# Enhancing students' functional literacy through authentic problems in equations and inequalities

Aruzhan Mataibayeva

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«SDU University»

Department of Pedagogy of Natural Sciences

Thesis Supervisor:

PhD., Assistant Professor, Nuri Balta

«SDU University»
School of Education and Humanities
Department of Natural Sciences Pedagogy

This is to certify that the Master's Thesis of

Aruzhan Mataibayeva

has met the thesis requirements of
SDU University

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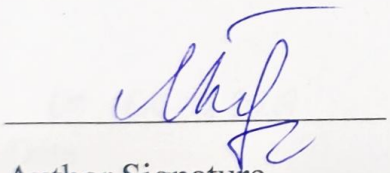
| | | |
|---|---|---|
| Thesis Supervisor | (Signature) | PhD., Assistant Professor<br>Nuri Balta |
| M.Ed. Program Coordinator | (Signature) | M.Ed., Senior Lecturer<br>Nurbek Sagyndyk |
| Head of Department of Natural Science | (Signature) | PhD., Associate Professor<br>Zhangyl Abilbek |
| Approved<br>Dean of the School of Education and Humanities | (Signature) | PhD., Assistant Professor<br>Dana Moldabayeva |

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SDU UNIVERSITY
FACULTY OF EDUCATION AND HUMANITIES
БИН 960240000550
1996

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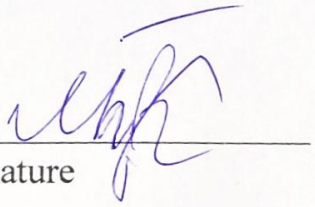
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# List of Abbreviations

BIL - Bilim-Innovation Lyceum

IEA - International Association for the Evaluation of Educational Achievement

NIS - Nazarbayev Intellectual Schools

OECD - Organisation for Economic Co-operation and Development

PISA - Programme for International Student Assessment

Q-Q Plot - Quantile-Quantile Plot

TIMSS - Trends in International Mathematics and Science Study

UNESCO - United Nations Educational, Scientific and Cultural Organization

# ABSTRACT

This study examines the effect of authentic problems involving equations and inequalities on Grade 6 students' mathematical literacy. A quasi-experimental quantitative design was employed with 26 students: 13 in the experimental group and 13 in the control group. Both groups completed a pre-test and a post-test. The experimental group learned through authentic real-world problems involving equations and inequalities, while the control group received traditional procedural instruction. Since the sample size was small and visual inspection showed some deviations from normality, non-parametric tests were used. The results showed that both groups improved after instruction. However, the Mann-Whitney U test indicated that the experimental group had significantly higher gain scores than the control group. In addition, the large effect size for the gain score comparison showed that this difference was practically meaningful. Therefore, authentic problems involving equations and inequalities can be considered a promising approach for supporting Grade 6 students' mathematical literacy.

*Keywords: functional literacy, mathematical literacy, authentic problems, equations, inequalities.*

# АҢДАТПА

Бұл зерттеуде теңдеулер мен теңсіздіктерге негізделген аутенттік есептердің 6-сынып оқушыларының математикалық сауаттылығына әсері қарастырылды. Зерттеуге 26 оқушы қатысты: эксперименттік топта 13 оқушы, бақылау тобында 13 оқушы болды. Зерттеуде квазиэксперименттік сандық дизайн қолданылды. Екі топ та алдын ала тест пен қорытынды тест тапсырды. Эксперименттік топ теңдеулер мен теңсіздіктерді шынайы өмірлік жағдаяттарға негізделген аутенттік есептер арқылы меңгерсе, бақылау тобы дәстүрлі процедуралық оқыту әдісімен білім алды. Таңдама көлемі шағын болғандықтан және деректердің таралуында қалыпты үлестірімнен визуалды ауытқулар байқалғандықтан, параметрлік емес статистикалық тесттер қолданылды. Нәтижелер екі топта да оқу соңында ілгерілеу болғанын көрсетті. Алайда Манн–Уитни U тесті эксперименттік топтың gain score көрсеткіштері бақылау тобына қарағанда статистикалық тұрғыдан едәуір жоғары екенін анықтады. Сонымен қатар gain score көрсеткіштерін салыстыру бойынша әсер мөлшерінің жоғары болуы бұл айырмашылықтың практикалық тұрғыдан да маңызды екенін көрсетті. Демек, теңдеулер мен теңсіздіктерге негізделген аутенттік есептерді 6-сынып оқушыларының математикалық сауаттылығын дамытуға бағытталған тиімді әрі перспективалы тәсіл ретінде қарастыруға болады.

*Түйінді сөздер: функционалдық сауаттылық, математикалық сауаттылық, аутенттік есептер, теңдеулер, теңсіздіктер.*

# АННОТАЦИЯ

Данное исследование изучает влияние аутентичных задач по уравнениям и неравенствам на математическую грамотность учащихся 6 класса. В исследовании был использован квазиэкспериментальный количественный дизайн с участием 26 учащихся: 13 учащихся в экспериментальной группе и 13 учащихся в контрольной группе. Обе группы выполнили предтест и посттест. Экспериментальная группа обучалась с использованием аутентичных задач, связанных с реальными жизненными ситуациями и включающих уравнения и неравенства, тогда как контрольная группа получила традиционное процедурное обучение. В связи с небольшим размером выборки и визуальными отклонениями от нормального распределения были применены непараметрические статистические тесты. Результаты показали, что обе группы улучшили свои показатели после обучения. Однако критерий Манна–Уитни показал, что gain scores экспериментальной группы были статистически значимо выше, чем у контрольной группы. Кроме того, большой размер эффекта для сравнения gain scores показал, что данная разница была практически значимой. Следовательно, аутентичные задачи по уравнениям и неравенствам могут рассматриваться как перспективный подход к развитию математической грамотности учащихся 6 класса.

*Ключевые слова: функциональная грамотность, математическая грамотность, аутентичные задачи, уравнения, неравенства*

# 1. INTRODUCTION

## 1.1 Background of the Study

Modern mathematics education increasingly emphasises not only what students know, but how they use mathematical knowledge in unfamiliar and practical situations. Over the past two decades, the discourse around schooling has shifted considerably away from the accumulation of factual content toward the development of competencies that equip learners to navigate complex, real-world situations. At the centre of this shift is the concept of functional literacy a broad, multidimensional construct that extends well beyond basic reading and writing to encompass the ability to interpret, reason, and communicate effectively across a range of domains, including the mathematical. UNESCO (2006) describes functional literacy as the ability to work with written and digital information in a way that makes sense and is purposeful in a person's social and professional life. This understanding has become widely used worldwide in national curricula, as education systems increasingly realize that schooling must prepare students not only for formal exams, but also for the complex demands they face outside the classroom. Large-scale international assessments have played a crucial role in conceptualizing and measuring the practical aspects of student learning through education systems. The Programme for International Student Assessment (PISA), conducted by the Organisation for Economic Co-operation and Development (OECD), and the Trends in International Mathematics and Science Study (TIMSS), conducted by the International Association for the Evaluation of Educational Achievement (IEA), are among the most influential international assessments of student achievement. While TIMSS primarily assesses students' mathematics and science achievement in relation to curriculum-based knowledge at the fourth and eighth grades, PISA is designed to measure 15-year-old students' ability to use their reading, mathematics, and science knowledge and skills to meet real-life challenges. Therefore, PISA is particularly relevant to studies focusing on mathematical literacy, authentic problem solving, and the application of mathematics in real-world contexts. It is

important to note that PISA results always reveal an alarming pattern: many students who successfully complete curriculum-based assignments face difficulties communicating and applying mathematical concepts in unfamiliar contexts. This discrepancy between knowledge of procedures and applied competence is typical not only for one country, but also for a wide range of educational systems.

## 1.2 Context of the Study

Kazakhstan is an example in this regard. As a country undergoing significant educational reform, Kazakhstan has invested heavily in modernizing its national curriculum as part of the State Education Development Program and initiatives aligned with the Education Reform Roadmap. Kazakhstani students participated in PISA and TIMSS tests, and the results of international testing indicate that they continue to experience difficulties with tasks that require contextual reasoning, interpretation, and application of mathematical knowledge in unfamiliar situations (OECD, 2019b; Mullis et al., 2020). These results indicate a tendency in math classes to favor procedural fluency over conceptual understanding and contextual application. This trend is due, at least in part, to long-standing learning traditions that place great emphasis on procedural precision and algorithmic practice. The reform documents recognized these challenges and called for a greater focus on critical thinking, problem solving, and practical application in real life; however, translating these aspirations into everyday educational practice remains a challenge.

## 1.3 Problem Statement

Equations and inequalities occupy a fundamental place in the mathematics curriculum. They serve not just as abstract algebraic objects that can be manipulated according to prescribed rules, but also as tools for representing relationships, constraints, and quantitative reasoning in the real world. A student who understands that inequality can model a budget solution or a resource allocation problem develops a qualitatively different type of mathematical thinking than someone who can solve the same expression mechanically, without taking into account the situation. However,

research consistently shows that students tend to approach equations and inequalities with a predominance of procedural aspects, viewing them as symbolic manipulations that need to be performed rather than as conceptual structures that need to be understood and applied (Kiran, 2020; Sfard and Linchevski, 1994). At the 6th grade level, when students in Kazakhstan first encounter formal work with equations and elements of inequalities, the foundation for a procedural or conceptual understanding is laid. The way this foundational material is taught can have long-term implications for students' mathematical development and, as a result, for their functional literacy. A growing body of research in mathematics education increasingly advocates the integration of authentic tasks based on real or plausible real-world contexts as a means of bridging the gap between procedural competence and applied mathematical thinking (Gravemeijer & Doorman, 1999; Lesh & Doerr, 2003).

Authentic tasks require students to interpret situations, create mathematical representations, apply appropriate procedures, and critically evaluate their results in terms of the original context. This process reflects what the PISA system describes as a cycle of mathematical modeling, which includes the processes of formulating, using and interpreting mathematical information (OECD, 2023a). When applied to equations and inequalities, authentic task-based learning can help students transition from mechanical manipulation of symbols to authentic mathematical thinking. However, the question of to what extent this approach can be effectively implemented in the Kazakh classes of the 6th grade and whether it will lead to a noticeable improvement in the mathematical literacy of students remains insufficiently studied.

## 1.4 Research Gap

Although authentic tasks and modeling-based tasks are widely discussed as ways to develop mathematical literacy, existing studies do not fully take into account the specific context of this study. Much of the available work is aimed at high school students, while the students of the 6th grade, who are at an important stage of the transition from arithmetic thinking to more formal algebraic thinking, receive less attention, while they are less focused on the students of the 6th grade. This is especially

true in Kazakhstan, where at this stage students begin to work more clearly with equations and inequality elements.

Another limitation concerns the context. Many studies on mathematical modeling and authentic tasks have been conducted at educational institutions in West or East Asia, while the data obtained in the classrooms in post-Soviet systems, such as Kazakhstan, remain limited. This is important because Kazakhstan is currently working on adapting competence-based educational goals to the traditions of teaching, which in the past attached special importance to procedural accuracy and algorithmic practice.

Finally, existing studies often examine mathematical modelling or authentic tasks in broad terms, without focusing specifically on equations and inequalities as the content through which mathematical literacy is developed. Yet these topics are especially important for the PISA processes of formulating, employing, and interpreting, since students must translate contextual relationships into algebraic representations and then interpret their solutions in relation to the original situation. Therefore, the present study examines authentic problems involving equations and inequalities with Grade 6 students in Kazakhstan, using the PISA mathematical literacy framework as the basis for both instruction and assessment.

## 1.5 Aim and Objectives of the Study

The aim of this study is to examine how the integration of authentic real-world problems involving equations and inequalities contributes to the development of mathematical literacy among grade 6 students in Kazakhstan.

The objectives of this study are to:

1. examine students' initial level of mathematical literacy related to equations and inequalities prior to the instructional intervention;
2. design and implement authentic modelling tasks involving equations and inequalities for Grade 6 students;
3. compare the effects of authentic modelling-based instruction and traditional procedural instruction on students' mathematical literacy;

## 1.6 Research Question and Hypotheses

Research question: To what extent does the integration of authentic problems involving equations and inequalities improve students' mathematical literacy compared with traditional instruction?

The purpose of this study is to examine how the integration of authentic real-world problems involving equations and inequalities influences the development of students' mathematical literacy. To address this purpose, a quasi-experimental research design is employed, involving a control group receiving traditional procedural instruction and an experimental group engaging with authentic modelling tasks. This design is appropriate for the proposed study because it allows for systematic comparison of instructional approaches under real classroom conditions, where random assignment is not feasible, while also enabling the examination of changes in students' modelling, interpretation, and reasoning skills. Based on the aim and research question of the study, it is expected that the integration of authentic problems involving equations and inequalities will have a positive effect on Grade 6 students' mathematical literacy.

H1: Students taught through authentic problems involving equations and inequalities will demonstrate significantly greater improvement in mathematical literacy than students taught through traditional instruction.

H0: There will be no statistically significant difference in the improvement of mathematical literacy between students taught through authentic problems involving equations and inequalities and those taught through traditional instruction. More specifically, the study hypothesis that students in the experimental group will show greater improvement in the PISA-aligned processes of formulating mathematical situations, employing mathematical concepts and procedures, and interpreting mathematical results in real-life contexts.

To address the research questions outlined above, this study employs a quasi-experimental quantitative design with an experimental group and a control group. Both groups complete a pre-test and a post-test designed to assess mathematical literacy

through authentic problems involving equations and inequalities. The experimental group receives instruction based on a sequence of authentic modelling tasks developed specifically for this study, while the control group receives the standard procedural instruction as provided in the existing curriculum. Students' responses are evaluated using an analytic rubric aligned with the PISA formulate–employ–interpret framework, enabling both an overall comparison of mathematical literacy scores between groups and a more granular analysis of performance across the three PISA processes. The methodology, assessment instrument, and analytical procedures are described in detail in Chapter 3.

# 2. LITERATURE REVIEW

## 2.1 Functional literacy: conceptual foundations and educational significance

Functional literacy is one of the most important concepts in modern educational research, especially in discussions about the relationship between students' ability to apply knowledge beyond academia and schooling. Earlier concepts of literacy focused primarily on reading and writing skills; however, modern education systems have expanded this concept to include the opportunity to participate in professional, social, and daily activities that require knowledge to be transformed into skills and used in real life. (Unesco, 2007). This has contributed to broader changes in educational priorities. Later, successful learning was associated not only with the acquisition of knowledge, but also with the ability to transfer and apply knowledge in unfamiliar contexts. However, UNESCO has now expanded this definition and described functional literacy as a person's ability to participate effectively in life activities where literacy is essential for functioning in society (Unesco, 2007). This definition was the beginning of an important shift in educational thinking. Literacy was no longer considered as just a technical skill related to reading, writing or reproducing information. Instead, it was explained by the ability to meaningfully use knowledge and skills in everyday life. Researchers such as Graff (Graff, 1995) and Street (Street, 2003) have also argued that literacy should be considered not only as an academic skill, but also as a socially significant skill that allows people to act effectively in their communities and fulfill professional duties. This improvement in understanding has become especially important in view of the current age of rapid technological development and globalization. Modern society requires people not only to possess theoretical knowledge, but also to flexibly apply this knowledge in unfamiliar situations. In many educational systems, students can demonstrate success in memorizing formulas, definitions or procedures, but still have difficulty putting this knowledge into practice. As a result, educational and political researchers are increasingly emphasizing the importance of transferred competencies, problem-

solving skills and logical thinking. Thus, functional literacy is closely related to the larger idea that education should prepare students not only for exams, but also for active participation in social, economic and professional life. One of the most influential international structures supporting this view is the International Academic Performance Assessment Program (PISA), developed by the Organization for Economic Cooperation and Development (OECD). Unlike traditional assessments, which focus mainly on the knowledge of the curriculum, PISA assesses how effectively students can apply the knowledge gained to solve real problems (OECD, 2023a). This difference is especially important because it changes the way educational achievements are interpreted. Success in education is no longer measured only by the reproduction of the material learned, but also by the ability to convey knowledge in various contexts and use it for reasoning, interpretation and decision-making. In this sense, functional literacy is a key indicator of whether education prepares students for the requirements of modern life. The importance of the development of mathematical literacy in Kazakhstan is also reflected in the recent PISA results. According to OECD reports, many Kazakh students still have difficulty completing math literacy tasks that require contextual reasoning, interpretation and mathematical modeling (OECD, 2023c). Although students can demonstrate procedural knowledge in school mathematics, the results of international assessments show that the application of mathematics in unfamiliar real-world situations remains a challenge for a large part of students. The concept of functional literacy is also closely related to the criticism of traditional approaches to learning, which are based on memorization. Earlier models of education often considered learning as a process of accumulating, memorizing and reproducing actual information. (Skinner, 1954; Bloom, 1956). While such approaches can provide short-term academic results, many researchers claim that they do not sufficiently develop higher-order cognitive abilities, such as analysis, evaluation, synthesis and problem solving. Students can successfully repeat rules or procedures without fully understanding how and when to apply them. Functional literacy challenges this approach by focusing on meaningful application rather than mechanical

repetition. So, a functionally competent person is not only someone who remembers information, but also someone who can adequately use knowledge in new context-dependent situations. This point of view is closely connected with constructivist and socio-cultural theories of learning. According to these approaches, knowledge is not gained passively, but is actively constructed through interaction, experience and participation in meaningful activities (Lave & Wenger, 1991). Learning becomes more efficient when students perform authentic tasks that require reasoning, communication, interpretation and cooperation. Therefore, educational approaches aimed at the development of functional literacy often focus on contextualized learning, question-based learning and problem solving, rather than on individual procedural exercises. These approaches encourage students to correlate the knowledge gained in the classroom with practical situations and help them develop a deeper understanding and flexible thinking.

