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# A REVIEW OF APPLYING REAL LIFE PROBLEMS IN TEACHING MATHEMATICS

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**Abstract**

This article affords an overview of current research on realistic mathematics education, examines the parameters of word problems that correctly reflect real life. This study aimed to analyze the use of the context of real life in the teaching of mathematics in school. This article also discusses the theoretical basis of the intervention. It proposes theoretical reasons for choosing the theory of realistic mathematics education (RME) for use with students with low academic performance.

*Keywords*: realistic mathematics education (RME), real-life context, word problems.

**Аннотация**

В статье представлен обзор современных исследований реалистичного математического образования, исследуются параметры словесных задач, которые правильно отражают повседневную жизнь. Это исследование было направлено на анализ использования контекста повседневной жизни при обучении математике в школе. В этой статье также обсуждаются теоретические основы реалистичного математического образования и предлагаются теоретические причины для выбора теории реалистичного математического образования для использования с учащимися с низкой успеваемостью.

*Ключевые слова:* реалистичное математическое образование, контекст реальной жизни, текстовые задачи.

**Аңдатпа**

Мақалада шынайы математикалық білім берудегі заманауи зерттеулерге шолу жасалады, күнделікті өмірді дұрыс көрсететін ауызша есептердің параметрлері қарастырылады. Бұл зерттеу мектепте математиканы оқытуда күнделікті өмірдің мәнмәтінін пайдалануды талдауға бағытталған. Сондай-ақ, бұл мақалада математикалық

білім берудің теориялық негіздері де талқыланады және үлгерімі төмен оқушылармен бірге пайдалану үшін математикалық білім берудің нақты теориясын таңдаудың теориялық себептері ұсынылады.

*Түйін сөздер:* шынайы математикалық білім беру, өмірлік контекст, мәтін есептер.

## Introduction

Mathematics is one of the mandatory subjects in education. Despite the fact that most people will not notice it, mathematics is especially needful for people to solve real-life problems, has a systematic logic and makes our brain work systematically. If a person is good at mathematics, then obviously he can find a solution to any real-life problem. This condition affects the cognitive attainment of students. Mathematics must be studied because it develops a higher level of thinking (Laurens, 2017). Many students are afraid and have difficulty learning mathematics. (Laurens, 2017). This means that teachers should think about teaching mathematics, it is necessary to make it more interesting and attractive for students.

According to some large-scale international studies TIMSS and PISA, the results of Kazakhstani students are high at the level of proficiency in the subject, but at the same time, the results at the level of coping with tasks inherent in a non-mathematical environment are much worse. According to A. Toybazarov and G. Nazarov (2018), students are much worse at solving problems which are based on real life cases. Tasks used in the context of real life in school education will help to assimilate the subject deeply and develop cognitive skills (Toybazarova & Nazarova, 2018). Thus, the relevance of this study is due to the need to study theoretical approaches and empirical works to summarize the techniques and strategies for working with the context of everyday life in school teaching. The significance of this study is that it focuses on the word problem, which is important in mathematics lessons. Word problems are often misunderstood. Thus, using RME in the classroom can provide examples based on real life that help students solve their problems and misconceptions and, as a result, improve their cognitive achievement. Therefore, this study aimed to examine the difference in cognitive achievement between students

who studied with RME and those who studied via traditional learning. The purpose of this study was to analyze the use of context of real life in teaching mathematics in schools.

According to Saragih and Napitupulu (2015): “Students in the future are expected to use mathematics and the way of thinking in real life, as well as study many sciences that emphasize logical construction and the ability to apply mathematics in life". This means that students are expected to develop higher-order thinking abilities (Hasibuan, 2019).

Learning math can be made easier and more pleasurable. Ease of learning can be accented when the content and context of the materials relate to the real-life activities of the students. Realistic math education is one of the main treatments that solves the problems associated with conventional and abstract mathematics education (Bray & Tangney, 2016). RME emerged out of Freudenthal's ideas that math is a part of human life (Freudenthal, 1971). In his opinion, students should be given the chance to rediscover math by processing a real situation or relations in the math, also a process that is important to them. Using unusual and enjoyable learning materials can be one of the several ways to empower and fortify math conceptions.This is because solving math problem is a way to develop creative thinking or reasoning that is logical, critical, and analytical. Moreover, Zakaria and Muzakkir (2017) affirm that the realistic mathematics education treatment is a correct method to develop the quality of the learning and teaching process.

