze, put forward their own hypotheses	Participants of the study who have reached level 6 possess the abilities of mathematical thinking and reasoning. They can develop new approaches and strategies to solve problems using mathematical operations. In addition, they are able to think independently, as well as to formulate and explain accurately actions and thoughts regarding their conclusions, interpretations and arguments, reveal the reason for choosing the correct answer.
5.	The ability to think independently and analyze	At this level, students can develop and work with models for complex situations, select, compare and evaluate appropriate solution strategies, use broad, well-developed thinking and find arguments to prove their point of view.

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| 4. | The ability to use existing knowledge and skills to obtain new information and demonstrate his skills. | Having reached the 4-level, the students are able to summarize the explanations and arguments based on an interpretation and discussions of presented mathematical situations, to work effectively with specific models for a particular situation, to develop and integrate different tasks, including the symbolic means and to direct them into the aspects of the real world situation, to demonstrate well-developed skills. |
| 3. | The ability to use existing knowledge and skills to obtain new information. | At the 3-level of competencies, students can clearly perform the described procedures, including those that require a consistent solution. Mathematical tasks of this level include fairly simple models and strategies for solving problems. They can work with percentages, fractions, decimal numbers and proportional ratios. Their decisions are reflected mainly in their interpretation and reasoning. |
| 2. | Ability to apply existing knowledge and skills in the simplest non-educational situations. | Students are not able to do crucial tasks that require interpretation and recognition of the situation by extracting the necessary information from one source. At this level students can use basic algorithms, formulas, procedures to solve problems associated with integers. They are able to demonstrate a literal interpretation of the results. |
| 1. | Low level of basic knowledge. | One of the easy levels make students answer questions using well-known facts. They can determine information and perform sequential procedures in accordance with the direct instructions in the task. |
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The practical significance of the research results presented in the article.

Based on the abovementioned, we formulate the goal of the program: to improve the professional competence of math teachers in solving and developing educational tasks aimed at the formation and development of students' mathematical literacy. The planned results are presented in Table 3.

Table 3. Expected Learning Results

No.	Know
1 .	- the content and means of formation and development of students mathematical literacy ;
2 .	- levels, criteria and indicators of mathematical literacy development ;
3 .	- requirements for the selection and development of tasks for the formation and development of mathematical literacy .
Be able to	
1 .	- to formulate goals, planned educational results, ways and means of formation and development of students mathematical literacy ;
2 .	- to analyze the tasks of PISA and correlate them with the planned results, typical tasks of mathematical literacy formation and development ;
3 .	-to select and develop training tasks for the formation of students mathematical literacy ;
Have practical experience	
1 .	- development of training tasks on the subject for the planned results of the formation and development of students mathematical literacy;
2 .	- design of educational tasks complex on the subject for the planned results of the formation and development of students mathematical literacy

One of the aspects that characterizes mathematical literacy is “mathematical competence”, which represents the most general mathematical abilities and skills, including mathematical thinking, written and oral mathematical reasoning, problem solving, mathematical modeling, the ability to use the mathematical apparatus, as well as modern information technologies in practical activities.

The mathematical competence of students is formed at the interactive lessons:

learn the content and means of students mathematical literacy development;

- determine the levels, criteria and indicators of mathematical literacy development;

- study the requirements for the selection and development of tasks for the formation of mathematical literacy;
- analyze PISA tasks and the main mistakes made by 15-year-olds while doing the tasks with test analysis and results of PISA testing;
- recognize the classification of practice-oriented tasks in mathematics.

The instruction results can be defined by choosing and working out training tasks to create and develop students mathematical literacy; formulating goals, planning educational results, ways and means for development of students' mathematical literacy; development of a mathematical game, preparation of visual materials set to accompany the educational process.

At the final test lesson, the teacher selects mathematical tasks on the topics of the types: “Mathematical subjects in life”: “Mathematics in the forest (in the field, on the river)”, “Mathematics in the shopping center”, “Mathematics of construction and repair”, etc.

University teachers, leaders of the program "Formation of practical mathematical literacy of schoolchildren" united into a project group aiming to develop a training manual as a tool for methodological support of math teachers in the process of preparing students for the international PISA test.

Before the development of the Manual, the authors analyzed the problems that a math teacher faces today and outlined the ways to solve them, focusing on completely specific goals: to form and shape students' skills in applying mathematical knowledge in everyday life: (analyze, adapt to changing conditions, work with various sources of information, graphs, tables, predict processes and phenomena), to be based on the previously studied material.

Basic requirements for a practice-oriented tasks should be based on different situations, connected with personal life, society, future profession, education, science.