Another important feature of functional literacy is its multifaceted character. Researchers generally agree that functional literacy cannot be reduced to a single skill or competence. Instead, it includes several interrelated areas such as reading literacy, scientific literacy, digital literacy and mathematical literacy. Each area reflects the different ways in which people interact with information and respond to challenges of daily life. For example, reading literacy involves not only understanding written texts, but also the critical evaluation of information, the identification of bias and the interpretation of meaning in different contexts (OECD, 2019a). Scientific competence includes the ability to evaluate actual data, to understand scientific reasoning and, as an informed citizen, to address issues related to science. Mathematical literacy, which is especially important for this study, refers to the ability to use mathematical knowledge and reasoning to solve contextualized problems and meaningfully interpret quantitative information.

The multifaceted nature of functional literacy also poses important methodological challenges for educational research. One of the biggest difficulties is that functional literacy largely depends on the context and involves the application of

knowledge in real situations. As a rule, traditional classroom assessments are designed to assess individual knowledge or fluency of conducting procedures under controlled conditions. Such assessments can show whether students remember the information, but they often cannot prove whether students can flexibly apply the knowledge gained in unfamiliar conditions (De Lange, 2003; Niss, 2011). For example, a student can correctly solve a mathematical equation in a textbook exercise, but it is difficult to use the same mathematical reasoning in a real financial or practical situation.

In addition, it is difficult to measure functional literacy as a whole, since it covers many areas and cognitive processes simultaneously. Large-scale international assessments such as PISA allow us to assess how these competencies are formed using carefully designed systems, contextualized psychometric analysis tasks, and large samples of participants. However, your classroom usually does not have access to these extensive resources. For this reason, many researchers focus on a specific and measurable component of functional literacy rather than trying to evaluate the entire design at the same time. Among these components, mathematical literacy has become one of the most widely studied areas. This is partly due to the fact that quantitative thinking is closely linked to many aspects of modern life, including financial decision-making, interpretation of statistical information, understanding technology, and solving professional problems (Steen, 2001; Gal, 2002). In modern society, people are constantly confronted with numerical information that requires interpretation and evaluation. Therefore, mathematical literacy is increasingly seen as a necessary competence for effective participation in both personal and public life.

Another reason for the increased attention to mathematical general education is methodical. Compared to some other areas of functional literacy, mathematical literacy has a more advanced assessment system. The PISA Mathematical Literacy System offers researchers structured and proven tools that focus on applying, comprehending, and solving contextual problems rather than simple procedural memorization. (OECD, 2023b; Niss & Højgaard, 2019). This makes mathematical literacy more practical for conducting empirical research in the classroom. In addition, mathematics courses

provide a visual environment to explore the differences between traditional procedural learning and approaches that focus on authentic problem solving and application in real-world settings. This distinction is especially important for studies that study the relationship between learning methods and students' ability to meaningfully apply knowledge. For these reasons, this study focuses on mathematical literacy as a measurable component of functional literacy. The functional competence itself is broader and includes many interrelated areas, providing a more specific and illustrative basis for learning how students apply knowledge in real situations. This study focuses on mathematical literacy, focusing not only on the study of students' procedural activities, but also on their ability to think, interpret and meaningfully use mathematics in real conditions.

Although functional literacy is often considered a comprehensive educational goal, researchers generally agree that it consists of several interrelated components, including literacy, scientific literacy, digital literacy, and mathematical literacy. Each of these areas reflects different ways of applying knowledge and skills in real life situations. However, since functional literacy is multidimensional, it is methodologically difficult to assess it as a whole within the framework of an examination study. Major international tests such as PISA enable the assessment of various areas of literacy through extensive testing systems and sophisticated assessment systems. In small educational studies, researchers often focus on the measurable component of functional literacy, rather than trying to evaluate the entire design at the same time. In the context of mathematical education, mathematical literacy is considered one of the most important components of functional literacy, as it reflects students' ability to apply mathematical knowledge in practical and contextualized situations. In addition, mathematical literacy has a well-developed theoretical framework and a PISA rating system, which makes it more suitable for conducting empirical research in the classroom. For these reasons, this study focuses on mathematical literacy as a measurable component of functional literacy. Because the research focuses on real-world mathematical problems involving equations and

inequalities, mathematical literacy provides the most up-to-date and effective framework for studying how students apply knowledge in real-world settings.

## 2.2 Mathematical Literacy: Definition and Conceptual Scope

Mathematical literacy has become one of the most frequently discussed concepts in mathematics education over the past few decades. However, the term is used in different ways in the literature, and this distinction is important for the present study. Jablonka (2003) argues that mathematical literacy should not be viewed as a neutral or self-evident concept, as different definitions reflect different educational, social, and political goals. Therefore, in any study that uses this concept, it is necessary to clarify which interpretation it accepts and why.

This dissertation examines mathematical literacy within the PISA framework. Unlike traditional notions of mathematical ability, which often focus on knowledge of procedures and precise calculations, PISA focuses on students' abilities to usefully apply mathematics in real-world situations. The OECD defines mathematical competence as the ability of a person to think mathematically and formulate, use and interpret mathematical data to solve problems in various real conditions, and to make informed judgments and decisions as an active and thinking citizen (OECD, 2023a). The key word here is the context: mathematical literacy manifests itself not in isolation, but in situations related to personal, professional, social and scientific life. This representation differs from the procedural orientation that dominates many mathematics classes. In traditional procedural classes, students are often first introduced to the rule, and then asked to train them with exercises. Although effective curricula in mathematics must combine the free mastery of procedures with conceptual understanding, the implementation of procedures is often of central importance for teaching practice (Kilpatrick et al., 2001). This creates a gap between knowing how to perform a certain procedure and knowing when, why and how this procedure can be used in a particular context.

Kusmaryono and Kusumaningsih (2023) similarly argue that there is a systemic gap between how mathematical literacy is taught in schools and how it is assessed in

PISA. What distinguishes mathematical literacy from procedural competence is not the absence of procedures, but the presence of judgement. A student who can solve a given equation correctly demonstrates procedural competence; a student who can decide that a real-life situation should be represented by an equation demonstrates mathematical literacy. This distinction is important for the present study because equations and inequalities are treated not only as symbolic objects to be solved, but also as tools for modelling contextual situations. Within the PISA framework, mathematics involves concepts, procedures, facts, and tools used to describe, explain, and predict phenomena, as well as to understand the role mathematics plays in the world (OECD, 2023b).

At the same time, PISA's view of mathematical literacy is not free from criticism. Critics such as Beccuti (2024) argue that PISA contained implicit criticism of traditional mathematics education programs from the earliest versions and therefore acts not only as an assessment tool, but also as a position on the type of mathematics education that should be valued. Whether this influence is considered a legitimate educational contribution or an exaggeration depends on how one understands the role of international assessments in shaping national educational priorities. For the purposes of this study, PISA is not used as a policy program, but as an analytical framework for assessing students' ability to formulate, use, and interpret mathematics in contextual assignments.

## 2.3 The PISA Formulate–Employ–Interpret Framework

Within the PISA framework, mathematical literacy is organised around three interrelated cognitive processes: formulating, employing, and interpreting mathematics (OECD, 2023a). These processes describe how students move between a real-world situation and a mathematical representation. For this reason, they are closely connected to the mathematical modelling cycle, where a situation is simplified, represented mathematically, solved, and then reconsidered in relation to the original context (Blum & Leiß, 2007; Lesh & Doerr, 2003).

The formulate process is especially important for the present study because it is the point at which a contextual situation is transformed into algebraic form. In tasks involving equations and inequalities, this means that students need to identify relevant quantities, recognise relationships or constraints, and decide how these can be represented mathematically. The difficulty of formulation lies in the fact that the mathematical structure is not given in advance. Unlike routine exercises, where students are asked to solve an already-formed equation, authentic problems require them to construct the representation themselves.

The employ process begins after the formation of a mathematical model. At this stage, students use mathematical concepts and tools to work with modeling. In the context of equations and inequalities, this may include solving an equation or inequality, comparing values, evaluating or verifying the consistency of the solution. Although this process is the closest to traditional mathematics education, PISA does not reduce it to mechanical calculations. Students are also expected to choose appropriate methods and monitor how logical their mathematical reasoning is (OECD, 2023a).

In the process of interpretation, students must return from the mathematical result to the real situation. The question here is not only whether the calculations are correct, but also whether the answer makes sense in context. For example, a solution to the inequality problem may be mathematically sound, but practically unwise if it ignores a budget constraint, minimum requirement, or other contextual constraint. In this sense, interpretation connects mathematical work with judgments and decision-making (Niss & Højgaard, 2019).

These three processes should not be understood as a fixed sequence that students complete once. In modelling-based problem solving, students may move back and forth between formulation, employment, and interpretation. An interpreted result may show that the original model was incomplete or that an assumption needs to be revised. This iterative movement is central to mathematical modelling and explains why the PISA

framework is appropriate for assessing students' mathematical literacy in authentic problems involving equations and inequalities (Blum & Leiß, 2007; Blum et al., 2007).

## 2.4 The PISA Framework as a Research and Classroom Tool

One reason why the PISA framework has become influential is that it offers researchers and educators a clear structure for analysing applied mathematical competence. Its descriptions of cognitive processes, mathematical content areas, and contextual categories make it possible to design and analyse tasks systematically. In addition, the international data collected through PISA allow researchers to compare education systems and examine factors associated with students' mathematical literacy across national contexts (Rutkowski & Rutkowski, 2009).

Beyond its use in large-scale assessment, PISA has also influenced classroom-based research. Stacey (2011) and Niss (2015) argue that PISA-oriented approaches can support the design of tasks that require students to use mathematics in meaningful situations rather than simply reproduce procedures. For this reason, PISA-like tasks and assessment tools are increasingly used in small-scale instructional studies examining how authentic tasks, modelling-based learning, and realistic mathematics education affect students' ability to formulate, employ, and interpret mathematics in context (Gravemeijer et al., 2017; Vos, 2018). Although such studies involve smaller samples than international assessments, they provide useful insight into how mathematical literacy can develop under classroom conditions.

The present study adopts the PISA framework in this classroom-based sense. It does not attempt to replicate PISA as a large-scale testing system. Instead, it uses the processes of formulating, employing, and interpreting to examine how Grade 6 students in Kazakhstan solve authentic problems involving equations and inequalities. In this way, the framework serves as both a conceptual basis for understanding mathematical literacy and a structured basis for assessing students' ability to apply mathematical knowledge in contextual situations.

## 2.5 PISA-Oriented Mathematical Literacy in Classroom Practice

High PISA scores and the development of mathematical thinking should not be considered identical results. This distinction is important because PISA is sometimes used in schools mainly as an assessment goal and not as a basis for rethinking learning. Estrobello and Cajandig (2026) found in a systematic review of the literature that an increase in mathematical literacy is more likely if teacher training, teaching materials and assessment methods match the PISA-related competencies. This suggests that the framework is unlikely to be effective if it is used only at the level of test preparation or isolated classroom tasks.

Research on realistic mathematical education helps to explain why such a correspondence is important. When students work with the tasks that are in a recognizable context, mathematical concepts become less detached from everyday reasoning. This idea is close to the logic of PISA, where students are expected to formulate, use, and interpret mathematics in relation to situations beyond routine exercises. However, applying this approach in ordinary classrooms is not straightforward. It requires changes not only in the type of tasks used, but also in the teacher's role. Teachers need to guide students through problems that may allow different strategies, incomplete information, or more than one reasonable path to a solution.

This does not mean that procedural knowledge becomes unimportant. A review of 44 experimental studies in elementary mathematics from 2014 to 2023 showed that effective instruction often develops conceptual understanding and procedural fluency together through problem-solving, active learning, and mathematical games (Bognar et al., 2025). Therefore, a PISA-aligned classroom should not be understood as a rejection of procedures. Rather, procedures need to be connected to interpretation, modelling, and reasoning.

Findings from PISA-based studies also challenge the assumption that student-centred instruction automatically leads to deeper mathematical understanding. Liu et

al. (2024), using data from two PISA cycles, found that teacher support, disciplinary climate, and cognitive activation were consistently beneficial for students from lower socioeconomic backgrounds, while purely student-directed instruction showed negative associations with achievement in several country contexts. This suggests that the role of the teacher remains central. It seems that the most important thing is not only to give students more independence, but also to create cognitive situations in which they need to explain, justify and link mathematical ideas.

A similar conclusion can be found in the international Wu study (2025), which is based on PISA data from 2022 in six countries. Using hierarchical linear modeling, the researchers found that socio-economic status, cognitive activation, and teacher support independently influence the differences between high-efficiency and low-efficiency systems. Taken together, these results suggest that math literacy is unlikely to improve just by changing the curriculum. This depends on whether mathematical reasoning becomes a regular part of teaching practice, including the selection of tasks, the way teachers lead the discussion, and how students should explain their decisions.

## 2.6 Mathematical Literacy in the Kazakhstani Context

The history of Kazakhstan's participation in PISA shows the real prospects for the application of this system. After the PISA results of 2009, the government made a number of changes to school programs that were compared with international standards, and commissioned experts from the University of Cambridge to develop a revised curriculum. This model of using the PISA results as a direct lever for education reform has made Kazakhstan a remarkable example of how international assessments interact with national policy. Sarmurzin et al. (2021) The results of PISA 2022 were mixed: Kazakhstan scored the lowest score ever in reading, while the country scored the second best in mathematics since its first participation in 2009, with a similar positive trend in the natural sciences. Their relative position in the world ranking has also improved and has climbed to 51st place out of the 81 participating countries.

These results must, however, be interpreted with caution given the global decline in scores attributable to the disruptions caused by the COVID-19 pandemic.

Kazakhstan's 2022 performance should be seen against the backdrop of a general worldwide decline caused by the pandemic, which led to temporary school closures, shifts to remote learning, and widespread disruption even in more developed countries.

According to Kazakhstan's national report on PISA 2022, mathematical literacy is defined as the ability to reason mathematically and to formulate, employ, and interpret mathematics in order to solve problems in a variety of practical contexts. This definition is consistent with the OECD's international conceptualisation of mathematical literacy. However, in the Kazakhstani educational context, the policy emphasis on improving mathematical literacy and international assessment outcomes creates a methodological tension for classroom practice. Preparing students for PISA-style tasks and developing genuine mathematical literacy are related goals, but they are not identical. For this reason, the present study does not treat authentic problems merely as preparation for international assessment; rather, it uses the PISA framework as a way to examine students' ability to formulate, solve, and interpret mathematical situations involving equations and inequalities. (Ministry of Enlightenment of the Republic of Kazakhstan, 2024)

A study on the impact of OECD policies on the Kazakh education system notes that the government has established clear PISA quantitative indicators, with mathematical achievements amounting to 470 points. If the reform efforts are aimed at reaching the point threshold, rather than changing the basic culture of teaching mathematics in the classroom, there is a risk that teachers will teach in the assessment format without understanding the conceptual orientation that gives meaning to the PISA tasks. Solving this problem requires not only updating the teaching material, but also constant professional development, which helps teachers to understand the difference between authentic mathematical thinking and superficial features of PISA task formats. Sarmurzin et al. (2021)

## 2.7 Authentic Problems in Mathematics Education

The use of authentic problems in mathematics education has become increasingly important in recent years, especially in discussions related to mathematical literacy and real-world application of knowledge.

### 2.7.1 Definition of Authentic Problems

Although the term "authentic problem" is widely used in educational research, researchers emphasize that authenticity involves more than simply adding a real-life context to a mathematical exercise. A problem is not considered authentic only because it includes familiar objects, prices, distances, or everyday situations. According to Palm (2007) and Vos (2011), authenticity depends on the relationship between the mathematical task and the real-world situation it represents. In authentic problems, the context is not decorative or secondary. Instead, the context itself becomes the source of the mathematical structure and influences how the problem should be interpreted and solved.

This distinction is important because it highlights the difference between performing mathematical procedures and engaging in genuine mathematical thinking. In many traditional mathematics exercises, students already know which operation or formula should be used because the structure of the task is clearly signaled by the textbook chapter or recently studied topic. The real-world context often serves only as a surface-level story around an already formalized mathematical problem. In such situations, students mainly practice procedural execution rather than contextual reasoning.

### 2.7.2 Difference Between Authentic Problems and Traditional Word Problems

Researchers have critically discussed the limitations of traditional textbook word problems for many years. Although it is often believed that verbal tasks associate school mathematics with real life, studies show that many of them do not develop meaningful problem-solving skills. Palm (2007), analyzing math textbooks, showed

that traditional verbal tasks usually contain all the necessary information, avoid unnecessary details and lead students to a predefined procedure. Selter et al. said that such tasks often teach students to convert words into operations mechanically, without assessing whether a decision really makes sense in a given context.

This allows students to get used to solving mathematical problems without critically thinking about the realism of their answers. Greer (1997) notes that students sometimes give mathematically correct solutions that do not coincide with the context, since they are completely focused on symbolic manipulations, and not on the real situation described in the task. In many exercises from the textbook, the contextual meaning becomes of less importance in comparison with the procedural accuracy. Authentic tasks try to overcome this limitation by making contextual reasoning an integral part of the solution process. In the case of authentic tasks, students cannot simply ignore the context, since an understanding of the situation is necessary to create an appropriate mathematical model.

### 2.7.3 Cognitive Demands of Authentic Problems

Compared to conventional exercises, authentic tasks place more complex cognitive demands on the learners. Solving authentic tasks requires students to participate in several interrelated processes, rather than following a single predefined algorithm. First, students need to carefully analyze the context and determine which information is mathematically relevant, and which details are less important. This process requires both a mathematical understanding and a situational judgment (Galbraith and Stillman, 2006). Students are expected to define the relationships between the quantities, recognize constraints and understand the purpose of the task before starting the calculations.

Secondly, authentic tasks require students to create mathematical representations on their own. Instead of getting a ready-made mathematical structure, students should decide how to mathematically model a situation. According to Lesh and Doerr (2003), this process is generative rather than reproductive, since students actively create mathematical representations, and not just use learned procedures. Such tasks often

involve assumptions, estimates and interpretations of incomplete or realistic information that more accurately reflect how mathematics is used outside the school environment.

