Organization of an Individual Approach to Teaching Mathematics to Non-Mathematical Pupils Under the Covid-19 Conditions

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Abstract

The problem of teaching mathematics in modern Ukrainian schools is general, but it has become more difficult for students with a non-mathematical background. Despite numerous studies of this problem, no specific recommendations have been made. Therefore, to develop and implement an experimental method of teaching mathematics aimed at activating the cognitive activity of non-mathematical specialties pupils. The goal was solved by conducting a questionnaire among students and teachers, which allowed us to reveal and deepen the aspects of the specified problem. Two groups were created: experimental and control. The experimental group studied according to the new model of education, and the control group - according to traditional methods of teaching mathematics. The study revealed a complex of interrelated problems, both for teachers and students. Among the problems, the lack of motivational mechanisms and a complex pedagogical approach to explaining mathematics and the limited amount of teaching mathematics to students with a non-mathematical background are of primary importance. The results of the study indicate the need to introduce the specifics of conducting classes, which would focus on understanding the subject through imaginative thinking. The need to develop textbooks and manuals, which would focus on a more in-depth and understandable teaching of the subject with exercises and tasks for humanitarian areas, has been proven. At the same time, such measures became urgent due to the introduction of quarantine measures of the Covid-2019 pandemic.

Keywords: mathematical training, students of non-mathematical specialties, cognitive activity, mathematics lessons, abstract thinking, figurative thinking, COVID-19

1. Introduction

Mathematics is a unique subject requiring clear differentiation of pupils. They all have different knowledge, skills, and development, perceive and process information differently, and therefore see mathematics differently. As a result, even in the same class, pupils do not show the same results in mastering the material. The problem of learning mathematics is complicated in the context of Covid-19, as it is necessary to solve the differentiation issue and ensure the possibility of practical remote work. It leads to the need for new technologies that can solve educational and pedagogical problems, considering the specifics of mathematics learning in different groups—using an individual approach following each pupil's personality (Mzomwe et al., 2019; Serdyuk & Tkachenko, 2013). This problem is especially relevant for teaching mathematics to non-mathematical students, who mostly do not have mathematical abilities. Such students do not find its practical application in everyday life and do not plan to connect their future professional activities with this subject. These factors reduce interest in studying math at school. The organization of mathematics teaching for such pupils is complicated. The work occurs in conditions of local contradictions that need to be resolved.

1. The goal of teaching mathematics to non-mathematical pupils is the formation a general mathematical culture of the individual. This involves mastering specific methods of mathematical activity for successful participation in social life. The problem arises from the fact that in non-mathematical classes, the importance of mathematical education is decreasing. As a result, learners only sometimes understand how mathematics can be helpful to them.

2. Mathematics is compulsory for all pupils, including non-mathematical classes. As a rule, non-mathematical

classes study the subject for three hours per week. At the same time, pupils of such classes have a significantly greater workload in studying humanities subjects. This factor reduces motivation to study mathematics, leading to disinterest in mathematical or natural sciences.

3. Non-mathematical pupils often have a negative attitude toward learning mathematics. They are mostly related to prejudice or psychological barriers developed during the years of their previous education. Such negative views do not allow learners to change their attitude toward the subject. Therefore they need to try to understand the essence of the topic and see how mathematics can be used in everyday life or in modelling of professional activities in the future. All of this contradicts an essential task of studying mathematics - the possibility of its use in practice to optimize activities.

4. Students often choose humanitarian specialties because they want to avoid dealing with mathematics. Despite this, many humanities pupils have to pass independent external testing in mathematics with the same tasks as mathematics students. According to the intermediate results, specialty and higher education institutions are chosen. At the same time, mathematics lessons continue even after choosing a humanitarian science. Pupils are forced to attend lectures but keep the average mark at a passing level. As a result, the motivation level and mathematical training of pupils only sometimes meet the expectations of mathematics teachers, creating barriers to the presentation of new material.

