

ON THE USE OF THE METHOD OF EXPEDIENT PROBLEMS TO ACTIVATE STUDENTS' COGNITIVE ACTIVITY IN THE PROCESS OF TEACHING MATHEMATICS IN THE NEW UKRAINIAN SCHOOL

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ABSTRACT

Formulation of the problem. The motivation of students to study a subject at school largely depends on the methodology used by the teacher in the teaching process, and his or her ability to convey new knowledge to students in an interesting and accessible form. This problem becomes especially relevant in the context of the New Ukrainian School project, which involves shifting the emphasis in the learning process from the teacher to the student and puts in the forefront the needs of the latter. For a child to be interested in learning and sufficiently motivated, a teacher should have an answer to the question "Why do we need to learn this?" The method of expedient problems gives one of the possible answers to this question, helps the teacher to motivate the student to study mathematics, and indicates directions for further use of mathematical knowledge. The importance of developing students' ability to apply mathematical knowledge in practice is further confirmed by the results of the International Comparative Studies PISA 2018 and PISA 2022, as well as statistical reports of the Ukrainian Center for Educational Quality Assessment in Mathematics.

Materials and methods. To achieve our goal, we use a theoretical analysis of the methodological literature related to the chosen research topic. We also implement empirical methods, including conducting our own survey via Google Forms, observing the educational process in secondary schools, and analyzing students' performance.

Results. To study the feasibility and possibility of using the method of expedient problems in teaching mathematics in the NUS, we surveyed 290 mathematics teachers with different pedagogical experiences and qualifications from all regions of Ukraine. In particular, we assumed the effectiveness of using expedient problems in the process of teaching mathematics. The survey was conducted anonymously and online via the Google Forms platform. The results of the survey show that a significant number of respondents are familiar with the method of expedient problems and regularly or constantly use such tasks in the learning process. In addition, they are convinced of the need to include such tasks in existing math textbooks. The survey also shows at what stages of the lesson and when studying which content areas of the mathematics course, in the opinion of the respondents, it is most appropriate to use the method of expedient problems.

Conclusions. To ensure the proper quality of students' acquisition of the necessary competencies envisaged by the New Ukrainian School project, the use of appropriate tasks at different stages of the lesson and in the study of different content areas of the school mathematics course is quite appropriate and possible. Although only half of the surveyed teachers currently use such tasks in their pedagogical activities regularly, most of the respondents consider them useful. In addition, teachers express a wish to provide methodological support for the effective implementation of appropriate tasks in the educational process, in particular, in the form of ready-made didactic materials and methodological recommendations for their creation.

KEYWORDS: *New Ukrainian School; competence-based approach to learning; motivation to learn; method of expedient problems; activation of cognitive activity.*

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ПРО ВИКОРИСТАННЯ МЕТОДУ ДОЦІЛЬНИХ ЗАДАЧ ДЛЯ АКТИВІЗАЦІЇ ПІЗНАВАЛЬНОЇ ДІЯЛЬНОСТІ УЧНІВ У ПРОЦЕСІ НАВЧАННЯ МАТЕМАТИКИ В НОВІЙ УКРАЇНСЬКІЙ ШКОЛІ

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АНОТАЦІЯ

Постановка проблеми. Мотивація учнів до вивчення предмета в школі багато в чому залежить від методики, яку застосовує вчитель у процесі навчання, його вміння в цікавій і доступній формі донести до учнів нові знання. Особливої актуальності ця проблема набуває в контексті реалізації проекту «Нова Українська Школа», який передбачає зміщення акцентів у процесі навчання з учителя на учня, ставить на чільне місце саме його потреби. Для того, щоб дитина була зацікавлена в навчанні та була достатньо мотивованою, варто вчителю мати відповідь на запитання «Навіщо вам потрібно цьому вчитися?». Метод доцільних задач дає одну з можливих відповідей на це запитання, допомагає вчителю мотивувати учня до вивчення математики, вказує напрямки для подальшого використання математичних знань. Важливість розвитку вміння учнів застосовувати математичні знання на практиці додатково підтверджують результати Міжнародних порівняльних досліджень PISA 2018 та PISA 2022, а також статистичні звіти УЦОЯО щодо тестування з математики.

Матеріали та методи. Для досягнення нашої мети ми використовуємо теоретичний аналіз методичної літератури, яка стосується обраної теми дослідження. Також ми впроваджуємо емпіричні методи, зокрема, проведення власного опитування через Google Forms, спостереження за навчальним процесом у загальноосвітніх школах і аналіз успішності учнів.