This paper will consider the specifics of using the context of real life in teaching mathematics: the possibilities and difficulties of working with the context in the classroom, word problems as a key element of working with the context in the classroom. This work was carried out to answer the research question; does the use of the RME approach have any significant impact on mathematical representation and problem solving?

**Literature review**

The habit of associating the study of mathematics with real life, as it was before, to an important degree allows solving verbal problems (Bonotto, 2010). However, word problems are in most cases the only examples allowed to students to elaborate basic sensory experiences in math and math modeling (Bonotto, 2010). The word problem does not often reach the idea of math modeling; and they often help pull students away from realistic thinking and reflection (Bonotto, 2010).

Using real-life context in teaching mathematics at schools has several advantages. Real-life context helps students understand the connection between mathematics and real life, how to use their knowledge in real life, and also makes it easier to find a connection between new and learned material (Parchman, 2006). In addition, many studies show that the using of real-life context in education provides more equal opportunities in the study of the subject, increases student interest in the subject (Bennett, 2005; Watanabe, 2007).

As Lave and Wenger (1991) put it, the use of real-life context is seen in most cases as situational learning). Within the confines of this conception, it is indicating the importance of concordance between the context of those tasks that are used in schools and the context of situations in real-life where this knowledge is assumed to be applied. This pedagogical approach draws our attention to the use of examples related to real life, also, the purpose of this approach is to teach students through actual experience (Jochems, Putter-Smitsnis, & Taconis, 2013; Rose, 2012)

Now, we will talk about the specification of the use of real life context in teaching math: how it works and the difficulties of this work with the context of real-life in auditory, materials as a key

element of working with context of real-life in auditory, promoting to a more fortunate assimilation of knowledge of teaching and presentation experience teachers.

**Practice-oriented teaching of mathematics in curricula**

The use of real-life context in the education system and mathematics is widely discussed in the world of modern sciences, among researchers and developers of curricula. As a result of some research, it was clear that daily work using real-life contexts in teaching mathematics plays an important role in the process of mathematics education (Cognition and Technology …, 1990).

In addition, teaching methods using applied aspects of mathematics is associated with the development of students' higher-order thinking abilities. It should be said that, in international practice, assessing the quality of mathematics education mainly considers the students' ability to use math in their daily work and in real life (Atweh,2011). For example, the international inspection of educational quality PISA is based on the idea of students' ability to apply their knowledges in real life (Peña-López, 2013).

In the mid-70s in the Netherlands the first program on realistic teaching of mathematics called "Realistic Mathematic Education" (RME) emerged, and then other countries also supported this program, then continued to develop in this direction (Freudenthal, Treffers, & Wiskobas, 1993). Then, in the UK and the USA, this concept was continued by the program "Mathematics in Context", this program was created in 1996 (Dickinson, 2011; NCTM, 2006). In 1997, Norway introduced new educational standards, according to these standards for teaching "real life" mathematics is regarded on a par with the subjects, which need to study: arithmetic, algebra and geometry and etc. (RMERC, 1999).

Let us consider the principles of teaching in the scope of the project RME. This approach was developed based on the ideas of Freudenthal (1973). He affirms that mathematics must be

associated with human activities in the real world, be related to the activities of students and pertinent social life. The second important moment in the RME program is the conceptualization of two ways of learning mathematics: horizontal and vertical (Treffers, 1993). In the Horizontal way, students turn to mathematics for the purpose of solving problems in real life. The vertical way of cognition of mathematics is the process of cognition already in the world of mathematical symbols. The RME approach evaluates the use of these two methods equally. So, according to Freudenthal (1973) and Treffers (1993), teaching mathematics should be based on two principles: independent cognitive activity of students and the use of the real-life context in teaching mathematics. In other words, in the RME program, the goal of math education is to support independent learning of students.

A. Treffers (1987) in his work described the main five aspects of the RME program:

- Using meaningful context of learning.
- Using simulating.
- The process of self-re-opening of learners, guided by a teacher.
- Interactive learning process.
- Understanding of mathematics as a subject in which many topics are intertwined.