Thirdly, students should apply mathematical reasoning within the model they have created. At this stage, they use procedures, concepts and strategies to solve the mathematical problem on their own. However, unlike the usual exercises from the textbook, the choice of strategy is not always obvious. When solving a problem, students may need to compare different approaches, evaluate the effectiveness of the methods, or reconsider their assumptions.

After all, authentic tasks require interpretation and justification of the results. Having received a mathematical solution, students must assess whether the answer is reasonable in relation to the initial situation. Blum and Leiß (2007) emphasize that interpretation is an important component of mathematical modeling, since mathematical answers are meaningful only if they can be correlated with reality. Therefore, students should explain their reasoning, substantiate their conclusions and assess how realistic their assumptions and results are. This requirement distinguishes authentic tasks from routine exercises, where the final numerical answer is often considered the only important result.

### 2.7.4 Benefits and Challenges of Authentic Problems

The growing interest in authentic mathematical problems is also related to the study of student engagement and motivation. Several studies show that students working with authentic tasks often show a higher level of interest, perseverance and awareness of the importance of mathematics compared to students working mainly with procedural exercises from a textbook (Boaler, 1998; Kramarski et al., 2002). When students realize the connection between mathematics and real life situations, they may have more desire to take an active part in solving problems, considering mathematics as meaningful, and not purely abstract.

An influential study by Boaler (1998) compared the students of two secondary schools with different approaches to learning. In one school, special attention was paid

to the project-oriented and contextualized teaching of mathematics, while in another school, mainly textbook-based methodological learning was applied. The results showed that students who were faced with authentic and open tasks showed a deeper conceptual understanding and were able to better apply mathematics in unfamiliar situations. It is important to note that these students have not shown weaker procedural skills, which challenges the widespread assumption that authentic problem solving reduces the more fluent execution of procedures.

Authentic tasks are also closely related to the development of critical thinking. In mathematical education, critical thinking involves the evaluation of assumptions, the analysis of representations and the recognition of limitations of mathematical models (Schoenfeld, 2006; Skovsmose, 1994). Authentic assignments stimulate this kind of thinking, because students have to constantly think about whether their mathematical models accurately reflect reality. For example, students may realize that a mathematically correct decision becomes unrealistic if important contextual factors are not taken into account. Such situations encourage students not only to do arithmetic, but also to ask questions, evaluate and reconsider their reasoning. The research of Stillman and Galbraith (1998) shows that students engaged in authentic modeling tasks often show richer mathematical thinking and more frequent use of self-monitoring strategies. Such students are more likely to check whether their intermediate results make sense and, if necessary, reconsider their approach. In this way, authentic tasks not only promote process competence, but also metacognitive development.

The relationship between authentic tasks and problem-solving skills has also been extensively discussed in research on mathematical education. Schoenfeld (2006) claims that solving problems involves not only the application of mathematical knowledge; it also includes strategic thinking, decision-making and self-regulation. Authentic assignments are especially effective for the development of these competencies, because students need to determine how to proceed in unfamiliar situations, rather than relying on immediately recognizable procedures. English (2016) further notes that authentic tasks help students develop the ability to transfer conceptual

understanding from context to context, which is an important aspect of mathematical literacy.

A study by Kramarski et al., (2002) found that students working with contextualized and authentic mathematical tasks are better able to cope with migration tasks that require the application of knowledge in unfamiliar situations. The researchers partly explain these results with the development of metacognitive abilities. Authentic assignments require students to monitor the progress of their reasoning, evaluate strategies, and make independent decisions throughout the assignment decision-making process. In contrast, traditional procedural tasks often offer an idea, offer a strategy, and limit evaluation to the accuracy of calculations.

The use of authentic tasks is also closely related to the PISA system of mathematical literacy. The three main processes within the PISA system - formulation, employ and interpretation - are closely related to the cognitive needs associated with solving authentic problems. Authentic tasks require students to formulate mathematical models based on real situations, use mathematical reasoning within these models, and interpret solutions according to contextual realities. Because of this agreement many researchers believe authentic tasks particularly suitable for the development and evaluation of mathematical literacy in the classroom.

Theoretical support for authentic mathematical learning can also be found in the tradition of realistic mathematical education developed by Van Den Heuvel-Panhuizen (2003). This approach emphasizes that mathematics should be related to meaningful situations and that students should take an active part in developing mathematical understanding by engaging with realistic tasks. From this point of view, the study of mathematics will be more effective if students see mathematics as a tool for the interpretation and organization of reality, and not as a set of isolated procedures.

Despite the strong theoretical and empirical support of authentic problem-solving-based approaches, the researchers also highlight some important limitations and problem points. From this perspective, students may be confused or fragmented if they are not guided sufficiently. Other researchers point out that authentic jobs can often be

difficult to assess consistently, because students can use several ways of solving and interpreting (Palm, 2007). Therefore, the effectiveness of authentic approaches to solving problems can largely depend on the development of tasks, the support of the teacher and the previous mathematical experience of students. The effectiveness of authentic assignments largely depends on the quality of the task development, the teacher's guidance and the willingness of students to deal with open situations. Poorly designed tasks may seem realistic at first glance, but they still represent common exercises from a textbook with an artificial context (Vos, 2011).

In addition, authentic assignments can cause difficulties for students who are not familiar with independent reasoning, ambiguity or contextual interpretation. A study by Sullivan et al. (2005) shows that it can be difficult for some students to solve problems in an authentic environment at first, as they have become accustomed to highly structured procedural learning. Without adequate scaffolding and educational support, students may experience confusion rather than productive participation.

Therefore, the successful performance of authentic mathematical tasks requires not only a realistic context, but also a thoughtful pedagogical design and the support of the teacher. These considerations show that the use of authentic tasks should not be considered as a simple substitute for traditional learning, but as a carefully worked out pedagogical approach aimed at developing a deeper mathematical understanding and mathematical literacy. As part of this study, the present study examines how authentic tasks involving equations and inequalities can contribute to the development of students' mathematical literacy in the classroom. The study conducted in Kazakhstan also revealed problems related to the limited use of practice-oriented mathematical problems in classroom teaching. Nurgabyl et al. (2023) examining mathematical literacy development through PISA-oriented tasks, found that practice-oriented and contextualized problems still represent only a small proportion of mathematics activities used in school practice. The researchers also note that mathematics instruction often remains strongly focused on procedural performance rather than on the application of mathematics in authentic situations.

### 2.7.5 Real Problems versus Authentic Problems

Although the terms "real problems" and "authentic problems" are sometimes used synonymously in mathematics education, research shows that there is an important difference between the two. A real problem is usually a mathematical problem that includes a context from everyday life. However, having a life story in itself does not make the task authentic. In some text tasks, a realistic situation is used only as an external background, while the solution still boils down to choosing numbers and applying a standard procedure without analyzing the meaning of the situation itself.

This problem is widely discussed in studies of text-based mathematical problems. Selter et al., (2000) argue that students often solve text problems while ignoring the realistic situation described. They call this phenomenon "suspension of thinking," that is, a temporary abandonment of meaningful reasoning. Their work shows that many school text assignments teach students to perceive context as unimportant and to look only for the expected arithmetic or algebraic operation. Palm (2008) makes a similar distinction, defining credibility as the degree to which a school assignment corresponds to a real-life situation. In his study, authenticity influenced students' willingness to use realistic considerations when solving text problems. The results showed that more authentic versions of tasks led to more realistic responses, while less authentic tasks were more likely to provoke superficial decision-making strategies.

Thus, the real problem in this study is understood not just as a problem with a life story, but as a problem that requires a context for mathematical reasoning. Authentic assignments require students to understand the situation, identify relevant information, construct a mathematical representation, apply an appropriate solution method, and interpret the result in accordance with the original context. This understanding also corresponds to the PISA Mathematical Literacy system, where mathematical literacy is seen as the ability to reason mathematically and formulate, apply, and interpret mathematics in various real-world contexts.

## 2.8 Equations and Inequalities as Tools for Mathematical Modelling and Authentic Problem Solving

### 2.8.1 Equations and Inequalities as Modelling Tools

Equations and inequalities are especially important for this study because they are based on the boundary between procedural algebra and mathematical modeling. In regular classes, students are often asked to solve equations or inequalities that have already been formed. But in real-world problems, you must first identify the connections between the limiting quantities and decide how these connections can be represented algebraically. This makes equations and inequalities suitable tools for testing students' mathematical literacy, especially when formulating mathematical situations within the PISA framework. Mason et al. (2005) also emphasize that algebraic thinking involves expressing relationships and structures, not just manipulating symbols. An equation expresses a ratio of equality between quantities, while an inequality expresses a relationship that contains an order, constraint, or range.

Although these terms are often introduced in an abstract symbolic form, they have much more meaning when related to real-world situations. For example, a linear equation can represent relationships related to cost, distances, fares, or financial planning. Situations such as comparing cellular tariffs, calculating transportation costs, converting units of measurement, or determining unknown quantities can be modeled in practice using equations. Similarly, inequality is especially useful when there are situations involving constraints or constraints rather than exact equality. Real-life examples may include maintaining costs within a certain budget, determining safe dosage ranges in medicine, or setting minimum and maximum conditions in planning and optimization tasks (Bazzini and Zamir, 2004).

When students see equations and inequalities in such contextualized situations, they view mathematics as a meaningful way of representing reality, rather than as a collection of disparate procedures. In such situations, algebra becomes associated with reasoning and interpretation, as students must think about how quantities are related and which mathematical representation best describes the problem. According to

Usiskin (1988), this understanding allows students to consider algebra not only as a symbolic manipulation, but also as a language for expressing quantitative relations. This approach is closely related to the development of mathematical literacy, as students use mathematics to interpret and analyze valid situations, rather than simply following learned algorithms.

### 2.8.2 Procedural Difficulties in Learning Equations and Inequalities

However, despite the practical importance of equations and inequalities, research shows that these topics are still taught using purely procedural approaches. In many traditional classrooms, math instruction mainly focuses on learning transformation rules and applying fixed algorithms to symbolic exercises. Students are usually taught to identify variables, simplify expressions, and perform algebraic operations correctly in order to get the only correct answer (Sfard and Linchevski, 1994). Fluency in procedures is undoubtedly an important aspect of mathematical literacy, and students need the opportunity to practice algebraic manipulations systematically. However, many researchers argue that studying procedures by itself often does not allow for a deeper conceptual understanding.

One of the most important part of procedural learning is that it allows students to learn how to manipulate symbols without understanding the meaning behind them. Hiebert and Grouws (2007) and Star (2005) note that procedural knowledge acquired without conceptual understanding often becomes difficult and difficult to transfer to unknown contexts. Students can successfully solve the equations presented in the textbook, but experience significant difficulties when they are asked to make up equations regardless of real-world situations.

Sfard and Linchevski (1994) distinguish between the operational and structural understanding of algebraic expressions. With operational understanding, students mostly view equations as procedures or instructions for performing calculations. In structural understanding, students understand equations as representations of relationships between quantities. This distinction is especially important in the context

of mathematical literacy, since constructing equations based on contextual situations requires structural consideration, not just procedural execution.

For example, students may know how to solve an equation like $3x + 5 = 20$ if it is already represented symbolically. However, you may have difficulties if you are asked to make up an equation yourself from a practical situation related to cost, distance, or fares. In such cases, the main task is not the algebraic manipulation itself, but understanding how quantities are related in a situation and how these relations can be represented mathematically. This ability to move from context to mathematical representation is closely related to the "formulation process" in the PISA mathematical literacy program.

Consequently, equations and inequalities related to mathematical literacy are becoming more than just procedural topics in the curriculum. They act as mathematical modeling tools that help students simplify, analyze, and interpret real-world situations. When students learn to use equations and inequalities in authentic contexts, they develop not only procedural skills, but also thinking, interpreting, and problem solving skills. This relationship between equations is uncontrollable by mathematical modeling, and is especially important in math literacy classes. Authentic assignments involving equations and inequalities, of course, require students to find the necessary information, formulate mathematical relationships, apply mathematical reasoning, and interpret the results in context. For this reason, equations and inequalities represent a suitable and meaningful mathematical field for exploring how authentic problems can contribute to the development of mathematical literacy.

At the same time, the researchers emphasize that simply adding real stories to procedural exercises does not automatically lead to meaningful learning. The effectiveness of contextualized learning depends on whether students really need to think about the situation on their own and make mathematical representations. If the mathematical structure is already obvious or the procedure is predefined, the task can remain procedural despite the contextual history. Thus, authentic assignments with

equations and inequalities should encourage students not only to calculate, but also to analyze relationships, assumptions, and substantiate their reasoning.

For these reasons, equations and inequalities occupy a particularly important place in research related to mathematical literacy and true mathematical education. Their flexibility and applicability in a variety of contexts make them suitable tools for exploring how students combine mathematical concepts with real-world reasoning. Thus, within the framework of this study, equations and inequalities are considered not only as topics of the curriculum, but also as mathematical tools that allow students to formulate, use and interpret mathematics in meaningful contexts.

### 2.8.3 Students' Misconceptions about Equations and Inequalities

The research literature on students' difficulties with equations and inequalities strongly supports these arguments and shows that many students have difficulties not only with procedures, but also, more importantly, with a conceptual understanding of algebraic relations. MacGregor and Stacey (1997), in their influential study of high school students' understanding of algebra, found that some of the most difficult difficulties arise not during the calculations themselves, but at an earlier stage of translating problematic situations into algebraic form. It was difficult for many students to understand what algebraic symbols really are. For example, students often perceived letters as symbols or abbreviations of objects, rather than as symbols of unknown or changing sizes. In addition, many students preferred to use arithmetic methods by trial and error rather than building algebraic representations, even when the structure of the problem explicitly provided for the use of equations.

These results are important because they suggest that students' difficulties are not solely related to mathematics. On the contrary, the problem is rather conceptual and epistemological in nature. Students may know how to manipulate algebraic symbols procedurally, but still cannot understand equations as representations of relations between quantities. This is often because traditional learning tends to focus more on symbolic manipulation than on representative meaning. Thus, students learn

to perform operations with equations without fully understanding why these operations make sense in the context of a particular situation.

The study of inequality reveals additional misconceptions that are also closely related to procedural learning. Studies by Tsamir and Bazzini (2004), Sfard and Linchevski (1994) show that many students mistakenly believe that inequalities behave exactly the same as equations in all algebraic transformations. For example, students may use the same procedures as when solving equations, without understanding why the inequality sign changes direction when multiplying or dividing by a negative number. These miscalculations often persist in students who successfully complete the usual exam exercises. This suggests that success in procedural matters alone cannot be considered as a reliable proof of a conceptual understanding of mathematics.

### 2.8.4 Contextualized Learning of Equations and Inequalities

Contextualized approaches to the study of equations and inequalities attempt to eliminate these limitations by focusing more on value, representation, and argumentation. In such approaches, equations and inequalities are considered not as isolated symbolic procedures, but as tools for representing and analyzing real-world situations. Students may encounter equations when comparing fares, analyzing transportation costs, examining budget constraints, or solving problems related to fares, distances, or quantity. In such situations, mathematical concepts naturally follow from the context, rather than being artificially imposed at the beginning of learning.

One of the main advantages of contextualized learning is that the meaning is established before the procedures are introduced. Students who understand the simulated situation for the first time often better understand the importance of algebraic operations. According to Carraher et al. (2017) Students who create equations themselves will consider algebraic transformations as operations on relations between quantities, rather than as arbitrary symbolic manipulations. In this way, fluency in procedures becomes linked to, rather than separated from, conceptual understanding.

Scientific evidence also confirms the effectiveness of contextualized approaches to the study of algebra. Koedinger and Nathan (2004) found that students often achieve

better results when solving problems with algebraic structure presented in a plot or contextual form than when solving equivalent formal symbolic equations presented without context. This discovery is especially important because it raises doubts about the assumption that the abstract symbolic form should always be the starting point in teaching algebra. Research shows that contextual understanding can actually support algebraic reasoning rather than distract it.

Research by Carraher et al.(2017) and Gravemeijer and Doorman (1999) show that students who learn using contextualized approaches demonstrate higher abilities to independently compose equations, recognize structural similarities between different tasks, and assess whether their solutions make sense in real-world situations. Such students are also more likely to transfer their mathematical knowledge to an unfamiliar context, as they view equations and inequalities as flexible representation tools rather than as fixed procedures tied to textbook exercises.

### 2.8.5 Equations and Inequalities within the PISA Modelling Cycle

The relationship between the contextualized study of algebra and mathematical modeling is very important both from a theoretical and educational point of view. In many real-world situations, equations and inequalities act as the main mathematical tools used for modeling. According to Blum and Leiß (2007), mathematical modeling begins with a real situation and continues with processes of simplification, mathematical analysis, and interpretation. In many cases, the resulting mathematical model takes the form of an equation, inequality, or a system of algebraic relations. Budget planning, optimization problems, cost comparisons, and feasibility constraints are all examples of situations in which equations and inequalities naturally become mathematical models.

This connection is particularly important in the PISA mathematical literacy program. The PISA development phase includes the definition of variables, the identification of mathematical relationships, the search for assumptions and the translation of real situations into mathematical form (OECD, 2023a). Each of these processes is directly related to the construction of equations and inequalities based on

contextual descriptions. Students should identify which quantities are relevant, decide how these quantities are related, and choose appropriate mathematical representations for a particular situation. In this sense, the ability to make up equations and inequalities is closely related to the development of abilities within the framework of the formation of mathematical literacy.

Researchers such as Niss (2015) and Stacey (2011) argue that the study of procedures often begins at the initial stages of mathematical activity, since students are usually given already created equations and simply asked to solve them. However, authentic contextualized assignments require students to be involved in the formulation process itself. Students should actively analyze situations, identify relationships, and create mathematical models on their own before starting calculations. This creates opportunities for deeper conceptual understanding and more meaningful mathematical reasoning.