Результати. Для вивчення питання доцільність і можливість використання методу доцільних задач під час навчання математики в НУШ було проведено опитування 290 вчителів математики з різним педагогічним досвідом та кваліфікацією з усіх областей України. Зокрема, нами було висунуто припущення про ефективність використання доцільних задач у процесі навчання математики. Опитування відбувалося анонімно та онлайн через платформу Google Forms. Результати опитування свідчать, що значна частина респондентів знайомі з методом доцільних задач і регулярно або постійно застосовують такі задачі в навчальному процесі. Крім того, вони переконані в необхідності включення таких завдань до діючих підручників з математики. У опитуванні також відображено на яких етапах уроку та при вивченні яких змістових ліній курсу математики, на думку респондентів, найбільш доцільно використовувати метод доцільних задач.

Висновки. Для забезпечення належної якості набуття учнями необхідних компетентностей, передбачених реалізацією проекту «Нова Українська Школа», використання доцільних задач на різних етапах уроку та при вивченні різних змістових ліній шкільного курсу математики є цілком доречним і можливим. І хоч наразі лише половина опитаних учителів опитаних постійно використовують такі задачі в своїй педагогічній діяльності, але більшість опитаних вважають їх корисними. Крім того, вчителі висловлюють побажання щодо надання методичної підтримки для ефективного впровадження доцільних задач у навчальний процес, зокрема, у вигляді готових дидактичних матеріалів та методичних рекомендацій щодо їх створення.

КЛЮЧОВІ СЛОВА: Нова Українська Школа; компетентнісний підхід до навчання; мотивація до навчання; метод доцільних задач; активізація пізнавальної діяльності.

INTRODUCTION

Statement of the problem. Analysis of current research. The New Ukrainian School (NUS), a project to reform the Ukrainian education system, is based on a competency-based approach to learning and aims to create a happy and self-realized personality in the future social and professional life. In other words, the NUS project involves shaping the content of school education based primarily on the needs of the child (NUS, 2024). According to the State Standard of Basic Secondary Education (MES of Ukraine, 2020), the mathematics field is also responsible not only for the formation of professional mathematical competence but also for the acquisition by students of many important general competencies that will contribute to the achievement of this goal. In this context, the problem of activating students' learning and cognitive activity in mathematics, their interest in the learning process itself, and not just in its results, becomes extremely important.

Many studies have been devoted to the problem of activating cognitive activity, both by Ukrainian (Lytvynenko, 2002; Pyrozhenko & Pometun, 2004; Mosiychuk et al., 2017; Kochubey et al., 2022; etc.) and foreign authors (Stain, 1998; Baumert et al., 2010; Brett 2012; Plöger et al., 2019; Mahfud et al., 2020; Bakken & Andersson-Bakken, 2021; etc.). Most of them emphasize the importance of students' emotional involvement in the process of cognitive activity in mathematics lessons, as well as a positive perception of mathematics as a science in general and its study at school in particular. Therefore, research on methods of achieving this emotional involvement and forming a positive emotional background in mathematics lessons is relevant and appropriate. The importance of developing students' ability to apply mathematical knowledge in practice is further confirmed by the results of international comparative studies PISA 2018 and PISA 2023 (Mazorchuk et al., 2019; Bychko et al., 2023), as well as statistical reports of the Ukrainian Center for Educational Quality Assurance on mathematics testing (UCEQA 2024).

At the end of the nineteenth century, a well-known mathematician and methodologist of the time, Semen Shokhor-Trotskyi, first proposed the method of expedient problems as an effective tool in teaching mathematics (Shokhor-Trotskyi, 1913).

His idea was to start mathematics lessons with tasks and problems that would encourage students to develop new ideas about the material being studied and to activate their mental activity. This approach not only paved the way for the acquisition of mathematical knowledge, but also encouraged students to actively participate in the learning process. It was this method that evolved into the modern concept of "Learning by doing", which is used in modern methodological science to stimulate students' interest in learning mathematics (sources).

The method of expedient problems can be used at different stages of the lesson and for different purposes, but in this article we will focus on its application at the stage of motivating students to cognitive activity. This stage plays a very important role in creating the basis for further successful learning of mathematics. Motivational tasks help to stimulate students' interest in the subject, forming a positive attitude towards learning. It is important to note that it is at the initial stage of the lesson that the activation of interest in the material being studied has a great impact on the further efficiency and effectiveness of the learning process.