**Teaching practices related to knowledge transfer**

One part of the studies, that have been devoted to the issues of the possibility of using subject knowledge to solve problems in the real life, is devoted to identifying the so-called "transfer", that is, the transfer of knowledge, as well as effective ways of teaching students to apply the acquired knowledge in practice. These studies are traditional for cognitive psychology and consider the wide application of knowledge (Bransford, 1999). In another part of the research, it is considered what the context of the situation should be.

A number of studies on knowledge transfer have asked questions about how to best prioritize learning. Namely, first of all, it is worth teaching the student general cognitive skills or focusing on teaching narrowly specific skills (Lehman & Nisbett, 1990; Halpern, Hansen, & Riefer, 1990). It is assumed that in the process of repeated repetition of an exercise, children can independently identify the underlying meta-schemas, internalize meta-cognitive ideas and apply them to solve problems they encounter outside of school (Van, 1990). So, in 1980, as part of his research, Gick and Holyoak (1980) showed an example of a successful transfer of knowledge by analogy in an experiment with the classic problem of Karl Duncker on the use of radiation to destroy a tumor. However, in subsequent studies of the effectiveness of knowledge transfer by analogy, it was shown that this phenomenon exists only under certain circumstances. Thus, in the work of A.L. Brown and M.J. Kane (1998) showed that children were better able to transfer subject knowledge to another context only if they had a deeper understanding of the subject. With regard to the role of context in classroom work, it has been shown that learners are more likely to apply their learned knowledge to understand new concepts in physics if the first learning context was presented as meaningful to the learners, rather than simply replicating knowledge (Hammer, 2005). In the work of Engle and colleagues (2012) showed that successful transfer of knowledge is due not only to the specifics of the teaching content, but also to the way the teacher inserts new material into the context of the entire teaching. So, in this study, the teacher wrote new material using the following tools:

1. Development of students' belief that they can use this knowledge in the future.

2. An indication of the connection between the studied material and the context of the situation in which the transfer of knowledge is supposed.

3. Encouraging students to build on their past experience with the subject.

4. Positioning of students as authors of separate links between the content of the lesson and the situation of knowledge transfer.

5. Positioning student authorship as an activity in which students master the role of independent development of a solution.

For example, it has been shown that the probability of knowledge transfer is twice as high for those students who learn in a “wide context” (expansive framing) compared to “bounded framing” (Engle, 2012). Within the framework of the "wide context", the teacher connects the content of the lesson with other topics in this and other disciplines, shows the connection between the topic of the lesson and situations in real life, refers to events that occur in the past or future tense. Within the framework of the “limited context”, the teacher, on the contrary, does not connect the content of the lesson with other situations in life, does not refer to the events of the students' personal lives. In addition, the use of “wide context” increases student motivation (Grover, 2014).

Finally, with regard to interdisciplinary connections, consider the results of the meta-analysis in the study by Hartzler (2000). Based on 30 studies, it was shown that students enrolled in math and science programs performed better on standardized tests than students enrolled in traditional curricula.

## Applied word problems as the main source of real life in a mathematics lesson

### Word problems

Word problems are one of the most common ways of teaching to apply subject knowledge in mathematics in practice (Gravemeijer, 2013; Shapiro, 1990; Toreshin, 1990). In addition, these tasks increase student motivation, demonstrate the importance of knowledge and skills in mathematics in life, and contribute to the development of general cognitive abilities (Fridman, 2005; Chapman, 2006).

In different concepts, such tasks are called realistic (real-life problems, realistic problems) (Cooper & Harries, 2009; Gainsburg, 2008; Pais, 2013), modeling tasks (Blum & Ferri, 2009; Frejd, 2012) contextualized tasks (Carvalho & Solomon, 2012; Palm, 2006), real-life problems (Peña-López , 2013), and applied tasks (Palm, 2006). In turn, in the most common definition, a textual problem of an applied nature is defined as “a problem posed outside mathematics and solved by mathematical means” (Toreshin, 1990). Expanding this definition, a word problem is a text that describes a situation, presumably familiar to the reader, and poses a question to this situation.