These results are important for mathematical education. The literature in this section shows that traditional procedural approaches are generally effective in helping students manipulate equations, but are much less effective if they help them create equations independently of real-world situations. However, from a mathematical point of view, the ability to formulate mathematical representations is one of the most important and cognitive aspects of problem solving. For this reason, many researchers argue that algebra lessons should go beyond a purely procedural approach and place more emphasis on representation, contextual thinking and authentic problem solving. This does not mean that you should abandon the ephemeral procedure of possession. Rather, procedural skills, as well as conceptual understanding, should be developed in order to achieve a broader goal, to help students understand how mathematics can be used in various situations. Therefore, the authentic context becomes important not as an additional enriching activity, but as a central environment in which students learn how equations and inequalities function as tools for understanding reality. Within the framework of this theoretical and pedagogical basis, this study examines the role of authentic contextualized tasks, including equations and inequalities, in the

development of students' mathematical literacy through a system for formulating, applying and interpreting PISA results.

## 2.9 Synthesis and Research Gap

### 2.9.1 Summary of Key Literature

The literature reviewed in the previous sections indicates a close relationship between ideas about functional literacy, mathematical literacy, genuine problem solving, and the role of equations and inequalities in mathematical education. While these topics are often discussed separately in educational research, together they form a coherent theoretical framework that explains how to develop mathematical literacy through learning.

The discussion begins with the broader concept of functional literacy, which has become one of the main goals of modern education. Researchers and international educational organizations are increasingly emphasizing that education should focus not only on memorizing knowledge, but also on students' ability to meaningfully apply knowledge in various life situations (UNESCO, 2007; Street, 2003). In this broader framework, mathematical competence is particularly important because quantitative thinking is closely linked to many aspects of daily life, including financial decision-making, information interpretation, understanding technology, and problem solving in a professional and social context.

The literature under consideration also shows that mathematical literacy is significantly different from the traditional procedural understanding of mathematical education. The PISA system defines mathematical competence through formulation, application and interpretation processes and emphasizes students' ability to move from real-life situations to mathematical representations (OECD, 2023a; Niss & Højgaard, 2019). In this context, mathematical competence is not limited to accurate calculations or algorithms. Instead, it includes the identification of relationships, the creation of mathematical models, the strategic application of logical conclusions and the evaluation of mathematical results in context. Such an understanding shifts the focus of mathematical education from procedural repetition to meaningful application and

contextual reasoning. At the same time, the literature on authentic mathematical tasks suggests that authentic tasks provide important opportunities for the development of these competencies. The researchers argue that authentic tasks differ from the usual exercises from the textbook in that students need to analyze situations, identify relevant information, create mathematical representations and justify their reasoning, rather than using only predefined routines. (Palm, 2007; Boaler, 1998; Blum and Leiß, 2007). These tasks, of course, correspond to the formulation, application, and interpretation processes described in the PISA framework. Authentic mathematical assignments require students to develop mathematical models based on contextual situations, strategically use mathematical concepts and procedures, and interpret their decisions based on real-world conditions.

The studied studies also show that equations and inequalities play a particularly important role in this process. Equations and inequalities are not only algebraic topics in the curriculum, but also presentation tools that allow students to model quantitative ratios in practical situations (Kieran, 2020; Sfard and Linchevski, 1994). Through equations and inequalities, students can represent costs, prices, constraints, comparisons and relationships between variables in a mathematically relevant way. This makes equations and inequalities especially relevant for the development of mathematical literacy, since they support the formulation stage of mathematical modeling, which many researchers consider to be one of the more cognitively complex aspects of mathematical activity.

Taken together, these literary sources give an insight into the consistent pedagogical direction. The literature supports learning approaches in which equations and inequalities are introduced through authentic contextual situations, students are encouraged to create mathematical representations on their own, and mathematical progress is evaluated not only on the basis of procedural accuracy, but also on the basis of students' ability to reason, interpret and link mathematics with reality. In theory, such approaches seem to be in good agreement with the goals of mathematical literacy described in the PISA framework.

### 2.9.2 Identified Research Gaps

However, despite this strict theoretical agreement, there are some important gaps in the existing research literature. A major limitation is that most of the studies on mathematical literacy have been carried out within the framework of major international evaluations such as PISA. These studies provide important information about the general level of mathematical literacy and educational trends in different countries, but they do not always explain how mathematical literacy develops at the class level or which specific learning methods most effectively contribute to its development (Rutkowski and Rutkowski, 2009; Hopfenbeck et al., 2018).

In addition, many classes in general are devoted to authentic mathematics teaching approaches to problem solving or modeling, without focusing specifically on equations and inequalities as a separate area of algebraic content. Other studies examine an authentic learning environment, but evaluate the results in terms of general achievements or commitment, and not specific formulation, application and interpretation skills defined within the framework of PISA. Therefore, the relationship between authentic learning, equations and inequalities and PISA-oriented mathematical competence remains relatively insufficiently studied in studies conducted in the classes.

Another important limitation is the pedagogical context. Much of the existing literature is based on European, North American or international research on a large scale. There are still a limited number of studies in Kazakhstan devoted to the development of mathematical literacy through authentic algebraic tasks. In addition, relatively few studies are aimed specifically at students of the 6th grade, although this stage is important for the transition from arithmetic reasoning to more formal algebraic thinking.

These gaps are especially important as the equations and inequalities often represent students' first sustained experience in the field of an algebraic representation and mathematical modeling. The way these concepts are introduced can greatly influence whether students develop only procedural skills or also acquire the ability to

use mathematics meaningfully in real-life situations. Thus, the study of authentic learning equations and inequalities at this stage can give important information about the development of mathematical literacy.

For these reasons, this study focuses in particular on the use of authentic equation and inequality-related tasks to promote the mathematical literacy of students in the framework of the PISA program "Formulating, applying and interpreting". By studying this relationship in the classroom with 6th grade students in Kazakhstan, this study aims to contribute to a growing amount of research related to authentic mathematics teaching, algebraic thinking and the development of mathematical literacy.

The second important aspect of the research gap concerns the age group that was most often studied in terms of mathematical literacy and authentic mathematics education. A large part of the existing research literature is mainly devoted to students of secondary schools, high schools or universities. This trend is partly due to the widespread assumption in many educational systems that students should first be fluent in procedural issues before getting acquainted with mathematical modeling, authentic problem solving or contextualized algebraic reasoning. According to this view, applied mathematical thinking becomes relevant only when students master the formal symbolic procedures.

However, many researchers argue that this assumption should be reconsidered. Studies on basic algebra and mathematical thinking show that younger students can usefully use contextualized mathematical thinking when learning and developing tasks coincide with their development (Carraher et al., 2017). Students of primary and primary classes can work with relationships between sizes, create ideas and think about contextual situations before developing an advanced fluent mastery of symbols. This perspective is especially important, since mathematical understanding develops not only through the repetition of procedures, but also through the possibility of linking mathematical ideas with meaningful situations.

The students of the 6th grade, who are the focus of this study, take a particularly important transitional stage in mathematical education. In many national curricula,

including the curricula of Kazakhstan, the 6th grade is a stage when students become more formally familiar with algebraic notations, variables, equations and inequalities. This transition from arithmetic thinking to algebraic is important from an educational point of view, since students begin to develop conceptual ideas that can greatly influence their subsequent mathematics lessons. Such researchers as Sfard and Linchevski (1994) and MacGregor and Stacey (1997) emphasize that students' first experiences in the field of algebraic symbolism often defined their understanding of algebra in the following years of training at school. When algebra is introduced mostly as a set of procedures and symbolic manipulations, students can develop fluency-treatments without a deeper understanding of representations.

At the same time, studies specifically devoted to learning authentic mathematics on this upheaval, remain relatively limited. Existing research in algebra, at an early age often focus on arithmetic-algebra thinking younger children, while many studies on mathematical modeling and authentic solution of tasks focus more on the students of the upper grades of high school. Therefore, the range of grades 5 to 7 remains relatively little studied in studies of mathematical literacy, authentic learning and contextualized algebraic thinking.

Another important aspect of the research gap is the pedagogical context and geographical representation. Much of the available literature on mathematical literacy, authentic problem solving and the study of algebra relates to the educational systems of Western Europe, North America, East Asia and Australia. In comparison, there is still a limited number of examination studies devoted to the study of these issues in the context of education in Central Asia, including Kazakhstan.

Kazakhstan is a particularly important region for several reasons. Firstly, Kazakhstan has been participating in the PISA assessment program since 2009, and the results of the international assessment still show that many Kazakh students have difficulty completing math literacy tasks compared to the OECD average (OECD, 2023c). These results emphasize the practical importance of learning approaches to

learning, which can help students develop stronger skills to apply mathematics in real conditions.

Secondly, over the past decade, major reforms of curricula have been carried out in the education system of Kazakhstan. The updated national educational standards are increasingly focusing on competence-based learning, critical thinking and the practical application of knowledge in accordance with international educational standards. However, some researchers point out that the reform of the curriculum itself does not automatically transform the practice of teaching. Teachers can still rely on methodological hints due to the complexity of the exams, limited learning resources, lack of time or insufficient preparation for open mathematical tasks. As a result, there may be a gap between the curriculum policy and the actual teaching in the classroom. This question is especially important in the context of mathematical literacy, where successful implementation often requires significant pedagogical changes, not just changes to the curriculum. Despite these reforms at the political level, there is relatively little empirical research that studies how such ideas are implemented in real school practice, especially in mathematical education. It is still not completely clear to what extent authentic approaches to solving problems have been integrated into the daily teaching of mathematics in Kazakh schools.

Thirdly, the historical tradition of teaching mathematics in Kazakhstan often emphasized procedural fluency, manipulation of symbols and algorithmic accuracy. Although these aspects of mathematical education remain important, this also causes problems to arise when teachers try to implement more open, contextualized and focused on literacy pathways in teaching. For this reason Kazakhstan offers especially meaningful context for the study of the relationship between education and procedural authentic study of mathematics.

Another aspect of the research gap concerns the specific combination of learning approach and mathematical content, which is covered in this study. Although authentic problem solving and mathematical modeling have been extensively studied in studies on mathematical education, relatively few studies focus specifically on equations and

inequalities as the fundamental mathematical field through which mathematical literacy is developed. Many studies involving authentic tasks use mixed mathematical content, statistics, geometry or general modeling actions, instead of paying special attention to algebraic representation through equations and inequalities (Vos, 2018; English, 2016).

At the same time, research that deals with exactly equations and inequalities is often still based on traditional or minimally contextualized learning. In many cases, contextualized tasks are still developed in such a way that they lead students to predefined procedures and limit the possibilities for real formulation and independent mathematical representation. Palm (2006) and Selter (2000) argue that many of the "real tasks" described in textbooks reproduce the same limitations as procedural exercises, since contextual situations do not really shape the process of mathematical reasoning.

Therefore, there is little empirical evidence of how reliably developed tasks, which include equations and inequalities, affect the mathematical competence of students within the framework of the PISA formulation, use and interpretation system. In particular, there are so far relatively few studies in the classroom that investigate how students in the 6th grade construct algebraic models based on authentic contextual situations and how such experiences affect their ability to formulate, apply and interpret mathematics meaningfully.

### 2.9.3 Contribution of the Present Study

It is within this combination of research gaps that the present study is conducted. The study does not attempt to reproduce large-scale international assessment studies. Instead, it focuses on a more specific class-level question associated with the development of mathematical literacy in authentic learning environments. More specifically, the study examines how authentic contextual tasks, including equations and inequalities, affect the mathematical competence of 6th grade students. To be able to influence the class within the framework of a system for the formulation, application and interpretation of PISA results in the context of Kazakhstan. In answering this

question, the study is intended to contribute both to the theoretical literature on mathematical literacy and to the practical discussion of teaching mathematics in Kazakhstan. The study also aims to provide exam data on how authentic algebraic tasks can help students to apply mathematics meaningfully in real-life situations, especially in an important transition from arithmetic to algebraic reasoning.

# 3. METHODOLOGY

## 3.1 Research Design

This study uses a quasi-experimental method of quantitative investigation to find out whether learning based on authentic mathematical problems can improve the mathematical competence of 6th grade students in the field of equations and inequalities. A quasi-experimental approach is suitable for this study, since the study is conducted within an existing educational center, where random distribution of students into groups is not possible. Instead, whole grades are given for the 6th grade. One class refers to the experimental group and the other to the reference group. The experimental team receives instructions based on real tasks, modeling tasks that require students to formulate, solve and interpret equations and inequalities in conditions of real contextual tasks. The control group follows the traditional procedural instructions, focusing on algebraic manipulation and routine tasks. Both groups study the same subject during the same period of study. To evaluate the mathematical literacy of students, quantitative preliminary and posttest analysis is used. Preliminary examinations determined the basic mathematical competence of each student and made it possible to statistically check the correspondence of the groups before the start of classes. Subsequent tests made it possible to evaluate the changes in academic performance associated with learning. Students' academic performance is assessed through a structured test consisting of authentic, context-based tasks involving equations and inequalities. The same assessment system is applied before and after the learning event, so that the learning outcomes can be compared within and between the groups. Both groups learned from the same teacher, which helps to reduce the likelihood that differences in results can be explained by the influence of the teacher, and not by the approach to learning itself.

Although the evaluation orders reflect the different phases of the simulation process, all data is analyzed quantitatively. Students' answers are evaluated using a predefined analytical scale of points, which assigns numerical marks to certain components of mathematical literacy. There is a lack of interviews, open, qualitative

coding or interpretative analysis of student stories. The main focus of the study is the comparison of numerical indicators of modeling efficiency in different groups and at different time periods. The quantitative data obtained from the calculation of the rubrics are used to study the differences in the development of mathematical literacy of students in experimental and control groups. This approach allows a systematic comparison of learning outcomes while maintaining methodological clarity and feasibility within the study.

## 3.2 Participants and Research Setting

About 26 students of the 6th grade who attend a private training center in Kazakhstan took part in the study. The center specializes in additional math classes: children come there after classes in the main school to deepen their knowledge and improve their academic performance. At the time of the study, all participants were between 11 and 13 years old. This age was not chosen by chance: it is in the 6th grade that the Kazakh mathematics program provides for the first introduction to equations and inequalities. Accordingly, the topic studied during the study completely coincided with what the children went through in the curriculum. The students were divided into two groups of 13 people each, an experimental and a control group. It is important to note that these groups were not formed specifically for classes: they existed even before the start, since they were created by the administration of the center during the next recruitment of students. For this reason, random distribution of children into groups was not carried out, which simply would not be possible within the framework of the actual work of the center. Instead, when distributing the groups under experimental conditions, the schedule of classes was taken into account. Special care was taken to ensure that none of the groups were in the notoriously better or worse conditions due to the time of day or the day of the week on which the lessons took place. The selection of participants was targeted. This means that both the place of study and the participants were selected according to predefined criteria: a suitable class, a topic directly related to the subject of study and the opportunity to complete a full set of 12 lessons in the program. At the same time, it is not claimed that this sample is representative of all

sixth-graders of Kazakhstan. Another task was to study in detail the functioning of the proposed pedagogical approach in certain clearly described conditions and to obtain results that could be useful for teachers and methodists working in similar conditions. Participation in the study was completely voluntary. The parents or guardians of all students received an informed consent form in advance. This document explained in detail what the purpose of the study is, what activities are being carried out, what data should be collected, and under what conditions this data should be stored and used. Children whose parents or guardians did not agree continued to attend classes normally, their learning process did not change, but their data were not included in the final analysis. It is important that no student suffers from any academic consequences, regardless of whether he participated in the study or not.

## 3.3 Research Instruments

Despite the fact that the assessment tasks reflect the various stages of the modeling process, all data is analyzed quantitatively. Students' responses are assessed using a pre-determined analytical score scale that assigns numerical scores to specific components of mathematical literacy. The main focus of the study is on comparing the numerical performance of authentic tasks in different groups and at different times. The quantitative data obtained as a result of scoring rubrics are used to study the differences in the development of mathematical literacy of students in the experimental and control groups. This approach allows for a systematic comparison of learning outcomes while maintaining methodological clarity and feasibility within the framework of the study. The main research tools used in this study were a preliminary test and a follow-up test designed to assess students' mathematical literacy using authentic mathematical problems involving equations and inequalities. The tests were developed on the basis of PISA-oriented mathematical literacy tasks and adapted to the educational context of Kazakhstan and the cognitive level of 6th grade students. The purpose of this tool was not only to evaluate students' procedural ability to solve equations and inequalities, but also to examine how students apply mathematical reasoning in authentic contextualized situations. Thus, the assignments required

students to analyze contextual information, construct mathematical representations, apply mathematical procedures, and interpret the solutions meaningfully. The test tasks were developed in accordance with the PISA mathematical literacy system, in particular, with three mathematical processes - formulate, Employ and interpret (OECD, 2023). This tool was designed to evaluate mathematical literacy rather than functional literacy in general. In the context of this study, mathematical literacy is considered as a measurable component of broader functional literacy and is implemented using the PISA "Formulate, Employ and Interpret" system.

1. The "Formulate" component was aimed at enabling students to identify mathematical relationships and translate authentic situations into mathematical form.
2. The "Employ" component assessed students' ability to use mathematical procedures and reasoning to solve a problem.
3. The "Interpretation" component assessed the students' ability to explain and justify their mathematical solutions in the original context of the problem.

The tool consisted of authentic contextualized tasks related to equations and inequalities. The test tasks were adapted from official PISA released items and PISA-like mathematical literacy tasks. Some tasks were based on official PISA items, such as "Exchange Rate", "Postal Charges", and "Climbing Mount Fuji", while other tasks were adapted from PISA-like or context-based mathematical literacy resources. All tasks were modified to fit the Kazakhstani educational context, Grade 6 students' mathematical level, and the topic of equations and inequalities. The students' answers were evaluated using an analytical score scale developed in accordance with the PISA "Formulate–Employ–Interpret" system. Each task was evaluated separately according to three parameters, which allowed for a more detailed analysis of the level of mathematical literacy of students, rather than relying solely on the final answers. This approach to scoring allowed us to check not only whether the students came to the right decisions, but also how they constructed mathematical representations and interpreted their results in an authentic context. The use of authentic PISA-oriented assignments and rubric-based assessments was considered appropriate for this study, as the purpose

of the study was to explore the development of mathematical literacy, not just procedural achievements. Using authentic contextualized tasks, this tool allowed researchers to assess students' ability to meaningfully apply mathematics in authentic situations.