Solving applied problems helps develop problem-solving, critical thinking, and creativity skills. They help students become more interested in mathematics, understand mathematical theory, and prove that the knowledge they have acquired can be applied in practice, including in everyday life. An additional effect of using motivational tasks is to increase students' self-esteem and belief in their abilities. This helps students to be more confident, which, in turn, increases their motivation to continue studying mathematics and achieve success in this area. In addition, motivational tasks can help to engage students who have not previously been interested in math, as well as create a positive emotional background in the classroom. Thanks to such tasks, students can feel that mathematics is not just a set of complex formulas and abstract concepts, but also an interesting and practical tool for solving real problems.

For example, one of the possible motivational tasks in an algebra course could be how to increase revenue from the sale of goods. Students could be asked to solve a problem in which they have to find a way to increase revenue while keeping costs at a minimum. This problem can be quite interesting, as it not only helps students understand not only algebraic methods, but also gives them the opportunity to put their knowledge into practice and experience the importance of math in real life.

The use of appropriate motivational tasks in the study of the main content areas of school mathematics (Numbers and Expressions, Equations and Inequalities, Functions and Their Graphs, Planar and Space Geometry, Elements of Combinatorics and Stochastics) has several advantages. Firstly, such tasks contribute to the implementation of the course on the applied orientation of the mathematics learning process, which helps students see the application of mathematics in real life. Secondly, solving practical problems contributes to the development of students' skills of analysis, critical thinking, and finding optimal solutions in their daily practical activities. Finally, thirdly, this approach makes it possible to establish a connection between abstract theory and its practical application, which can stimulate students to be more active and interested in learning the material in math classes. Although the method of expedient problems is not all-pervasive, and other approaches to learning new material in mathematics lessons should not be underestimated, this method is attractive because it allows students to solve problems independently through communication with classmates. In this context, the teacher only needs to organize the discussion, providing support with appropriate questions.

In this paper, we plan to formulate and experimentally test the hypothesis about the feasibility and possibility of using the method of expedient problems at different stages of the mathematics lesson in the NUS, as well as to find out how popular this method is among the community of Ukrainian mathematics teachers and how they use it in their pedagogical activities. Based on our own pedagogical experience and the results of the analysis of the teacher survey, we will also formulate some recommendations for NUS mathematics teachers on the prospects and possibilities of using the method of expedient problems to activate students' cognitive activity.

METHODS OF RESEARCH

To achieve the research objectives, we use a theoretical analysis of the methodological literature related to the chosen topic. We also use a number of empirical methods: conducting our own survey using Google Forms, observing the educational process in secondary schools, and analyzing students' achievements. In this article, we also use various methods of scientific cognition: comparative analysis to find out different points of view on the problem; systematization and generalization to formulate conclusions and recommendations for enhancing students' cognitive activity in mathematics lessons; we also summarize our own pedagogical experience and the authors' observations of the process of teaching mathematics in Ukrainian schools.

RESULTS OF THE RESEARCH

The theoretical analysis provides the basis for formulating a hypothesis about the appropriateness of using the method of expedient problems in teaching mathematics to secondary school students. To test this hypothesis and determine the prospects for further use of expedient problems in the educational process, we conducted a survey of teachers. The survey was conducted anonymously and online using Google Forms. It involved 290 teachers working with students in grades 5-11 of secondary schools from all regions of Ukraine, who had different work experience and qualifications. Below is a list of questions and an analysis of the answers. If the question included multiple answers, the percentage of the total number of respondents who chose this option is indicated for each of them.

Question 1. Are you familiar with such a method of teaching mathematics as the Method of Expedient problems and how often do you use it ("According to this method, mathematics is taught using tasks. The study of any topic begins with tasks, which naturally provides motivation to study theoretical material. When studying the theoretical material of a topic, students mainly solve problems" (Slepkan, 2006)?)

Answer option	Quantity	%
Yes, all the time	16	5,5
Yes, often	104	35,9
Yes, sometimes	142	48,9
Yes, I do not use	13	4,5
No, I don't use it at all	15	5,2

As we can see, almost all of the surveyed teachers (about 90%) use expedient problems in their work to varying degrees, while only 5% of the respondents are not familiar with the definition of an expedient task. This is natural, since all respondents have a pedagogical education, and thus should be familiar with the classical theory and methods of teaching mathematics, where the corresponding definition is introduced. In addition, the need to activate students' learning and cognitive activity in various ways is always relevant, and the use of appropriate tasks for this purpose seems quite natural.

Question 2. In your opinion, at what stages of the lesson should the method of expedient problems be used (several options are possible)?