It can be concluded that there are contradictions between the need for techniques, technologies and means and the need to activate the interests of humanitarian students in mathematics. Experienced teachers search for methods of motivation to study mathematics by selecting the necessary material, further improving the methodology, tools, and teaching principles. All of these are the subject of further research.

The study aims to develop and implement an experimental method of teaching mathematics aimed at activating the cognitive activity of non-mathematical specialties pupils.

2. Methodology of the Research

Theoretical: analysis of psycho-pedagogical, educational, and normative pedagogical documents, scientific and methodical literature; theoretical analysis of the mathematics lessons organization; classification, systematization, and generalization of lessons; theoretical design and modelling of mathematics lessons for high school students; mathematical statistics methods.

Empirical: pedagogical experiment; monitoring the communication between teacher and student in the classroom (in the learning environment), between students. Communication features between teachers and students of physics and mathematics faculties of pedagogical higher educational institutions. The method of surveying teachers of mathematical disciplines and non-mathematical pupils in questionnaires is used. According to the data collection results, the quality of knowledge in mathematics is analyzed by observing oral answers and using the analysis of written tests.

The methodological basis of the study is formed by the conceptual provisions of the theory of cognition; the concept of secondary education; psychological theories; the theory of the gradual formation of mental actions; the theory of problem and developmental learning; the theory of heuristic learning; the concept of didactics, systemic and structural approaches; modern theories of school mathematics education development; the theoretical basis of the modern lesson structure; the provisions of mathematics teaching methods in the context of digital technologies.

The peculiarities of mathematical education of different pupils' categories are highlighted in the scientific literature. According to the results of a critical analysis of the literature, it is clear that mathematics teachers should pay special attention to setting goals and objectives (Ivanova, 1999; Lovyanova, 2015; Panisheva, 2011; Rakov, 2005; Serdjuk, 2011; Symonova, 2012). At the same time, their activities should involve selecting effective methods and techniques, forms and tools that allow to form and develop the student's cognitive processes and willingness to independent work in the study of mathematics (Aslam et al., 2021; Behlol et al., 2018; Mzomwe et al., 2019). It stimulates pupils' cognitive activity and shows them the necessity of mathematics in life and the possibility of its use in solving standard or non-standard challenges (Blazar & Kraft, 2017; Chang & Beilock, 2016; Devine et al., 2018; Passolunghi et al., 2019).

The joint activity of teachers and pupils in teaching mathematics can significantly increase learning effectiveness. It leads to better performance among pupils. They can work in a favourable psychological background and successfully use mathematical theories in solving practical problems (Mata et al., 2012; Semeraro et al., 2020; Zulkarnaen, 2018). Combining these factors creates the prerequisites for a positive attitude and perception of mathematics as an exciting science.

Statistical information was collected among non-mathematical pupils who attend the final grades of secondary schools in Ukraine. The survey involved 281 people in total.

Before the experiment, psychological testing was conducted to determine the pupils' activity in non-mathematical classes. Then, diagnostic testing was organized to determine the quality of knowledge before the experiment's implementation. At this stage, the main task was to assess the teacher's cognitive interest in mathematics.

At the next stage, the real possibilities of problem-solving of pupils' motivation to learn while studying mathematics were determined. For this purpose, a set of techniques and means of training intensification and tools for developing cognitive interest in mathematics are used. In addition, the study considered the psychological and pedagogical characteristics of students of non-mathematical specialties and the conditions in which the training is conducted.

As a result, two groups of pupils were created: experimental and control. The experimental group studied according to the new teaching model, and the control group studied using conventional methods of learning mathematics. Determining the pupils' activity level at this stage was done using the same methods as at the beginning of the study.