In PISA testing, practice-oriented math assignments are classified into 4 categories:

- type of cognitive activity (1 of 4: to reason, formulate, apply and interpret);
- content areas (1 of 4: “Quantity”, “Uncertainty and Data”, “Changes and Dependencies”, “Space and Form”);

- context (1 of 4 situations: personal, social, professional (learning), scientific);
- type of response required for the task (1 of 3: a choice of answer, a closed free answer and an open free answer).

It becomes obvious that in order to form (or check) the level of students skills, to apply mathematical knowledge in everyday life , a math teacher needs to go through the following steps:

- To carry out a selection of tasks previously given in PISA testing and tasks developed by Russian researchers (Link: <http://www.centeroko.ru/> Federal State Budgetary Institution Educational Development Institute of the Russian Academy of Education Center for Educational Quality Assessment);
- To conduct testing;
- To reveal the lack of students knowledge and skills;
- To eliminate defects (to work out new tasks , to supply PISA issues by supplementary questions).

Application of this method reveal the difficulties which Russian student acquires when solving the mathematical problem:

- it's difficult for a student to understand the essence of a practice-oriented task;
- it's difficult to build a mathematical model (interpret the life situation in the language of mathematics);
- it's difficult to interpret the resulting mathematical solution, etc.

It is these stages of mental activity that are included in the content of PISA testing tasks. Russian schoolchildren are able to solve academic mathematical problems , but they do not have sufficiently developed skills for solving practice-oriented mathematical problems.

To understand the essence of a practice-oriented task, the student must “live through” the situation described in the task: this becomes possible if he has already encountered a similar situation in life. Otherwise, the math teacher will have to model a real situation and problem, which is solved by mathematical methods.

To simulate a real situation, it is proposed to use mathematical games (teamwork) and project activities of schoolchildren in the training process .

In the process of the game students themselves modify the plot of the problem. The main result of this work is that the student gradually learns to work independently with a practice-oriented mathematical task.

So, the product of the project is a training manual on the formation of students mathematical competence for grades 7-8 “Life as a mathematical plot” (Sachkova et al., 2019).

The manual consists of two parts: the first part, “Practical Tasks”, contains unique tasks in the logics of PISA standards , the implementation of which will allow students in grades 7-8 to form mathematical competence. These tasks will contribute to the development of :

- abilities to analyze graphs; calculate the probabilities of independent events; create a mental dynamic image; perform non-standard tasks and look for answers to questions that are quite rare and seen for the first time in life ; use statistics to study various real-life phenomena and processes; perform actions with various units of measurement;
- semantic reading skills (including reading and interpreting quantitative information presented in various forms); constructing mathematical models, information retrieval and work with graphic data;
- spatial and geometric representations, visions of mathematical models in specific life situations.

The first part of the manual contains 36 practice-oriented tasks (80 questions) of various complexity, connected with every day life situations , school life, and future profession. On the pages of the manual mathematical formulas and points in the coordinate system come to life, children glue mathematical wallpapers, play with a math cube, get acquainted with some professions, play football, learn to plan, predict, analyze, etc. The topics of the training manual correlate to the topics of math lessons in grades 7-8.

The content of basic mathematical knowledge, skills and recommendations for solving tasks are formulated in the second part of the manual "Recommendations for solving and evaluating practice-oriented tasks".

Using this manual, a math teacher will be able to transfer from abstract mathematical concepts to solving practical problems in a student's real life and to use tasks for gifted children while preparing them for

olympiads, thereby to solve actual problems of fulfilling adequately the requirements for the federal state standard of general education, as a social contract between the individual, society and the state.

Conclusion

Thus, the relevance of education quality improvement today is becoming increasingly important, and enshrined in the priorities of state power, formulated by the President of Russia. It is emphasized that the quality of education is a system-forming and dominant factor in the social development of the individual, society and state.

Philosophical, social and pedagogical approaches to the consideration of the “quality of education” concept have revealed that this phenomenon determines the conditions and effectiveness of the educational process in society. Basing on this fact, its compliance with the needs and expectations of society is considered in the context of a comparative study of PISA general education quality and emphasizes that the results of PISA correlate with the economic and social development of the country. Therefore, the results of this study are of great importance for the educational policy in many countries. Practical ways proposed to improve the index of the Russian general education system in determining the mathematical literacy of 15-year-old students in the international PISA study include:

the training and methodological manual "Life as a mathematical plot" for the formation of students mathematical competence for grades 7-8, which presents unique tasks in the logics of the international PISA test standards and the Program “Formation of Practical Mathematical Literacy of Schoolchildren” to master the skills of math teachers for improving their professional competence in solving and developing educational tasks for the formation and development of schoolchildren mathematical literacy.

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