Answer option	Quantity	%
Motivation of educational and cognitive activity	221	76,2
Updating basic knowledge and methods	116	40,0
Formation of new knowledge and ways of action	180	62,1
Reinforcement, formation of skills and abilities	144	49,7
Reflection on educational and cognitive activity	70	24,1
Assessment of students' learning achievements	51	17,6

The answers to this question show that the method of expedient problems is most effective at the stage of motivation of educational and cognitive activity, as the student needs to be interested, show the need to study a new topic, and reach most of the audience. At the stage of updating basic knowledge, forming new skills, and consolidating the use of the method of expedient problems is less popular, but still effective, because having learned the basic concepts in the previous stages, the student can already solve problems that were previously beyond his or her reach, which inspires faith in opportunities, increases self-esteem, and motivates further study of mathematics in general. As for reflection and evaluation, the low popularity of the choice is also understandable: much less class time is allocated to these stages, which is sometimes a problem for fully capturing the essence of the task at hand.

Question 3. To which content area in the course of algebra in secondary school, in your opinion, is the method of expedient problems most applicable (multiple choices are possible)?

Answer option	Quantity	%
Numbers and expressions	148	51,0
Equations and inequalities	226	77,9
Functions and their graphs	173	59,7

We focused our attention on algebraic content lines, because for geometric material, the division by content lines does not reflect the possibilities of applying the method. Here it is better to choose another basis for classification, for example, the class of geometric objects being studied (triangles, quadrilaterals, circle and circle, polyhedra, bodies of rotation, etc.) Unfortunately, the content area "Elements of combinatorics and stochastics" is currently presented in secondary schools in a rather fragmented manner, and therefore it is predictably among the outsiders, not because of its lesser importance, but because of the scope of study.

Among the algebraic content areas, the most popular among the surveyed teachers is the content area "Equations and Inequalities" (almost 78% of respondents). This choice is quite natural, since equations and inequalities are a mathematical model of many processes from different fields: physics, chemistry, biology, economics, etc.

Question 4. In your opinion, what is the best source of relevant tasks?

Answer option	Quantity	%
A current math textbook	75	25,9
Collections of tasks	103	35,5
Internet	52	17,9
Own imagination	49	16,9
Other option (specify)	11	3,8

As we can see, the opinions of the surveyed teachers were divided on this issue, as it would be natural, in our opinion, to choose an existing textbook as a source of appropriate tasks. Indeed, a textbook is a book that is always at hand, always with students and teachers. However, current mathematics textbooks, unfortunately, do not contain an appropriate number of appropriate tasks, they are used in explaining new material rather fragmentarily - both to motivate cognitive activity and to form new knowledge and ways of doing things. The results of the survey show that teachers are dissatisfied with the number of appropriate tasks in textbooks and that an urgent problem is to increase the number of such tasks in NUS math textbooks.

The most popular source of appropriate tasks (more than a third of respondents) was collections of tasks, which is also understandable, since for each individual class and even sometimes for each individual student, an appropriate task should be selected personally. Only about one in six of the respondents mentioned their own imagination as the best source of appropriate tasks, which also seems natural, since there are not many teachers capable of pedagogical creativity. It is somewhat surprising that the Internet is still not a trend as a source of appropriate tasks, which further emphasizes the relevance of such developments and the appropriateness of their placement on the Internet. Among the other options mentioned, it was said that all of the above are the best sources, i.e. they work together.

Question 5. In your opinion, is the method of expedient problems applicable to every topic of the secondary school algebra course?

Answer option	Quantity	%
Yes, to all of them	26	9,0
To most	186	64,1
No, only to some topics	77	26,6
This method is not appropriate for algebraic topics	1	0,3

As noted above, the method of expedient problems cannot claim to be universal, since we should not forget about the classical methods of teaching mathematics. However, it is quite popular among teachers and is constantly used by them in their pedagogical activities - almost two-thirds of respondents believe that it is appropriate for studying most topics in the algebra course.

Question 6. How do you assess the degree of students' interest in learning mathematics when using the method of expedient problems?

Answer option	Quantity	%
High degree of interest	78	26,9
Moderate level of interest	187	64,5
Low level of interest	9	3,1
I have no information	16	5,5

Almost two-thirds of the respondents said that the use of expedient problems has a moderate effect on the level of students' interest in learning mathematics. This is also consistent with our theoretical considerations, since none of the teaching methods can act as a panacea for activating cognitive activity, including the method of expedient problems studied in this paper. One of the possible reasons for the moderate effect of using expedient problems is that teachers were unable to find an area of direct interest to students in a particular class when studying a particular topic. Teachers who do not have information about the degree of students' interest in mathematics after using the method of expedient problems (less than 6%), in our opinion, should conduct a survey among their students, because without feedback it is difficult to improve the educational process.