3. Results and Discussion

Pupils taking a non-mathematical course are usually humanitarians. It involves the advanced study of philological and social humanities subjects. In Ukraine, almost a quarter of high school students choose the humanities in their studies. According to the concept of specialized education in Ukraine, approved in 2013, studying in humanities classes creates conditions for quality education through their abilities, needs, interests, and future professional orientation. However, mathematics in humanities classes remains an essential subject and needs to provide in-depth study. Regardless of the choice of professional direction, any student will have at least three weekly lessons. The following objectives determine the content of mathematics education in high school:

1. Pupils can use identical expressions transformations, including power, irrational, trigonometric, and logarithmic. Pupils should solve appropriate equations or inequalities and understand their practical use.

2. During the study of trigonometric, exponent and exponent classes of functions, replenishment of the concept of a numerical function. Pupils should be able to investigate and use the listed functions to describe and investigate processes and phenomena.

3. Acquaintance with differential and integral calculus methods and practical use based on elementary skills.

4. The ability to apply statistical probability models in the process of solving problems in practice based on the skills of recognizing random events, the ability to calculate the probability of events.

5. Applying knowledge about the properties of spatial figures. In the process of solving problems, using the acquired knowledge about calculating the surface area of volumes and figures.

6. Knowledge is formed about mathematical axiomatic theories

In order to study the problems of preparation of non-mathematical classes pupils, a survey of teachers and high school graduates was conducted. A total of 172 teachers and 198 pupils took part in the survey. The observation included the study of not only the pupils' attitude to the subject but also the behavioural patterns of teachers. During the study, observations were made on using teaching experience in teaching mathematics. Respondents were offered several options for answering the questions.

The study results showed that more than half of the teachers do not feel uncomfortable teaching mathematics in non-mathematical classes. Thus, 61.6% of respondents consider such teaching comfortable. At the same time, 35% of respondents feel comfortable working with natural sciences students. Moreover, 21.6% of teachers identify comfortable conditions for working with students who have chosen the economic profile. However, only 10% of teachers report comfortable conditions for teaching mathematics to students of humanitarian profile. More problems arise in teaching mathematics to students of sports and aesthetic profiles. In particular, only 5 % of respondents consider teaching mathematics in such classes comfortable.

We found that about 45% of the respondents determined that it is most difficult to work with high school students. students. 51.6% of respondents note that teaching in sports aesthetic classes is the most problematic. 36.6% - identify humanities classes as problematic. 18.3% - identified the teaching of mathematics as problematic. 10% of respondents noted the problem of teaching the economic profiles pupils. The main difficulties of natural and mathematical disciplines teachers in humanities classes are defined in Table 1.

Table 1. Main Challenges of Studying Mathematical Disciplines by Non-Mathematics Pupils

The question	Number of pupils
It is difficult to teach the material because it is difficult and incomprehensible for pupils	41.6 %
It is difficult to teach the material in a plain language	16.6 %
It is difficult to get pupils interested in their subject: they have a different focus	48.3 %
The textbook for classes of this profile does not reflect its specifics	25 %

Description: compiled based on the author's survey

Analysis of mathematics lessons in humanities classes (Shyshenko & Shvets, 2019) showed the following.

1) Pupils need to pay more attention to homework. In particular, it may be performed incompletely or not performed at all.

2) The purpose and tasks of the lesson is informal, which does not allow students to realize the importance of the topic.

3) When presenting the material, teachers often focus on the possibility of using these methods of mathematical analysis in practice. At the same time, less attention is paid to everyday practical use, while historical events are given more time.

4) Teachers need to pay more attention to the description of problems and the independent work of students.

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3) When presenting the material, teachers often focus on the possibility of using these mathematical analysis methods in practice, focusing less on everyday practical use. At the same time, historical events are given more time.

4) Teachers need to pay more attention to describing the problems and independent pupils' work.

5) Mathematics teachers need to use the software more widely. In particular, presentations are limited, while much more attention is paid to textbooks.

6) The main tasks performed by pupils are primarily reproductive in nature. However, at the same time, there need to be more practical tasks.