The defining characteristic of a word problem with an applied orientation is the degree of "realism" of what is happening in the conditions of the problem. On the one hand, these can be cases from the real life of a student or from the life of society, with the inclusion of real names and events in the text, and on the other hand, these can be tasks with a fictitious context that has nothing to do with real life. In addition, the context of a word problem is often hypothetical, unrealistic, not related to the life of students, and also does not represent any new information for them (in contrast to problems in real life) (Gerofsky, 1999). In most cases, problems in real life are poorly structured, complex tasks (Dixon & Brown, 2012). Learning from such tasks contributes to the development of general problem-solving skills in students, however, in school, students most often face only well-structured, standardized tasks aimed at learning subject material (Johnson et al., 2011). Thus, decontextualized teaching material is criticized for its rigidity and incompleteness (Spiro et al., 2012). Although such information develops students' skills to successfully solve typical problems in exams, in real life students cannot use the material they have learned to solve non-standard problems (Cognition and Technology ..., 1990).

Let us further consider the key parameters of word problems that correctly reflect reality and define them as applied problems.

**Parameters of applied word problems**

In modern studies, many different definitions of applied word problems are presented, as well as various characteristics of the theoretical model of such problems. However, the creation of a unified theoretical model sets the goal and structure for defining applied problems, thus, it is a necessary element in the process of their development. Therefore, the purpose of this review is precisely to identify a common set of characteristics of applied problems.

The first parameter of an applied word problem is to formulate its conditions in the context of real life. However, a person's day-to-day problems can be rooted in innumerable contexts. Therefore, to the ordinary situations of applied word problems, the characteristics defining them must be established.

In the international study PISA, all the variety of real-life situations of a student was divided into three groups of sources (Watanabe & Ischinger, 2009). First, these are situations that are directly related to the student's daily experience. Secondly, situations are considered as sources. The last but not the least, the source of the context of a word problem of an applied nature may lie in the interaction of a person with the outside world. It should be noted that the purpose of using an applied word problem in teaching mathematics is to apply to students the concepts and procedures learned in the lessons. This means that the formulation of the conditions of a problem in ordinary language implies the need to translate its conditions into the language of mathematics. The process of modeling, or, in other words, fixing the relations between the objects of the problem, is a mandatory step in solving any word problem, including the problem of an applied nature (Talyzina, 1988; Fridman, 1977; Blum & Niss, 1991). In addition, the received answer must be

evaluated taking into account the given contextual conditions, that is, it must be interpreted. Thus, the parameter of ordinary semantics in applied problems actually implies the presence of two processes - mathematical modeling and interpretation of the results obtained.

In addition to formulating the problem in real life language, the context should determine the need to solve it. Therefore, the second criterion of an applied word problem is the situational significance of the context. Thus, a task aimed at demonstrating the applicability of knowledge in mathematics to real life should have two characteristics - be formulated using ordinary semantics and have situational significance.

It is necessary to consider another classification of word problem, namely their division into well-structured and poorly-structured problems (Kitchener, 1983; Schraw et al., 1995). Well-structured tasks are typical school tasks that require the application of a limited number of rules, concepts and principles, and are learned in relation to a given situation (Jonassen, 1997). In turn, poorly structured tasks are embedded in the context of real life or arise in this context. Their solution is not algorithmic or predictable. Also, they may require the application of knowledge from different subject areas. However, they are embedded in the context of reality, and therefore are more interesting and meaningful for students. From this point of view, poorly structured tasks reflect reality more than well-structured ones.

**Techniques for working with the context of word problems**

Let us further consider what techniques of working with the context of word problems in the classroom are considered in the literature. In the research, there are two main strategies for working with context when solving a word problem. Thus, in the work of Gilligan (1993), the following learning strategies were proposed for students: separate and connected knowledge. It is

assumed that the way of working with context in word problems depends on which way of learning the student adheres to (Buerk, 1985).

Further, Bruner (1985) proposed two different models of cognition: paradigmatic and narrative. Paradigmatic, or logico-centrist, cognition is focused on a narrow epistemological question - "how to find out the truth." This method of cognition is focused on clarifying the universal principles that apply to any situation, and, therefore, excludes the influence of contextual characteristics. On the other hand, narrative or humanistic cognition focuses on the broader and inclusive epistemological question of the meaning of experience. That is, the narrative model of cognition is sensitive to the context and associated with the interpretation of texts. Thus, these two models of cognition can be correlated with strategies for solving word problems in mathematics. So, in the case of the predominance of the paradigmatic model of cognition, the student focuses on mathematical models and identifying the fundamental and universal structure of the problem, free from context. That is, the solution to the problem is to extract the structure from the surrounding context and apply a well-known algorithm to solve the problem. And in the case of the predominance of the narrative model of cognition, the student focuses, on the contrary, on the social context of the task. That is, the solution to the problem is to interpret the context, identify the main roles, plot, etc.