The validity of the assessment instrument was supported through expert review and curriculum alignment. The test tasks and the scoring rubric were reviewed by the research supervisor and mathematics teachers working with Grade 6 students. The purpose of the review was to examine whether the tasks were appropriate for students' age and cognitive level, whether they were aligned with the Grade 6 mathematics curriculum, and whether they reflected the objectives of the study.

Particular attention was paid to the content validity of the instrument. The reviewers checked whether the tasks were related to equations, inequalities, and problem-solving, and whether they required students to apply mathematics in real-life contexts. The tasks were also examined in terms of their alignment with the PISA mathematical literacy framework, especially the processes of formulating, employing, and interpreting mathematics. Based on the feedback received, the wording of some tasks was simplified, numerical values were adjusted, and the contexts were adapted to make them more understandable and relevant for Grade 6 students in Kazakhstan.

The scoring rubric was also reviewed to ensure that it could be consistently applied to students' open-ended responses. Students' answers were evaluated according to predefined criteria based on five indicators of mathematical literacy: identifying mathematical aspects and variables, translating the problem into mathematical language, selecting and applying a solution strategy, performing mathematical calculations, and interpreting the result in context. Each indicator was scored from 0 to 2 points. This scoring procedure helped reduce subjectivity and allowed students' mathematical literacy to be assessed not only through final answers but also through their reasoning process.

The reliability of the assessment was supported by using the same test structure and the same analytical scoring rubric for both the pre-test and the post-test. To increase

scoring reliability, a sample of students' responses was reviewed twice using the same rubric. In cases where the score was unclear, the response was checked again according to the rubric criteria. This procedure helped ensure consistency in the evaluation of open-ended answers and increased the reliability of the quantitative scores used for further analysis.

## 3.4 Development of Authentic Tasks

The authentic mathematical tasks, which are used both in practical lessons and in the assessment tools, were developed according to a basic process aimed at really meeting the requirements of mathematical literacy, rather than simply integrating routine exercises into the superficial form of real language. The task was considered truly mathematical in the corresponding sense, when students had to perform at least two of the three processes that underlie the PISA system of mathematical literacy: the formulation of the mathematical representation of the real situation, the use of mathematical procedures to work within the framework of this notion, and the reverse interpretation of the result in relation to the original context.

In addition to the PISA and PISA-like tasks used for the assessment instrument, the classroom tasks used during the intervention were selected and adapted from supplementary educational materials used in the educational center and preparation books for BIL and NIS entrance examinations. These materials were used as sources of practical and context-based mathematical problems.

In cases where the existing PISA element contained a suitable pattern, but the context or numbers did not match the target audience, the element was changed. In some cases, this required a complete replacement of the settings while maintaining the mathematical structure; in other cases, it required a simplification of the numerical requirements, so the main task was algebraic reasoning, and not arithmetic complexity. In all cases, changes were made in order to preserve the authentic character of the task: the mathematical question, of course, should arise from the described situation, rather than impose it.

The original tasks, which were developed for practical classes, were also specially distributed among twelve lessons. The early lessons used tasks that required a relatively simple formulation, where the connection between a real situation and an equation or inequality was obvious. When the task was performed, tasks appeared in which the level of formulation required a more detailed analysis of the situation, the limitations were less obvious, or the interpretation of the mathematical result required an assessment of whether the answer made sense in the original context. This gradual increase in demand was aimed at helping students to gradually develop their thought processes, rather than facing all difficulties from the very beginning.

The selection and adaptation of authentic tasks for data collection instrument were also guided by selected aspects of authenticity proposed by Schlüter and Besser (2024). In their Model for Authenticity in Modelling Test Items, authenticity is not treated as one general characteristic of the whole task, but as a set of separate aspects, such as real-world context, events, objects, question or assignment, data, figures, use of mathematics, and purpose. In the present study, these aspects were used as guiding criteria for selecting and adapting tasks rather than as a separate full-scale coding procedure. Therefore, the tasks were selected and modified to include realistic contexts, meaningful numerical information, practical questions, appropriate use of mathematics, and a clear real-life purpose. Task authenticity was evaluated using criteria adapted from Schlüter and Besser's (2024) Model for Authenticity in Modelling Test Items (MAMTI). The model includes eight aspects: real-world context, events, objects, question/assignment, data, figures, use of mathematics, and purpose. In this study, these aspects were applied to determine whether the selected and adapted tasks represented meaningful real-world situations involving equations and inequalities.

*Table 3.4.1. Authenticity Criteria Used for Task Selection and Adaptation*

| **Authenticity aspect** | **Meaning in this study** | **Application in task selection/adaptation** |
|---|---|---|
| Real-world context | Does the overarching real-world context actually exist outside of school? | Tasks were selected around real-life contexts such as currency exchange, postal charges, internet tariffs, bank deposits, shopping decisions, and route planning |
| Events | Are they events that actually happen outside of school? | Tasks included realistic actions such as exchanging money, sending parcels, choosing a tariff, saving money, or planning a hiking route. |
| Objects | Are they reality-based objects that actually exist outside of school? | The adapted tasks included familiar objects and services such as tenge, , Tele2 tariffs, bank deposits, and the Ile Alatau/Talgar Peak context. |
| Question/assignment | Does it represent a question that actually arises for people in the real-world context? | Students were asked to make practical decisions, such as deciding whether a tariff should be changed, or determining the latest safe starting time. |
| Data | Is it data that people actually encounter outside of school? | Numerical values such as prices, distances, time limits, speeds, and percentages were adjusted to be understandable for Grade 6 students. |
| Figures | Is it a representation that people actually encounter outside of school? | This criterion was considered when a task included tables, diagrams, or visual data. For example, tariff tables or postal charge tables were used as realistic forms of information. |
| Use of mathematics | Does the expected use of mathematics correspond to that which is actually used in the real-world context? | Students used equations, inequalities, arithmetic operations, percentages, comparison, and interpretation to solve problems that could arise in the given context. |
| Purpose | Does the mathematical solution serve a practical purpose in the situation? | The tasks required students to use mathematics to support a real-life decision, not only to find an isolated numerical answer. |

*Note.* Adapted from Schlüter and Besser's (2024) Model for Authenticity in Modelling Test Items (MAMTI). The model evaluates authenticity through separate aspects rather than assigning a single overall authenticity score.

In this study, the authenticity of the tasks was not treated as a general label attached to any word problem. Instead, the selection and adaptation of tasks were guided by selected authenticity aspects discussed by Schlüter and Besser (2024), including real-world context, realistic events or objects, meaningful data, realistic question or assignment, use of mathematics, and purpose. Since the tasks were adapted for educational purposes, the study did not claim that the tasks were fully authentic in a holistic sense. Instead, authenticity was examined through separate aspects, following the atomistic approach of the MAMTI model. Therefore, the tasks were selected or modified only when the mathematical problem was connected to a realistic situation and required students to interpret the result in relation to that situation. An example of authenticity analysis for one adapted task is presented in Appendix X.

## 3.5 Scoring Rubric and Assessment Criteria

The students' answers were evaluated both at the preliminary and subsequent exams using a rubric developed to evaluate the quality of mathematical literacy based on three aspects of the PISA process: formulation, application and interpretation. Instead of awarding points exclusively for the correct final answers, the section awards sub-points for answers that demonstrate competence in one or two of these processes, even if a complete solution is not found. This approach is consistent with the opinion that mathematical literacy is a multi-part skill and that learning aimed at its development should be evaluated in such a way as to reflect its complexity. Each task in the tools was analyzed to determine which of the three processes is needed first, and the criteria for the headings were formulated accordingly. For a task based on the formulation, the student could get a score for the correct determination of the corresponding quantities, the corresponding variables and the construction of an equation or inequality that would accurately reflect this situation, even if his subsequent algebraic work contained errors. For a task focused on the employment

process, remuneration was awarded for the correct and systematic application of algebraic procedures to a particular view. For tasks that require interpretation, a grade was given for answers that translated the mathematical result into the context of the task and explained whether this result made sense and why. Each answer was evaluated on a three-level scale for each relevant aspect of the process: full enumeration, partial enumeration, or no enumeration. The total score for this task was the sum of the points for the corresponding measurements, and the total score was the sum for all tasks. This structure made it possible to obtain an evaluation profile for each student, which reflects not only the overall performance, but also which aspects of the process were worked out to a greater or lesser extent, although the result variable used in the statistical analysis was the total score.

*Table 3.5.1. Indicators of Mathematical Literacy Processes Used in the Scoring Rubric*

| **Mathematical literacy process** | **Code** | **Indicator** |
|---|---|---|
| Formulate | FO1 | Identifying the mathematical aspects of the problem in real-context situations and identifying the variables in the problem |
| Formulate | FO2 | Converting problems into suitable mathematical language, including variables, symbols, and mathematical models |
| Employ | EM1 | Designing and implementing strategies to find mathematical solutions |
| Employ | EM2 | Applying mathematical facts, rules, algorithms, and structures to find a solution |
| Interpret | IN1 | Interpreting the mathematical result obtained |

*Note.* Adapted from Andari and Setianingsih (2021). The indicators were used in the present study to assess students' mathematical literacy based on the PISA processes of formulating, employing, and interpreting mathematics.

## 3.6 Data Collection Procedure

The data collection procedure was carried out in several stages and covered the whole period of the study. Before the educational intervention, both the experimental and control groups completed a pre-test. The purpose of the pre-test was to determine students' initial level of mathematical literacy in solving real-life problems related to equations and inequalities.

The main data collection instrument was a mathematical literacy test consisting of five open-ended tasks. The tasks were adapted from official PISA released items and PISA-like mathematical literacy tasks. They were selected because they required students not only to perform calculations but also to understand a real-life situation, identify relevant information, construct a mathematical model, and interpret the result in context. The adapted test included real-life contexts such as currency exchange, postal tariffs, internet plans, bank deposits, and hiking route planning.

The original tasks were adapted to the Kazakhstani educational context and the mathematical level of Grade 6 students. During the adaptation process, names, currencies, numerical values, and real-life settings were changed. Some contexts were localized, for example by using Kazakhstani tenge, local service providers, and familiar geographical settings such as the Ile Alatau. The tasks were translated into Kazakh, and the wording was adjusted to make the questions understandable for Grade 6 learners. After the pre-test, the educational intervention was conducted over four weeks and included 10 lessons for each group. Each lesson lasted approximately 80 minutes and focused on equations and inequalities within the Grade 6 mathematics curriculum. Both groups studied the same mathematical topics, but the instructional approaches were different. The control group was taught through a traditional approach. Lessons in this group mainly included teacher explanation, worked examples, and routine exercises related to equations and inequalities. The main focus was on algebraic procedures,

transformations, and solving equations or inequalities without an extended real-life context.

In the experimental group, each lesson was organized in two stages. The first stage, lasting approximately 40 minutes, focused on developing students' conceptual and procedural understanding of equations and inequalities. At this stage, students solved equations and inequalities in direct mathematical form in order to learn the necessary methods. The second stage, also lasting approximately 40 minutes, focused on authentic real-life mathematical tasks. These tasks were connected to situations familiar to students, such as shopping, mobile phone tariffs, travel expenses, budget limitations, and other everyday contexts.

The authentic tasks used in the experimental group were selected by the researcher from supplementary mathematics materials, including NIS and BIL preparation resources, materials used in the educational center, and publicly available online educational resources. These tasks were chosen because they included context-based mathematical problems suitable for Grade 6 students and related to the topics of equations and inequalities. The tasks were not redesigned by the researcher; instead, they were selected based on their relevance to the lesson objectives, Grade 6 curriculum level, students' age, and the PISA mathematical literacy processes: formulating, employing, and interpreting. During the lessons, the selected tasks required students to analyze real-life situations, identify relevant information, construct equations or inequalities, apply appropriate solution strategies, and interpret the results in context. Therefore, the intervention aimed to develop students' mathematical literacy through authentic problem solving. At the end of the intervention, both groups completed a post-test. The post-test was used to identify changes in students' mathematical literacy after the intervention. Students' responses in both the pre-test and post-test were evaluated using the same analytical scoring rubric based on the PISA mathematical literacy processes: formulating, employing, and interpreting. The obtained scores were entered into a spreadsheet and used for quantitative analysis, including within-group and between-group comparisons.

## 3.7 Ethical Considerations

Since the participants were students of the 6th grade, ethical issues were carefully considered at each stage of the study. Prior to the data collection, the written consent of the parents or guardians of the students was obtained. The consent explains the purpose of the study, what students need to do, what types of data are collected, and how this data is stored and used. Parents and students were informed that participation was voluntary and that the refusal to participate does not affect the lessons, grades or the relationship of students with the educational center.

The study was also designed in such a way that it does not disadvantage the control group. The students of the control group continued to receive regular math lessons at the center throughout the study period. After the intervention, the authentic tasks and study materials used in the experimental group were handed over to the educational center so that they could later be used with other students. The data of the students were treated confidentially. The completed test papers and written answers were used for research purposes only. Each student was provided with digital codes, and these codes were used instead of names when entering data and analysis. In the dissertation the results are presented at the group level, so identifying the individual students is not possible. Physical documents were kept in a safe place, and with digital files were protected by a password. In the study was not used, no deception. Students and parents were informed that in the course of the research were two approaches to learning mathematics. Students of the experimental group in advance did not report exact tasks, but they knew that their results before and after the exam will be used for research purposes.

The researcher's role as a lecturer and data analyst was also considered as a possible source of bias. Since independent assessment on a second grade scale was not used, an analytical rubric established in advance was used in the study, adapted from the system of mathematical literacy PISA for evaluations to improve coherence. The answers of all students before or after the test were classified according to the same criteria. In addition, statistical analysis was planned, until the final interpretation of the

results and subsequently not selected. These measures do not exclude the researcher's possibilities of influence, but they make the scoring procedure more systematic and the analysis more transparent.

## 3.8 Data Collection Instrument

The mathematical literacy test consisted of five open-ended questions. The questions were adapted from PISA released items and PISA-like mathematical literacy tasks. The test assessed students' ability to solve real-life mathematical problems by formulating the situation mathematically, employing appropriate mathematical procedures, and interpreting the result in context. The Kazakh version of the test is provided in Appendix C, while the adapted English version is provided in Appendix B. A table showing the original sources of the test items and the main adaptations made by the researcher is presented in Appendix A. The scoring rubric is presented in Appendix D.

*Table 3.8.1. Sources and Adaptations of Test Items*

| Test item | Original task | Source type | Adaptation |
|---|---|---|---|
| Question 1 | Exchange Rate | Official PISA released item | Context localized from international currency exchange to KZT–TRY; name, country, currency, and values were changed. |
| Question 2 | Postal Charges | Official PISA released item | Currency changed to tenge; postal tariff table was simplified; budget condition was added. |
| Question 3 | Internet Tariff | PISA-type/context-based mathematical literacy task | Provider changed to Tele2; tariff names, and values were localized. |
| Question 4 | Investments | PISA-like mathematical literacy task | Currency changed to tenge; context localized to bank deposits. |
| Question 5 | Climbing Mount Fuji | Official PISA 2012 released item | Context changed to Talgar Peak/Ile Alatau; distance, time limit, and reflection questions were adapted. |

# 4. ANALYSIS AND RESULTS

The data of this study were analyzed using quantitative methods. Students' pre-test and post-test results were scored according to a rubric adapted from the PISA Mathematical Literacy Framework. The rubric focused on three mathematical processes: formulating, employing, and interpreting. These processes were considered suitable for this study because they show how students understand real-life situations, construct mathematical models using equations or inequalities, solve them, and interpret the meaning of the answer in context.

After scoring the tests, the total score of each student was entered into Excel. Descriptive statistics, including mean, median, standard deviation, minimum, and maximum values, were calculated for both the experimental and control groups. These statistics were used to summarize students' performance before and after the intervention.

*Table 4.1. Descriptive Statistics for Pre-test and Post-test Score*

| Group | Test | *N* | *M* | Median | *SD* | Variance | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Experimental | Pre-test | 13 | 15.62 | 18.00 | 7.54 | 56.92 | 4 | 25 |
| Experimental | Post-test | 13 | 21.54 | 23.00 | 9.42 | 88.77 | 8 | 34 |
| Control | Pre-test | 13 | 15.92 | 18.00 | 6.86 | 47.08 | 4 | 25 |
| Control | Post-test | 13 | 18.15 | 20.00 | 8.16 | 66.64 | 4 | 28 |

Before conducting the inferential statistical analysis, descriptive statistics were calculated for the pre-test and post-test scores of both the experimental and control groups. The purpose of this step was to summarize the general performance of students before and after the intervention.

The descriptive statistics showed that the experimental group's mean score increased from 15.62 in the pre-test to 21.54 in the post-test. This indicates an average improvement of 5.92 points. In the control group, the mean score increased from 15.92 in the pre-test to 18.15 in the post-test, with an average improvement of 2.23 points.

Therefore, both groups showed improvement, but the increase in the experimental group was higher than in the control group.