7) Only specific teaching methods are used in education, while modern and progressive lessons such as training, seminars, individual tasks, and group methods are rarely used.

8) Control students' knowledge using traditional methods of organizing independent and collected works. At the same time, sufficient attention is paid to other methods of control.

9) In mathematics lessons, teachers often ignore the pupils' psychological state, which does not allow for establishing close relationships between the teacher and the pupil.

In the process of studying of mathematics in non-mathematical classes, the activation of students' cognitive activity occurs under such conditions:

1) High level of emotional stress during the lesson. Students of humanitarian specialties cannot feel comfortable in the mathematics lesson and therefore are afraid to solve problems independently.

2) Pupils are focused on solving problems during theoretical material, and its practical significance is determined.

3) Orientation on the use of the studied materials in everyday life and solving problems of economic, ecological, psychological, linguistic and socio-historical direction.

4) Formation of situations of success in studying mathematics, particularly stimulating positive evaluation of essential tasks for students of humanitarian specialties.

5) Mastering by students the techniques of memorizing educational material, using the iconic and symbolic form of memorization.

6) Formation of self-control skills.

In order to determine the motivation of non-mathematical students studying mathematics, a questionnaire was conducted, and its results are presented in Table 2.

Table 2. Characteristics of Learning Motivation Among Non-Mathematical Specialties Pupils in the process of Mathematics Studying

Motives of learning activity in the process of studying Mathematics	Number of pupils (%)	Number of persons
Requirement of parents, school administration, teachers, classmates, friends	18.2 %	36
To be an educated person who has his own opinion on any issue and is well-informed in many branches of modern science	23.7 %	47
To study successfully and get a certificate with good grades	63.6 %	126
To gain deep and solid knowledge	27.3 %	54
To be always ready for the next lessons	27.3 %	54
Not to lag behind in the study of Science and Mathematics	9 %	18
To ensure successful future professional activity	27.3 %	54
To feel the respect from the teacher	9 %	18
To be an example for classmates, friends	0	0
To avoid punishment for underachievement	45.5 %	90
To get intellectual pleasure	9 %	18
To apply acquired knowledge in professional or daily activities	4.5 %	9
Interest in Mathematics as a science	2 %	4

Description: compiled based on the author's survey

The mathematical competence of pupils refers to both key and subject competencies. Mathematical competence is necessary for all pupils, including non-mathematicians. It should be among the personality qualities and form a set of knowledge that will help to work effectively in various fields of activity. Also, mathematical competence as a subject competence means that humanities pupils gain experience in specific activities that allow them to understand the laws of mathematics and use them effectively in their work. The analysis of the survey results revealed several problems:

1) limitation of the educational process in time. Since mathematics is studied at the usual level in classes with humanitarian profiles, it is not easy to ensure the effectiveness of mathematics lessons having 3 hours a week. Moreover, due to the lack of time to solve practical or non-standard problems, pupils need to gain the skills to apply mathematics in life.

2) lack of motivation for pupils' cognitive activity in non-mathematical classes during mathematics study. In particular, pupils need to be made aware of their learning content and, therefore, cannot determine the purpose of studying the subject and the need for the relevant topic.

3) a negative attitude determines the presence of pupils' psychological barriers when studying mathematics to the subject, which is reflected in difficulties in doing homework and other written work that involves self-directed learning.

4) lack of particular tasks that would allow us to study mathematics in depth. Often, teachers purposely underestimate the information level to increase the overall success rate. At the same time, the solution of training exercises is limited, and more attention should be paid to non-standard or creative tasks.

5) problems of pupils' work evaluation and independent learning caused by low requirements for the presentation of material and evaluation of students' work.