Finally, consider the difficulties that can arise when working with context in a word problem. In general, students are often inclined to solve applied problems in mathematics without taking into account the contextual peculiarities of the situation (Verschaffel et al., 2000; Greer, 1997). For example, to solve the following problem, students mechanically performed various mathematical operations with numbers, but did not take into account the context of the situation, either when simulating conditions, or when interpreting the results: “There are 12 sheep and 13

goats on the ship. How old is the captain of the ship? " (Selter, 1994). Such unrealistic methods of solving applied problems are the subject of much research. Thus, it is believed that students exclude the context of the problem from its solution, as they follow an established informal norm in mathematics lessons: “Do not think about the real situation, focus on the mathematical content” (Gravenmeijer, 1997). Moreover, in mathematics lessons, it is more common practice to repeat and practice the learned solution algorithm than to make sense of the material learned about real life (Schnoefeld, 1991). For example, first of all, when solving a problem, students try to identify its structure and assign it to a certain type by recognizing key words (Hegarty et al., 1995). Thus, it is important to note that teachers themselves, when solving both standard and atypical word problems, tend to exclude the context of the problem (Rosales et al., 2012).

It is important to note that teachers can face various difficulties in using the learning context. Thus, in a study by Avargil and her colleagues (2012), the following difficulties were identified when using the context in teaching chemistry:

1. Lack of special training required to discuss theoretical material in the context of real life.

2. Difficulty in moderating class discussions.

3. Students are better at solving equations and performing math calculations, but they are much worse at word problems.

In the same study, a model of the professional competence of chemistry teachers was proposed in the context of their ability to use context in teaching (Avargil, 2012). The model consists of three stages. At the lower, first stage, teachers are proficient in the subject content of instruction and have teaching skills. Such teachers were well-versed in the traditional content of the subject, but did not develop cognitive skills in students. Moreover, such teachers viewed

context as irrelevant in the teaching of chemistry. At a higher, second level, teachers are able to develop the cognitive skills of students using a contextual approach. At the highest level of professional development, teachers are able to independently develop contextual assignments to assess students' knowledge of chemistry.

Another important factor in solving word problems is the characteristics of students: their academic performance and the socio-economic status of their families. Thus, in the work of B. Cooper and Harries (2009), it was shown that students from families belonging to the working class took into account and used their knowledge of real life to a greater extent when solving word problems compared to students from better-off classes. In addition, a number of studies have shown that the success of solving a word problem is also associated with the overall performance of students in mathematics. For example, Suydam (1980) has shown that capable learners tend to exclude details of the context of a problem, but remember its structural features. Less capable students, by contrast, tend to remember specific details first.

Summarizing all of the above, students avoid considering the situation in the real life for two reasons:

1) the stereotypical and unrealistic nature of those word problems that are included in textbooks;

2) The techniques that teachers use when working with word problems in the classroom (Mason & Scrivani, 2004; Verschaffel et al. 1999).

However, there is no reliable empirical research to support these claims that specifically examines the work of the teacher with word problems. Thus, the results obtained further actualize the issue of considering not only the frequency, but also the qualitative features of the application of certain practices in teaching applied mathematics.

## Conclusions

The review of modern research presented in this paper allowed us to summarize information regarding the use of the context of real life in teaching mathematics. It was shown that teaching the applicability of knowledge in mathematics in real life should be carried out in an expanded context: demonstrating the connection between the content of the lesson and other topics in this and other disciplines; demonstrating the connection between the topic of the lesson and situations in real life; referring to events in the past or future tense. In addition, learning should be conducted using poorly structured tasks that require students to solve non-standard and unfamiliar tasks. The parameters of word problems that correctly reflect real life were considered. In this review, attention was drawn to the need to examine the views of teachers regarding the use of context in teaching mathematics.

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