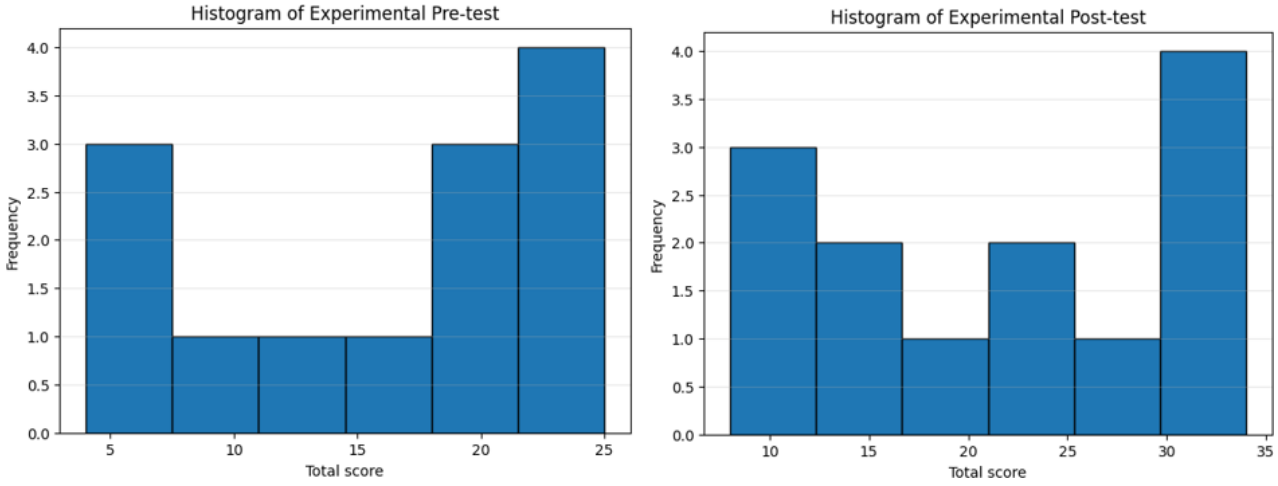
Before selecting the appropriate inferential statistical test, the assumption of normality was examined using the Shapiro-Wilk test. The results showed that all p-values were greater than .05. Specifically, the p-value was 0.1407 for the experimental pre-test, 0.1772 for the experimental post-test, 0.3274 for the control pre-test, and 0.2011 for the control post-test. These results indicate that the distributions did not significantly deviate from normality according to the Shapiro-Wilk test.

*Table 4.2. Results of the Shapiro-Wilk Normality Test*

| **Dataset** | **Shapiro-Wilk statistic** | ***p*** | **Result** |
|---|---|---|---|
| Experimental pre-test | 0.9016 | .1407 | Normally distributed |
| Experimental post-test | 0.9089 | .1772 | Normally distributed |
| Control pre-test | 0.9287 | .3274 | Normally distributed |
| Control post-test | 0.9129 | .2011 | Normally distributed |

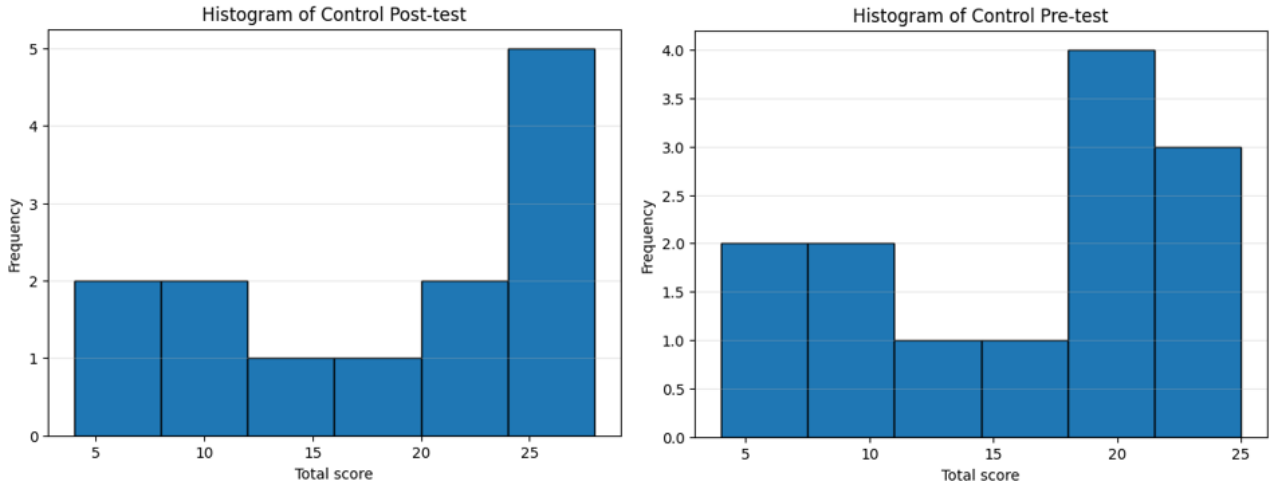
In addition to the Shapiro-Wilk test, histograms and Q-Q plots were used to visually examine the distribution of the scores (see Appendix ) Although the Shapiro-Wilk test did not indicate statistically significant deviations from normality, the histograms and Q-Q plots showed some deviations from an ideal normal distribution. This may be related to the small sample size, as each group included only 13 students. Moreover, the scores were based on a rubric and had a limited possible range, which also needed to be considered when choosing the statistical method.

*Figure 4.1. Histogram of pre-test and post-test of Experimental group*




Therefore, although the Shapiro-Wilk test results did not violate the normality assumption, the small sample size, bounded rubric-based scores, and visual

*Figure 4.2. Histogram of pre-test and post-test of Control group*




The Mann-Whitney U test was used to compare the experimental and control groups, while the Wilcoxon signed-rank test was used to examine within-group changes from pre-test to post-test. The analysis was conducted in five steps: first, to compare the pre-test scores of the two groups; second, to examine improvement within the experimental group; third, to examine improvement within the control group; fourth, to compare the post-test scores of the two groups; and fifth, to compare the gain scores of the experimental and control groups.

*Table 4.3. Results of Non-parametric Tests*

| Step | Comparison | Test | Statistic | *p* | Result |
|---|---|---|---|---|---|
| 1 | Experimental pre-test vs. control pre-test | Mann-Whitney U test | U = 84.00 | 1.000 | Not significant |
| 2 | Experimental pre-test vs. experimental post-test | Wilcoxon signed-rank test | W = 0.00 | <0.001 | Significant |
| 3 | Control pre-test vs. control post-test | Wilcoxon signed-rank test | W = 0.00 | 0.001 | Significant |
| 4 | Experimental post-test vs. control post-test | Mann-Whitney U test | U = 105.50 | 0.292 | Not significant |
| 5 | Experimental gain score vs. control gain score | Mann-Whitney U test | U = 158.50 | < 0.001 | Significant |

First, the Mann-Whitney U test was used to compare the pre-test scores of the experimental and control groups in order to check whether the two groups were comparable before the intervention. The result was not statistically significant, U = 84.00, p = 1.0000, indicating that there was no significant difference between the groups at the beginning of the study.

Second, the Wilcoxon signed-rank test was conducted to examine the difference between the pre-test and post-test scores within the experimental group. The result showed a statistically significant improvement, W = 0.00, p = 0.0002. This indicates that students in the experimental group improved significantly after the intervention.

Third, the Wilcoxon signed-rank test was also conducted for the control group. The result was statistically significant, W = 0.00, p = 0.0010, showing that the control group also improved from pre-test to post-test.

Fourth, the Mann-Whitney U test was used to compare the post-test scores of the experimental and control groups. The result was not statistically significant, U = 105.50, p = 0.2924. Therefore, the post-test comparison alone did not show a significant difference between the two groups.

Since the post-test comparison alone did not show a statistically significant difference, gain scores were calculated by subtracting each student's pre-test score from their post-test score. These gain scores were used to represent the amount of improvement in students' mathematical literacy. The Mann-Whitney U test was then used to compare the gain scores of the experimental and control groups. The result showed a statistically significant difference, $U = 158.50$, $p < 0.001$. This indicates that the improvement in the experimental group was significantly greater than the improvement in the control group.

*Table 4.4. Effect Size for the Main Comparison of Improvement*

| **Comparison** | **Test** | **p** | **Effect size** | **Interpretation** |
|---|---|---|---|---|
| Experimental gain score vs. control gain score | Mann-Whitney U test | < 0.001 | rrb = 0.88 | Large effect |

In addition to statistical significance, effect size was calculated to interpret the practical magnitude of the intervention effect. For the Mann-Whitney U test, rank-biserial correlation was used as the effect size measure. The effect size for the comparison of gain scores was large, rrb = .88. This suggests that the difference in improvement between the experimental and control groups was not only statistically significant but also practically meaningful.

# 5. DISCUSSION AND CONCLUSION

The purpose of this study was to find out whether the use of authentic assignments with equations and inequalities can contribute to the development of mathematical literacy in 6th grade students. The results showed that the results improved in both the experimental and control groups from the preliminary examination to the subsequent testing. However, the experimental group showed greater improvement than the control group.

The first comparison of the results before testing did not reveal a statistically significant difference between the experimental and control groups, U = 84.00, p = 1,000. This suggests that the two groups were comparable in terms of mathematical literacy before the intervention. Consequently, later differences in improvement can be interpreted based on the different learning approaches used during the study.

The group analysis showed that the results of the experimental group improved significantly from the preliminary test to the subsequent one, W = 0.00, p <0.001. The average score increased from 15.62 to 21.54, indicating an average improvement of 5.92 points. This result shows that authentic assignments involving equations and inequalities had a positive impact on students' mathematical literacy. A possible explanation is that authentic assignments required students to relate mathematical ideas to real-world situations, find relevant information, compose equations or inequalities, solve them, and interpret the meaning of their answers in context.

There was also a statistically significant improvement in the control group, W = 0.00, p = 0.001. The average score increased from 15.92 to 18.15, with an average improvement of 2.23 points. This means that traditional methodical teaching has also helped students to learn. Thus, the results obtained should not be interpreted as evidence of the inefficiency of traditional education. Rather, both approaches contributed to student progress, but the experimental group showed greater improvement.

Comparison of the results after the test between the experimental and control groups revealed no statistically significant difference, U = 105.50, p =292. This means

that the study cannot claim that the experimental group significantly outperformed the control group based on the final results after the test. However, since the purpose of the study was to examine improvements from the pre- and post-test period, the gain scores were also calculated by subtracting each student's pre-test scores from the post-test score.

A comparison of the indicators of changes revealed a statistically significant difference between the experimental and control groups, U = 158.50, p <0.001. This indicates that the students in the experimental group have made significantly more progress than the students in the control group. In addition, the effect value for this comparison was large, rrb = 88. This suggests that the difference in improvement was not only statistically significant, but also practically significant. Thus, the use of authentic assignments seems to have a significant positive impact on the development of students' mathematical literacy.

This conclusion is important because mathematical literacy is not limited to solving routine exercises. This includes the ability to apply mathematics in real-world situations, formulate mathematical relationships, use appropriate mathematical procedures, and interpret results in context. Authentic tasks can facilitate this process because they place equations and inequalities in meaningful situations rather than just presenting them as abstract symbolic tasks. As a result, students can better understand why mathematical concepts are useful outside of the classroom.

The greater progress in the experimental group can be explained by the task structure for solving real-world problems. In traditional education, students often focus primarily on procedures and correct answers. On the contrary, authentic assignments require students to analyze the situation, decide which mathematical model is correct, use equations or inequalities to solve the problem, and explain the result according to the original context. This process is closely related to the PISA mathematical literacy system, in particular to the processes of formulation, use and interpretation of mathematical data.

Overall, the results show that authentic assignments involving equations and inequalities can contribute to the development of students' mathematical literacy. Although the comparison of the results after the test itself was not statistically significant, a comparison of the indicators of changes showed that the results improved significantly in the experimental group than in the control group. The significant effect further confirms this interpretation and shows that the difference in improvement was almost significant.

**Conclusion:** This study examined the impact of authentic assignments, including equations and inequalities, on the level of mathematical literacy in 6th grade students. Although functional literacy in education is a broader concept, this study focused on mathematical literacy as a measurable indicator of students' ability to apply mathematics in real life. The study was conducted in accordance with the PISA mathematical literacy system, especially regarding the processes of formulation, use and interpretation of mathematical data.

The results showed that the results improved in both the experimental and control groups from the preliminary examination to the subsequent testing. This suggests that both approaches to learning have contributed to students' learning to some extent. However, the experimental group, which was trained using authentic tasks, showed greater improvement than the control group, which underwent traditional procedural training.

The comparison of the results after the test between the two groups was not statistically significant. Thus, the study cannot claim that the experimental group performed significantly better than the control group based on the results after the test. However, a comparison of the change indicators showed that the experimental group had made significantly more progress. The large size of the effect also indicated that this difference was practically significant. This confirms the conclusion that authentic assignments had a positive impact on the development of students' mathematical literacy.

The results suggest that authentic problems can create a more meaningful learning environment for equations and inequalities. Instead of considering equations and inequalities using only abstract symbolic methods, students are encouraged to relate them to real-life situations, build mathematical models, solve problems, and interpret their answers in context. This process contributes to the development of mathematical literacy, as it helps students move from routine calculations to contextual application of mathematics.

Final authentic assignments with equations and inequalities can be considered as a promising educational approach for the development of mathematical literacy in 6th grade students. The results of the study show that this approach can help students to meaningfully understand mathematical concepts and how they can be applied in real life.

# 6. LIMITATIONS

Although this study provides useful information about the potential role of authentic assignments in developing students' mathematical literacy, some limitations should be recognized. First, the study was conducted on a relatively small sample of 6th grade students from an educational center. Thus, the results cannot be generalized for all 6th grade students in Kazakhstan. To confirm that similar results can be obtained in broader classrooms, a larger sample from different schools, regions, and educational contexts is needed.

Secondly, the study used a quasi-experimental approach, and the students were not randomly distributed between the experimental and control groups. As a result, pre-existing differences between the groups may affect the results. Although the preliminary test was used to test the skills of elementary-level students, it cannot completely rule out the possibility that the groups before the intervention differed in motivation, previous knowledge, learning habits, or general mathematical skills.

Thirdly, the duration of classes was relatively short. Authentic problem-solving learning may require students to spend more time exploring the interpretation of real-world situations, building mathematical models, and explaining their reasoning. A longer intervention could provide a clearer picture of how students' mathematical literacy develops over time and whether the observed improvement is stable.

Another limitation is related to the role of teacher and researcher. Since active leadership, interviews, and classroom assistance are essential for effective problem solving, the teacher's role can affect student engagement and academic achievement. If the researcher was also involved in teaching or evaluating assignments, this could lead to bias on the part of the researcher. Therefore, in future research, the possibility of involving independent lecturers or observers should be considered in order to reduce the possible influence of the researcher on the learning process and the interpretation of the results.

In addition, the students' answers were evaluated using a heading adapted to the PISA mathematical literacy system. Although this section provides a clear framework

for evaluating the processes of formulation, use, and interpretation in evaluating students' written responses, there may still have been some subjectivity. Future studies should involve two or more independent evaluators, and they are required to consider the validity of the results in order to increase the reliability of the assessment.

Finally, this study focused only on equations and inequalities. Although these subjects are very important for mathematical modeling and reliable problem solving, mathematical literacy is broader and covers other fields of knowledge such as geometry, statistics, probabilities, and functions. Future research may find out whether authentic task-based learning has a similar effect on other math subjects and students in different grades.

In general, future studies should use larger and more diverse samples, longer intervention time, random distribution, or, if possible, with better selection and more effective independent evaluation procedures. These improvements will provide more reliable evidence of the effectiveness of authentic assignments to support students' mathematical literacy within the broader framework of functional literacy.

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# LIST OF APPENDICES

## Appendix A - Original Sources and Original Versions of the Adapted Test Items

| Test item | Original task | Source type | Source |
|---|---|---|---|
| Question 1 | Exchange Rate | Official PISA released item | OECD, 2006, pp. 53–54 |
| Question 2 | Postal Charges | Official PISA released item | OECD, 2006, pp. 105–106 |
| Question 3 | Internet Tariff | PISA-type / context-based mathematical literacy task | Wijaya et al., 2018 |
| Question 4 | Investments | PISA-like mathematical literacy task | *PISA like test items mathematical literacy: Questions*, n.d., p. 18 |
| Question 5 | Climbing Mount Fuji | Official PISA 2012 released item | OECD, 2013, pp. 46–48 |

**Original task №1: Exchange Rate**

Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student. She needed to change some Singapore dollars (SGD) into South African rand (ZAR).

Question 1: Mei-Ling found out that the exchange rate between Singapore dollars and South African rand was: 1 SGD = 4.2 ZAR Mei-Ling changed 3000 Singapore dollars into South African rand at this exchange rate. How much money in South African rand did Mei-Ling get?

Question 2: On returning to Singapore after 3 months, Mei-Ling had 3900 ZAR left. She changed this back to Singapore dollars, noting that the exchange rate had changed to: 1 SGD = 4.0 ZAR How much money in Singapore dollars did Mei-Ling get?

Question 3: During these 3 months the exchange rate had changed from 4.2 to 4.0 ZAR per SGD. Was it in Mei-Ling’s favor that the exchange rate now was 4.0 ZAR instead

of 4.2 ZAR, when she changed her South African rand back to Singapore dollars? Give an explanation to support your answer.

**Original task №2: Postal Charges**

The postal charges in Zedland are based on the weight of the items, to the nearest gram, as shown in the table below:

| Weight | Charge |
|---|---|
| Up to 20 g | 0.46 zeds |
| 21 g – 50 g | 0.69 zeds |
| 51 g – 100 g | 1.02 zeds |
| 101 g – 200 g | 1.75 zeds |
| 201 g – 350 g | 2.13 zeds |
| 351 g – 500 g | 2.44 zeds |
| 501 g – 1000 g | 3.20 zeds |
| 1001 g – 2000 g | 4.27 zeds |

Question 1: Jan wants to send two items, weighing 40 grams and 80 grams respectively, to a friend. According to the postal charges in Zedland, decide whether it is cheaper to send the two items as one parcel, or send the items as two separate parcels. Show your calculations of the cost in each case.

**Original task №3: Internet task**

An internet provider Inter-NET offers two different programs. Program Smile charges customers 30,500 IDR as monthly fee and 40 IDR/1 Megabyte (MB). Program Shine charges customers 20,000 IDR as monthly fee and 52 IDR/1 MB. The registration fees, including the price of modem, for both programs are the same, namely 300,000 IDR. In January, Doni subscribed to the program Shine. In May Doni used 550 MB of internet data. How much money did he pay in May?