Question 7. What advantages do you see in using the method of expedient problems in teaching mathematics? The most popular answers to this question include the following:

- students can answer the question "Why do we need to learn this?"
- conscious learning of mathematics;
- students become more motivated;
- applied orientation of what is learned;
- avoidance of formalism when learning a new topic;
- development of logical and critical thinking;
- development of students' competencies.

This list is a generalization of the opinion of the interviewed teachers, but there were many more advantages listed. It seems natural to us to choose these positive aspects of using the method of expedient problems, and we believe that this list is an excellent motivator for the use of such tasks in mathematics lessons in NUS.

Question 8. In your opinion, what difficulties can be encountered when using the method of expedient problems?

Among the shortcomings highlighted by the respondents were the following:

- the need to spend a lot of time preparing such tasks;
- lack of data sources for such tasks;
- Difficulties in using tasks with regard to student differentiation;
- general inability of students to use mathematics in practice;
- students' inability to analyze the conditions of a story problem;
- the possibility of choosing a task that will not interest students.

We believe that these difficulties can be overcome, in particular, by teachers studying scientific and methodological literature on this issue, taking advanced training courses and participating in webinars on this topic, as well as other forms of self-education directly related to the use of appropriate tasks. But any path begins with the first step, so we advise teachers to at least try to use this method of activating learning and cognitive activity in mathematics lessons in the NUS.

Summarizing all the survey data, we can note that, in general, according to the respondents, the use of the method of appropriate tasks in teaching mathematics in NUS has significant potential to increase students' interest and motivation. However, the survey shows that teachers need to be careful when choosing and using tasks, paying special attention to the interests and level of students' preparation. It is also important to consider diversity in teaching materials in order to make learning as effective and interesting as possible for each student. The importance of aligning the use of appropriate tasks with

the general methodology of teaching mathematics and the characteristics of each individual class also requires teachers to constantly improve themselves and search for new methods and approaches to teaching. This may include participation in professional development programs, sharing experiences with colleagues, and using innovative technologies in teaching, etc.

CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

According to our pedagogical experience and the survey of Ukrainian mathematics teachers, the method of expedient problems is well-known and quite popular in the learning process. This method is appropriate for activating the cognitive activity of NUS students, increasing their motivation to learn mathematics and apply mathematical knowledge in practice. Relevant tasks really help to increase students' interest in new mathematical knowledge and make the acquisition of this knowledge emotionally positive and conscious.

At the same time, the survey shows that only a few teachers tend to create expedient problems on their own, even though they see the need for such tasks for most topics in the school mathematics course. Currently, there is a certain shortage of sources of high-quality expedient problems, as they are present only fragmentarily in textbooks, and it is difficult to find them on the Internet, especially in its Ukrainian-language sector. Therefore, it can be assumed that the community of experts in the field of mathematics didactics is requested by mathematics teachers to create a sufficient number of expedient problems, in particular, to include such tasks in existing mathematics textbooks.

One of the possible answers to this request is the 7th grade mathematics textbook by the NUS team of Oleksandr Shkolnyi, Yevhen Nelin, Andrii Mylianyk, and Yuliya Prostakova, which has been approved by the Ministry of Education and Science of Ukraine for use in the educational process. In this textbook, which is currently being piloted (pilot manuals: Shkolnyi et al., 2023), each item begins with a discussion of a relevant task that motivates students to study the relevant educational material. It is planned to continue to implement this approach in the NUS math textbooks for grades 8 and 9.

Another possible answer to the teachers' request to create a sufficient number of appropriate tasks is separate textbooks with motivational appropriate tasks, which, although infrequently, continue to be published in Ukraine (Voyevoda 2012; Merzliak et al., 2024; etc.), as well as certified courses and publications for teachers on Ukrainian educational resources on the Internet (e.g., MAS, 2024; Vseosvita, 2020; Osvitoria, 2023; etc.). Such manuals and e-resources will to some extent satisfy the need for teachers to have appropriate tasks and will contribute to the proper formation of professional and general competencies of NUS students.

In general, we recommend the widespread use of expedient problems in the study of all topics of the school mathematics course and at different stages of the mathematics lesson in the NUS. At the same time, the selection of appropriate expedient problems should be carried out taking into account the characteristics of the student group and the peculiarities of the methodological style of an individual mathematics teacher. With proper training and self-education, it will not be difficult for a teacher to select such tasks, in particular, using didactic materials that are currently being actively created by specialists in mathematics teaching methods.

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