Tasks:

a. Underline all information given in the task and circle only the information we need to answer the question.

b. Reformulate the task with less words by leaving out unnecessary information.

c. How much money did Doni pay in May?

d. What strategy can we use to solve Doni's problem?

e. When Doni's internet usage is increasing, is it better for him to change the internet program? If so, when should he do it?

**Original task № 4: Investments**

Susan invested Rs 1,50,000 in a scheme offering 12% per annum. Find the amount she gets after a year if interest is compounded half yearly. She then invested a certain amount of money in two schemes A and B, which offer interest at the rate of 8% per annum and 9% per annum, respectively. She received Rs 1860 as annual interest. However, had she interchanged the amount of investments in the two schemes, she would have received Rs 20 more as annual interest. How much money did she invest in each scheme? She now thought of investing the total money in a single scheme with an interest equal to mean of both the rate of interests. Which of the three is a better scheme?

**Original task №5: Climbing Mount Fuji**

Question 1: Mount Fuji is only open to the public for climbing from 1 July to 27 August each year. About 200 000 people climb Mount Fuji during this time. On average, about how many people climb Mount Fuji each day?

A. 340 B. 710 C. 3400 D. 7100 E. 7400

Question 2: The Gotemba walking trail up Mount Fuji is about 9 kilometres (km) long. Walkers need to return from the 18 km walk by 8 pm. Toshi estimates that he can walk up the mountain at 1.5 kilometres per hour on average, and down at twice that speed. These speeds take into account meal breaks and rest times. Using Toshi's estimated speeds, what is the latest time he can begin his walk so that he can return by 8 pm?

Question 3: Toshi wore a pedometer to count his steps on his walk along the Gotemba trail. His pedometer showed that he walked 22,500 steps on the way up. Estimate Toshi's average step length for his walk up the 9 km Gotemba trail. Give your answer in centimetres.

## Appendix B - Adapted English Version of the Mathematical Literacy Test

**Question №1** Aidana is preparing to travel to Turkey for a three-month summer vacation. Before the trip, she exchanges Kazakhstani tenge (KZT) into Turkish lira (TRY).

A) The exchange rate is 1 TRY = 10.6 KZT. Aidana exchanges 300,000 KZT into Turkish lira. The exchange office charges a commission of 100 TRY. How many Turkish lira does Aidana receive after the commission? Show your full solution.

B) Three months later, Aidana returns to Kazakhstan with 780 TRY left. She exchanges this money back into tenge. The new exchange rate is 1 TRY = 12.34 KZT, and the exchange office charges a commission of 2,000 KZT. How many tenge does Aidana receive after the commission? Show your full solution.

C) During these three months, the exchange rate changed from 1 TRY = 10.6 KZT to 1 TRY = 12.34 KZT. Was this change beneficial for Aidana when exchanging her remaining Turkish lira back into tenge? Explain your answer.

**Question №2** Aybek wants to send two items to a friend. The weight of the first is 40 g, the second is 80 g

Postal rates:

| Weight | Cost |
|---|---|
| Up to 50 g | 850 KZT |
| Up to 100 g | 900 KZT |
| Up to 150 g | 1000 KZT |

Aibek has 1,200 tenge in his hands. He wants to send two items in the cheapest way.

A) Find the total cost if Aybek sends the two items separately.

B) Find the total cost if Aybek sends the two items together.

C) Which option is cheaper?

D) Which option can Aybek choose if he has only 1,200 KZT? Explain your answer.

**Question №3** The Tele-2 Internet provider offers two different tariffs.

| Tariff | Monthly fee | Cost per 1 MB | Registration fee with modem |
|---|---|---|---|
| My Tariff | 5,590 KZT | 20 KZT | 15,000 KZT |
| My Tele2 | 3,590 KZT | 40 KZT | 15,000 KZT |

In January, Aruna signed up for the tariff "My tariff". In May, he used 150 MB of Internet. How much did Aruna pay in May? Underline all the information provided in the report and mark only the information necessary to answer the question.

A) briefly rewrite the report, deleting unnecessary information

B) How much did Aruna pay in May? Internet usage in Aruna is growing. Now he has to decide whether he needs to change the tariff.

C) What strategy can be used to solve Aruna's problem?

D) If Aruna's internet usage is increasing, is it beneficial for him to change the tariff? When to do it, if it is effective

**Question №4** Ayazhan's parents invested 150,000 tenge in the bank at a rate of 12% per annum. If interest is accrued every six months, how much money will they receive in 1 year? Then they invested a certain part of the money in two types of deposits: A and B. These investments generate 8% and 9% of income per year, respectively. During the year, they received 1,860 tenge of profit. However, if they had exchanged the invested money between the two deposits, the annual income would have been 20 tenge more. How much did they put into each deposit? Then they thought about putting all the money in just one deposit, the interest rate of which is equal to the arithmetic mean of these two rates. Which of these three options is more effective? Write the full solution path and justify your answer.

**Question №5** Aruzhan and his friends plan to climb to the top of Talgar in the Trans-Ili Alatau. The length of the selected route is 4 km (one way). The average speed of the Aruzhan during ascent is 1.5 km/h, and during descent its speed is 2 times higher. They rest for 30 minutes on the way. They have to make it down the mountain before 17:00 for security reasons, and Aruzhan wants to find out when to set off with his friends.

A) How can he calculate the total time required for this? Write explaining your point of view.

B) According to Aruzhan's plan, they should be back by 17:00. If they leave at 1 p.m., will they make it? Calculate and explain your answer.

C) Aruzhan wants to know when he should hit the road, at least lately. Try to find out what time he can leave at the latest hour, and justify your decision.

D) Due to road fatigue, the climbing speed has decreased to 1 km/h. Will their plan change in this case? Can he still make it before 17:00?

E) Does Aruzhan consider this route safe or should he change his plan? What is the best decision to make? Why?

F) Do all the calculations in this report fully correspond to real life? What factors can affect the result? (for example: weather, difficulty of the road, fatigue...)

# Appendix C - Kazakh Version of the Mathematical Literacy Test

**Сұрақ №1** Айдана жазғы демалыста Түркияға үш айға баруға дайындалып жатыр. Сапар алдында ол қазақстандық теңгені (KZT) түрік лирасына (TRY) айырбастайды.

A) Валюта бағамы: 1 TRY = 10,6 KZT. Айдана 300 000 KZT ақшасын түрік лирасына айырбастады. Айырбастау пункті 100 TRY комиссия ұстайды. Комиссия ұсталғаннан кейін Айдана қанша түрік лирасын алады? Толық шешімін көрсетіңіз.

B) Үш айдан кейін Айдана Қазақстанға қайтып келді. Оның қолында 780 TRY қалды. Ол бұл ақшаны қайтадан теңгеге айырбастады. Жаңа валюта бағамы: 1 TRY = 12,34 KZT. Айырбастау пункті 2 000 KZT комиссия ұстайды. Комиссия ұсталғаннан кейін Айдана қанша теңге алады? Толық шешімін көрсетіңіз.

C) Осы үш ай ішінде валюта бағамы 1 TRY = 10,6 KZT-тен 1 TRY = 12,34 KZT-ке өзгерді. Айдана қалған түрік лирасын теңгеге айырбастаған кезде бұл өзгеріс оған тиімді болды ма? Жауабыңызды түсіндіріңіз.

**Сұрақ №2** Айбек досына екі зат жібергісі келеді. Біріншісінің салмағы 40 г, екіншісінікі 80 г

| **Салмақ** | **Құны** |
|---|---|
| 50 г-ға дейін | 850 KZT |
| 100 г-ға дейін | 900 KZT |
| 150 г-ға дейін | 1000 KZT |

Айбектің қолында 1200 теңге бар. Ол екі затты ең арзан жолмен жібергісі келеді. Қай тәсілді таңдауы керек?Айбек екі затты бөлек жібергендегі жалпы шығынды өрнек түрінде жазыңыз. Айбек екі затты бірге жібергендегі жалпы шығынды табыңыз. Айбек үшін қай жағдайда шығын оның ақшасынан аспайды? Егер Айбекте 1200 теңге болса, ол қай тәсілді таңдай алады?

**Сұрақ №3** Интернет провайдері Tele-2 екі түрлі тариф ұсынады. “Мой Тариф” тарифі:

| **Тариф** | **Ай сайынғы төлем** | **1 МБ құны** | **Модеммен бірге тіркелу ақысы** |
|---|---|---|---|
| My Tariff | 5 590 KZT | 20 KZT | 15 000 KZT |
| My Tele2 | 3 590 KZT | 40 KZT | 15 000 KZT |

Қаңтар айында Аруна “Мой тариф” тарифіне жазылды. Мамыр айында ол 150 МБ интернет қолданды. Мамыр айында Аруна қанша ақша төледі?

A) Есепте берілген барлық ақпараттың астын сызыңыз және тек сұраққа жауап беру үшін қажет ақпаратты ғана белгілеңіз.

B) Қажетсіз ақпаратты алып тастап, есепті қысқаша түрде қайта жазыңыз

C) Аруна мамыр айында қанша ақша төледі? Арунанын интернетті қолдануы артып келеді. Енді ол тарифін ауыстыру керек пе деген мәселені шешуі керек.

D) Арунанын мәселесін шешу үшін қандай стратегия қолдануға болады?

E) Егер Арунанын интернет қолдануы өсіп жатса, оған тарифті ауыстырған тиімді ме? Егер тиімді болса, оны қашан жасауы керек

**Сұрақ №4** Аяжанның ата-анасы 150 000 теңгені жылдық 12% мөлшерлемемен банкке салды. Егер пайыз жарты жыл сайын есептелсе, онда 1 жылдан кейін олар қанша ақша алады? Содан кейін олар ақшаның белгілі бір бөлігін А және В атты екі салым түріне салды. Бұл салымдар сәйкесінше жылына 8% және 9% табыс әкеледі. Бір жылда олар 1860 теңге пайда алды. Алайда, егер олар салған ақшаларын екі салым арасында орындарымен ауыстырса, онда жылдық табыс 20 теңгеге артық болар еді. Олар әр салымға қанша ақша салған? Содан кейін олар барлық ақшаны пайыздық мөлшерлемесі осы екі мөлшерлеменің арифметикалық орта мәніне тең болатын бір ғана салымға салуды ойлады. Осы үш нұсқаның қайсысы тиімдірек? Толық шешу жолын жазыңыз және жауабыңызды негіздеңіз.

**Сұрақ №5** Аружан достарымен бірге Іле Алатауындағы Талғар шыңына шығуды жоспарлап отыр. Таңдалған маршруттың ұзындығы 4 км (бір бағытта). Аружан көтерілу кезінде орташа жылдамдығы 1,5 км/сағ, ал түсу кезінде оның жылдамдығы одан 2 есе жоғары. Жол барысында олар 30 минут демалады. Олар қауіпсіздік мақсатында сағат 17:00-ге дейін таудан түсіп үлгеруі керек Аружан достарымен бірге жолға қашан шығу керектігін анықтағысы келеді.

A) Ол бұл үшін жалпы жолға кететін уақытты қалай есептей алады? Өз ойыңызды түсіндіріп жазыңыз.

B) Аружанның жоспары бойынша, олар 17:00-ге дейін қайтып келуі керек. Егер олар сағат 13:00-де шықса, үлгере ме? Жауабыңызды есептеп, түсіндіріңіз.

C) Аружан ең кеш дегенде қай уақытта жолға шығуы керек екенін білгісі келеді. Оның ең кеш дегенеде сағат нешеде жолға шығуына болатынын анықтап көріңіз және өзіңіздің шешіміңіщді негіздеңіз.

D) Жолда шаршағандықтан, көтерілу жылдамдығы 1 км/сағ-қа дейін төмендеді. Бұл жағдайда олардың жоспары өзгере ме? Ол әлі де 17:00-ге дейін үлгере ала ма?

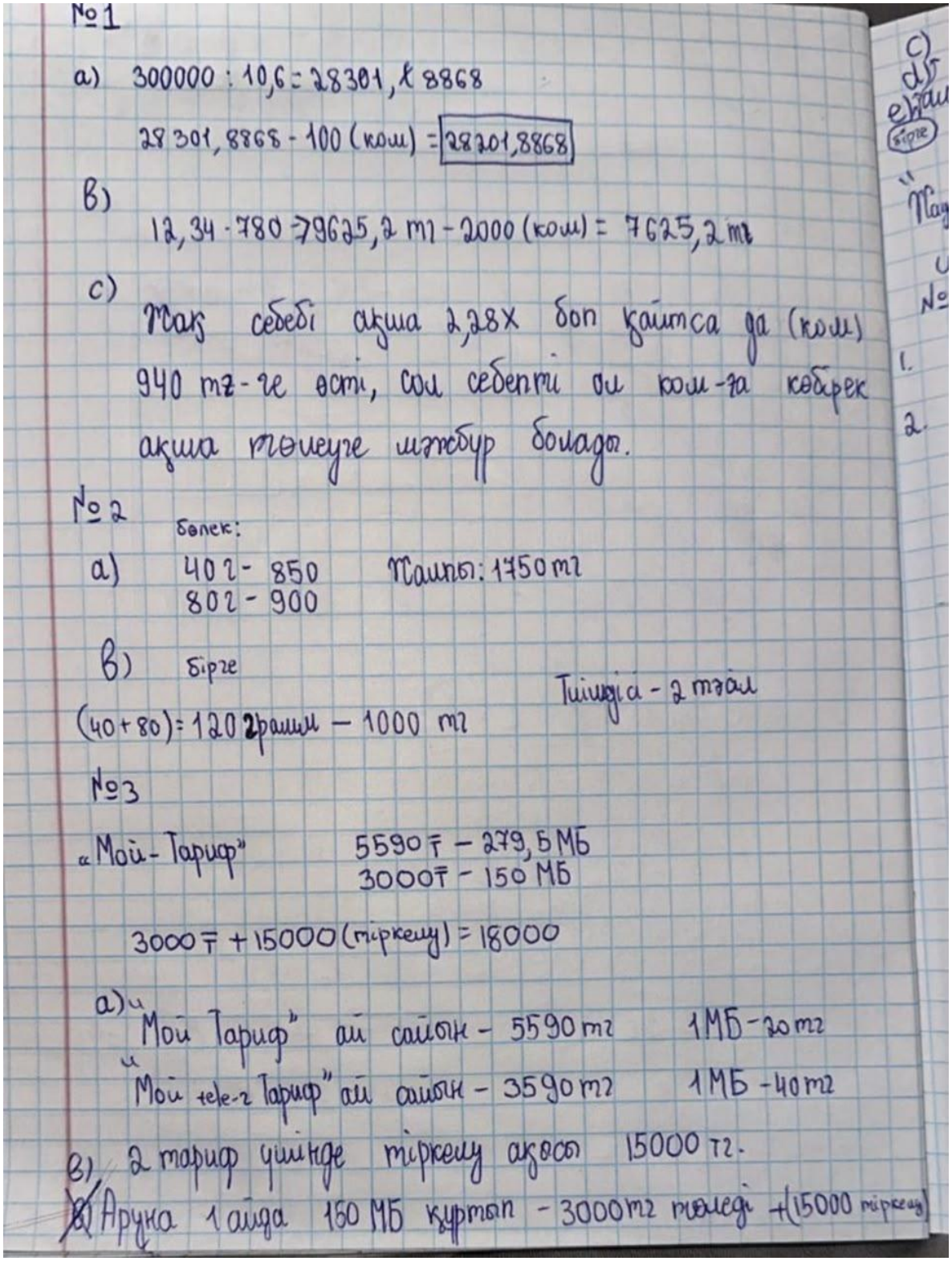
E) Аружан бұл маршрутты қауіпсіз деп санай ма, әлде жоспарын өзгертуі керек пе? Қандай шешім қабылдаған дұрыс? Неліктен?

F) Бұл есепте барлық есептеулер нақты өмірге толық сәйкес келе ме? Қандай факторлар нәтижеге әсер етуі мүмкін? (мысалы: ауа райы, жолдың күрделілігі, шаршау…)

## Appendix D - Kazakh Version of the Mathematical Literacy Test

| Mathematical literacy process | Code | Indicator | 0 points | 1 point | 2 points |
|---|---|---|---|---|---|
| Formulate | FO1 | Identifying the mathematical aspects of the problem in real-context situations and identifying the variables in the problem | Does not identify relevant information or variables | Partially identifies some elements or variables | Correctly identifies all relevant variables and information |
| | FO2 | Converting problems into suitable mathematical language, including variables, symbols, and mathematical models | No mathematical model | Incomplete or incorrect model | Correct mathematical model (expression, equation, or inequality) |
| Employ | EM1 | Designing and implementing strategies to find mathematical solutions | No clear strategy | Strategy is partially correct but incomplete | Appropriate and complete solution strategy |
| | EM2 | Applying mathematical facts, rules, algorithms, and structures to find a solution | Incorrect calculations | Partially correct calculations | Correct calculations and procedures |
| Interpret | IN1 | Interpreting the mathematical result obtained | No interpretation or irrelevant answer | Partial or unclear interpretation | Clear and correct interpretation in context |

## Appendix E - Sample Student Response and Scoring Example



№1

a) 300000 : 10,6 = 28301,8868

28 301,8868 - 100 (ком) = 28201,8868

B)

12,34 · 780 = 9625,2 тг - 2000 (ком) = 7625,2 тг

c)

Мақ себебі ақша 2,28х бол қайтса да (ком) 940 тг-ге өсті, сол себепті ол ком-ға көбірек ақша төлеуге мәжбүр болады.

№2

Бөлек:

a) 40 г - 850 Тапт: 1750 тг
80 г - 900

B) бірге

(40+80) = 120 грамм — 1000 тг

Тиімді - 2 тәсіл

№3

«Мой-Тариф» 5590 ₸ — 279,5 МБ
3000 ₸ - 150 МБ

3000 ₸ + 15000 (тіркеу) = 18000

a) "Мой Тариф" ай сайын - 5590 тг 1МБ - 20 тг

"Мой tele-2 Тариф" ай сайын - 3590 тг 1МБ - 40 тг

B) 2 тариф үшінде тіркеу ақысы 15000 тг.

Ақша 1 айда 150 МБ қуттап - 3000 тг төледі + (15000 тіркеу)

c) Маған айында - 3000 (Мой Тариф)

d) Ал егер "Мой tele-2 тариф"-та қолданатын болса:

e) Маған айында - 6000 (Мой tele-2 тариф)

"Пайда: ауыстырмаған тиімді, себебі Аруна 3000 тг-ге шығына кетер еді."

№4.

1. 150000 · 0,12 = 18000 теңге

2. (0,08 x = 1860 - 0,09 y)

| A банк | | B банк | |
|---|---|---|---|
| x · 0,08 | + | y · 0,09 | = 1860 |

| B банк | | A банк | |
|---|---|---|---|
| x · 0,08 | + | y · 0,09 | = 1880 |

№5

4 км : 1,5 + 4 : 3 = 4,5

13:00 + 4,5 сағ = 17:30 17:30 ≠ 17:00

a) 4 км : 1,5 + 4 : 3 = 4,5 сағ уақыт кетеді

b) яғни, 13:00 + 4:30 = 17:30 ≠ 17:00

c) 12:30-да ол тура 17:00-де жетеді.

d) 4,5 + 4 ÷ 3 = 5,8(3) 13:00 + 5 сағ 80 мин =

19:20 ≠ 17:00. Пайда: ұтқырлейді.

e) яғни, 30 мин дамыса, маршрутқа себеп бар

f) иә, ала райып, шаруашылық.

| Question | FO1 | FO2 | EM1 | EM2 | IN1 | Total |
|---|---|---|---|---|---|---|
| Question 1 | 1 | 1 | 1 | 1 | 1 | **5/10** |
| Question 2 | 1 | 1 | 1 | 1 | 0 | **4/10** |
| Question 3 | 2 | 1 | 1 | 1 | 1 | **6/10** |
| Question 4 | 1 | 1 | 0 | 1 | 0 | **3/10** |
| Question 5 | 2 | 1 | 1 | 1 | 1 | **6/10** |
| **Total** | | | | | | **24/50** |

| Question | Expert justification |
|---|---|
| **Question 1** | The student identified some relevant numerical information and attempted to use it in the solution. However, the response did not clearly present all variables and conditions from the real-life context. The mathematical representation was incomplete, and the solution steps were not fully justified. The final answer was partly connected to the context, but the explanation was not sufficiently clear. Therefore, the student received partial scores for all five indicators. |
| **Question 2** | The student wrote some given information and attempted to compare quantities, which shows partial understanding of the problem. However, the mathematical model was not clearly developed, and the reasoning was incomplete. Although there was an attempt to solve the problem, the final interpretation was missing or unclear. For this reason, the student received 0 points for IN1. |
| **Question 3** | The student demonstrated better understanding of the context by identifying the relevant tariff prices and data amounts. The answer shows that the student attempted to compare different options mathematically. However, the mathematical model was not fully explicit, and the strategy was not completely explained. The calculations and interpretation were partially correct, so most indicators received partial credit. |
| **Question 4** | The student attempted to work with percentages and correctly found part of the required calculation. However, the solution was not completed, and the system or equation was not correctly developed. The strategy was unclear, and there was no final interpretation in the context of the problem. Therefore, this response received the lowest score. |
| **Question 5** | The student identified the main information related to time and attempted to compare the result with the required condition. The response shows a clear attempt to reason within the context of the problem. However, the mathematical model and calculation process were not fully accurate or clearly explained. The final conclusion was related to the context, so the student received partial credit for most indicators. |

# Appendix F - Example of Authenticity Evaluation of One Adapted Task

**Question 1**

| Aspect | Authenticity judgement | Rationale |
|---|---|---|
| Real-world context | Authentic | The task is based on the real-life context of exchanging currency before and after international travel. |
| Events | Authentic | The described events, such as travelling abroad and exchanging money, commonly occur outside school. |
| Objects | Authentic | The task includes real-world objects and currencies, including Kazakhstan, Turkey, KZT, TRY, exchange rate, and commission. |
| Question/assignment | Authentic | The question asks students to determine the amount of money received after exchange and commission, which reflects a practical financial situation. |
| Data | Authentic / Partially authentic | The exchange rate was based on real currency information; however, some values may have been adapted for educational purposes. |
| Figures | Not applicable | The task does not include figures, tables, or visual representations. |
| Use of mathematics | Authentic | The solution requires division, multiplication, subtraction of commission, and interpretation, which correspond to real financial calculations. |
| Purpose | Authentic | The calculation serves a practical purpose: determining the amount of money after currency exchange and evaluating whether the rate change was beneficial. |

## Appendix G - Sample Lesson Plan for the Experimental Group

| Lesson | Activity / Topic | Source of materials |
|---|---|---|
| Lesson 1 | Pre-test | Researcher-prepared assessment instrument |
| Lesson 2 | Percentage problems | Selected from R. Akhmetov's problem-solving book |
| Lessons 3–4 | Motion problems | Selected from R. Akhmetov's problem-solving book |
| Lesson 5 | Age problems | Selected from R. Akhmetov's problem-solving book |
| Lessons 6–7 | Joint work problems | Selected from R. Akhmetov's problem-solving book |
| Lesson 8 | Problems requiring equation construction | Selected from R. Akhmetov's problem-solving book |
| Lessons 9–11 | Problems requiring inequality construction | Selected from OpenStax materials on *Linear Inequalities in One Variable with Applications* and Khan Academy materials on *Linear Inequality Word Problems* |
| Lesson 12 | Post-test | Researcher-prepared assessment instrument |

**Сабақ туралы жалпы мәлімет**

| **Бөлім** | **Теңдеулер мен теңсіздіктер. Мәтінді есептерді шығару** |
|---|---|
| Пәні | Математика |
| Сынып | 6-сынып |
| Сабақтың тақырыбы | Теңдеу және теңсіздік арқылы есептер шығару |
| Сабақ ұзақтығы | 80 минут |
| Сабақ түрі | Практикалық сабақ |
| Оқу материалы | Р. Ахметов есептер жинағынан алынған стандартты тапсырмалар; мәтінді есептер парағы |

**Сабақ барысы**

| Сабақ кезеңі | Уақыты | Мұғалімнің әрекеті | Оқушының әрекеті |
|---|---|---|---|
| Ұйымдастыру кезеңі | 3 мин | Оқушылармен амандасады. Сабақтың мақсаты мен құрылымын таныстырады: алғашқы 40 минутта стандартты теңдеу мен теңсіздік тапсырмалары, кейінгі 40 минутта мәтінді есептер қарастырылатынын айтады. | Сабаққа дайындалады, дәптерін ашады, сабақ мақсатын тыңдайды. |
| Өткенді қайталау | 5 мин | Теңдеу мен теңсіздікке қатысты негізгі ережелерді сұрайды: теңдеуді шешу, теңсіздіктің таңбасын өзгерту, шешімдер жиынын жазу. | Сұрақтарға жауап береді, негізгі ережелерді еске түсіреді. |
| Стандартты тапсырмаларды түсіндіру | 7 мин | Тақтада бір теңдеу және бір теңсіздік шешіп көрсетеді. Жақшаны ашу, ұқсас мүшелерді біріктіру, айнымалыны бөліп шығару, жауабын жазу қадамдарын түсіндіреді. | Шешу жолын дәптерге жазады, мұғалімнің сұрақтарына жауап береді. |
| Жеке жұмыс: стандартты теңдеулер мен теңсіздіктер | 15 мин | Р. Ахметов жинағынан алынған стандартты теңдеу және теңсіздік тапсырмаларын береді. Оқушылардың жұмысын бақылайды, қажет жағдайда бағыт береді. | Тапсырмаларды жеке орындайды. Теңдеулер мен теңсіздіктерді шешеді, жауаптарын жазады. |
| Жауаптарды тексеру және қатемен жұмыс | 10 мин | Бірнеше тапсырманың шешу жолын тақтада талдайды. Жиі кездесетін қателерге назар аударады: таңбаны дұрыс өзгертпеу, ұқсас мүшелерді қате біріктіру, жауапты толық жазбау. | Өз жауаптарын тексереді, қателерін түзетеді, қажет болса сұрақ қояды. |
| Мәтінді есептерге көшу | 5 мин | Енді дайын теңдеу немесе теңсіздік берілмейтінін, оқушылар оны есептің шартынан өздері құруы керек екенін түсіндіреді. Мәтінді | Тыңдайды, мәтінді есепті шешудің ерекшеліктерін түсінеді. |

| | | | |
|---|---|---|---|
| | | есепте ең алдымен шартты түсіну маңызды екенін айтады. | |
| Модельдеу қадамдарын түсіндіру | 7 мин | Мәтінді есепті шығару қадамдарын түсіндіреді: шартты оқу, маңызды ақпаратты белгілеу, белгісізді анықтау, айнымалы енгізу, теңдеу немесе теңсіздік құру, шешу, жауапты түсіндіру. | Қадамдарды дәптерге жазады, мұғаліммен бірге қысқа мысалды талдайды. |
| Жұптық жұмыс: мәтінді есепті талдау | 15 мин | Оқушыларға бір мәтінді есеп береді. Есеп шартындағы маңызды ақпаратты белгілеуді, белгісіз шаманы анықтауды және математикалық модель құруды тапсырады. | Жұппен жұмыс істейді. Есеп шартын талдайды, белгісізді белгілейді, теңдеу немесе теңсіздік құрады, шешеді. |
| Шешімді талқылау | 8 мин | Бір-екі жұптың шешімін тыңдайды. «Неліктен осы айнымалыны таңдадыңдар?», «Неліктен осындай теңдеу/теңсіздік құрдыңдар?», «Жауап нақты жағдайда нені білдіреді?» деген сұрақтар қояды. | Өз шешімдерін түсіндіреді, басқа жұптардың жауаптарымен салыстырады. |
| Қорытынды және рефлексия | 5 мин | Сабақты қорытындылайды. Стандартты тапсырма мен мәтінді есептің айырмашылығын атап өтеді. Оқушылардан қай кезең қиын болғанын сұрайды. | Қысқаша жауап береді, өз ойын айтады. |

## Appendix H - Sample Tasks Used During the Intervention

**Біріккен жұмыс есептері**

1. Бірінші бригада тапсырманы 30 күнде, ал екінші бригада осы тапсырманы 45 күнде орындайды. Егер екі бригада тапсырманы бірігіп орындаса, оны неше күнде аяқтайды?

2. Айбек велосипедті 20 минутта, Аңсар 12 минутта, ал Шыңғыс 15 минутта жөндейді. Егер олар велосипедті үшеуі бірігіп жөндесе, неше минутта аяқтайды?

**Пайызға байланысты есептер**

3. Олжастың анасына түскі ас дайындау үшін 2 сағат уақыт кетті. Ет тағамдарын дайындауға уақыттың 35%, салат дайындауға 25% жұмсалды. Қалған уақыт десерт дайындауға кетті. Олжастың анасы десерт дайындауға қанша уақыт жұмсады?

4. PlayStation ойын приставкасының бастапқы бағасы 180 000 теңге болды. Дүкендегі жеңілдік кезінде оның бағасы алдымен 20%-ға төмендетілді, содан кейін тағы 25%-ға арзандатылды. Тауардың соңғы бағасы қанша?

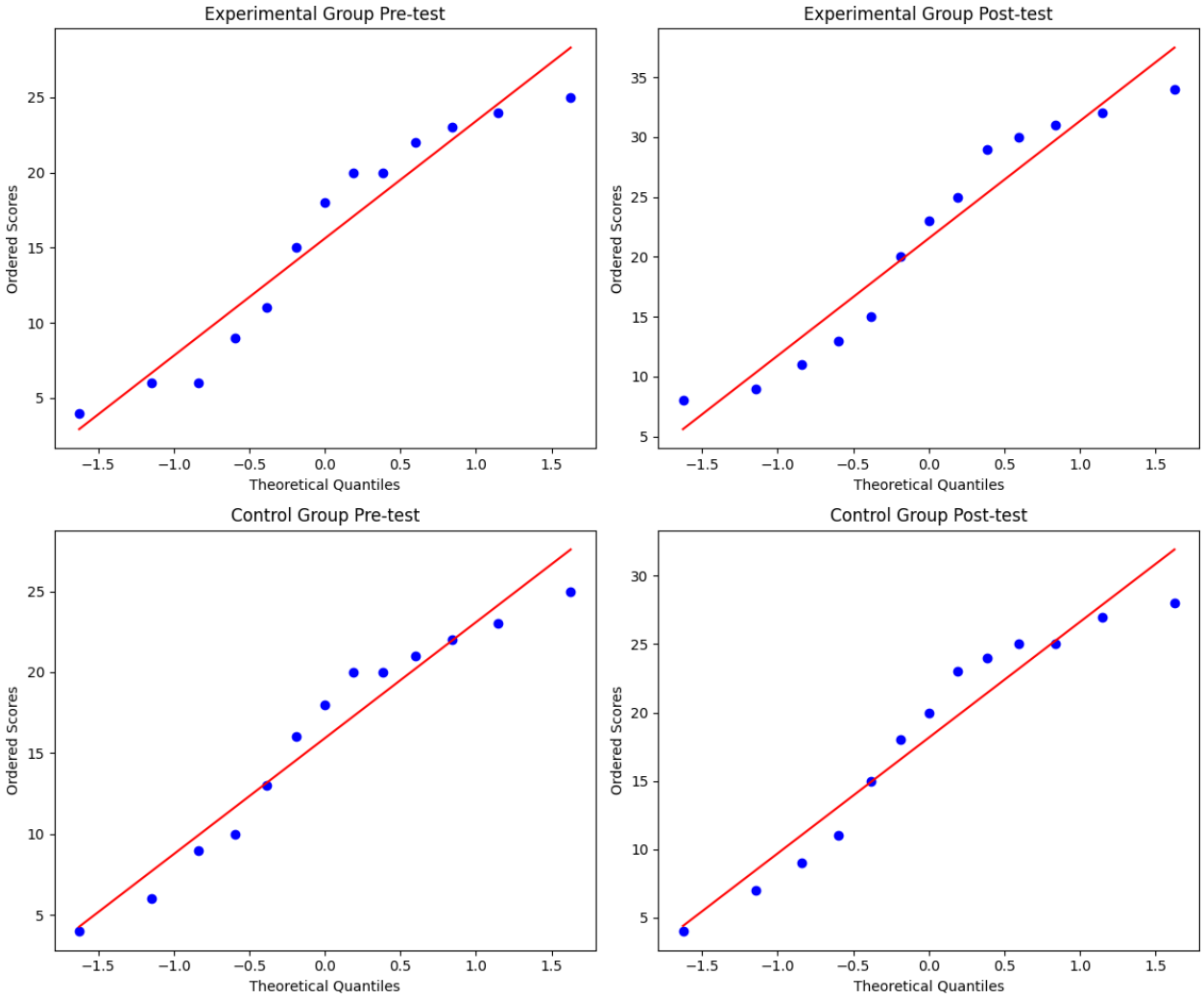
**Қозғалыс есептері**

5. А пунктінен В пунктіне бір мезетте екі автобус жолға шықты. Бірінші автобустың жылдамдығы 72 км/сағ, ал екінші автобустың жылдамдығы біріншісінен 1,5 есе артық. Автобустар жолға шыққаннан кейін 2,5 сағаттан соң олардың арақашықтығы қанша болады?

**Неравенство / Теңсіздік есептері**

6. Динараның екі жұмысы бар. Ол бариста болып жұмыс істейді және сағатына 13 доллар алады. Сонымен қатар ол иллюстратор болып жұмыс істейді және сағатына 30 доллар алады. Динара аптасына 45 сағаттан артық жұмыс істегісі келмейді және аптасына кемінде 625 доллар табыс тапқысы келеді. Бариста жұмысы оған аптасына ең көбі 30 сағат жұмыс істеуге мүмкіндік береді. Мұндағы x - Динараның бариста болып жұмыс істейтін сағат саны, ал y - иллюстратор болып жұмыс істейтін сағат саны. Осы жағдайды сипаттайтын теңсіздіктер жүйесін құрыңыз.

# Appendix I - Q-Q Plots for Pre-test and Post-test Scores



# Appendix J - Parent Consent Form and Educational Center Permission

Білім беру орталығы “QYRMYZY”

Келісім

Мен, Байболатова Гүлнар баламның 6-сынып оқушысы ретінде зерттеуге қатысуына өз еркіммен рұқсат беретінімді растаймын.

Зерттеуге қатысуға арналған ақпарат:

1. Қатысу ерікті кез келген уақытта бас тартуға болады.
2. Оқушыдан тест алынады.
3. Барлық жауаптар анонимді болады: жеке деректер сақталмайды, оқушының аты-жөні көрсетілмейді.
4. Оқушыға моральдік немесе физикалық қысым көрсетілмейді.

Қолы: 

Ата-ана/Қамқоршының аты-жөні: Байболатова Гүлнар

Күні: 27.03.2026

Білім беру орталығы "Qyrmyzy"

Келісім

Мен, Удербаева. Қ. А білім беру орталығы "Qyrmyzy" 6-сынып оқушыларына арналған "Оқушылардың функционалдық сауаттылығын теңдеулер мен теңсіздіктерге қатысты өмірлік жағдаяттарға негізделген (аутенттік) тапсырмалар арқылы арттыру" тақырыбындағы зерттеуді жүргізуге келісім беремін.

Зерттеуге қатысуға арналған ақпарат:

1. Қатысу ерікті, кез келген уақытта бас тартуға болады.
2. Барлық жауаптар анонимді болады: жеке деректер сақталмайды, оқушының аты-жөні көрестілмейді.
3. Оқушыға ешқандай моральдік немесе физикалық қысылым көрсетілмейді.

Қолы:

Директор аты-жөні: Удербаева. Қ. А

Күні: 06.03.2026