The study determined the psychological and pedagogical features of teaching mathematics to pupils of non-mathematical specialties. Such learners usually have well-developed imaginative thinking but do not develop abstract thinking, which is necessary for solving mathematical problems. For example, they have problems writing them down using signs when perceiving graphs of functions and mathematical formulas. Students need help formulating definitions or proving theorems due to a lack of detailed knowledge in this area. It was also found that senior pupils cannot make a plan for proving a theorem or give the required fragment if necessary. Students of non-mathematical specialties need more extensive explanations during problem-solving and individual teacher consultations.

According to the identified peculiarities, combining the study results into three groups is essential to form a differentiated approach to learning, each of which determines the pupils' knowledge level and motivation for learning. Each group has three additional subgroups; therefore, there are nine such groups, as shown in Figure 1.

Experimental mathematics teaching is carried out by considering the principles of learning differentiation. All educational process stages will be carried out in the future, considering the students' division into these groups. At the same time, forms, methods, techniques, and means of teaching are chosen in accordance with the peculiarities of teaching specific topics. The study shows that the new material should begin with a didactic attitude that allows students to understand the need for such material. As a result, it increases the motivation level for independent and class work.

The study showed that in the lessons on algebra and the basics of analysis, it is most effective to work out the frontal work methods. The most effective teaching method is communication between teacher and student. They allow showing the applied aspects of the new material. In geometry classes, it is essential to pay attention to the use of materials in everyday life, in particular in construction and design.

Figure 1. Groups of Non-Mathematics Pupils at Mathematics Lessons

Description: grouped by the authors for the survey

It was found that at the motivation stage, it is challenging to find an approach for each student, i. e. to impress them with the need to study the current topic. If the student realizes the importance of this issue, the knowledge should be consolidated with practical tasks. The most effective form of educational work is working in pairs or groups under the teacher's guidance. The most effective methods used in learning mathematics are didactic games, the use of emotional coloring of materials, and historical references that interest children best. At this stage, it is advisable to offer long-term homework to solve applied problems that can be used in everyday life, for example, to build a project.

The study proves that it is adequate to determine the goals and objectives of students at the stage of setting goals and objectives, which should be recorded in table form. Such work systematizes knowledge and goals and updates pupils' background knowledge. Pupils need to fill in the self-confidence scale, which is an effective tool to overcome psychological barriers to learning mathematics. Studies have shown that school lectures effectively teach new material in mathematics lessons to non-mathematics pupils.

In the study of new material during the lessons of algebra and basic analysis, the effectiveness of the lesson was proved through the presentation of main problems and the plan for new material presentation. In this way, students can control the perception of the material in different ways, in particular through the creation of a lecture plan, asking questions to the teacher, highlighting unclear points, and drawing up theses, notes, or diagrams. A feature of such a lecture is the separation of individual elements of essential knowledge that can be explained without the use of complex mathematical terminology. The use of examples allows us to understand how applied problems can be solved. In geometry lessons for non-mathematical pupils, it is necessary to take measures to increase attention to research (Rumanová et al., 2020). In this case, making reference notes, performing drawings for theorems, formulating basic statements, and learning how to illustrate them are advisable. An essential component of working with students is illustrating the presented material.

Let us consider the practical use of the above techniques in the example of a fragment of the mathematics lesson "numerical functions" for 10th-grade students of non-mathematical specialties.

A fragment of the lesson "Numerical functions."

The teacher offers his students a choice of several tasks from the practical field of application (Shvets & Prus, 2007; Sokolenko et al., 2010): sociology, economics, ecology, history, linguistics, and sports.

Sociological task as an example. In 1980, about 4.4 billion people lived on Earth. The population growth rate is 1.7% per year. Draw a graph of population change based on this growth. The graph shows the number of decades on the abscissa axis and the population in billions on the ordinate axis. Plan the size of the population in 2015 and indicate what it was. Determine the deviation of the planned indicator from the actual to understand the reliability of the forecast. What will the world population be at the same growth rate in 2050 and 2222? (Shvets & Prus, 2007);

An economic problem example. The relationship between the daily milk yield in liters and the cow's age is given by the function $y = -9.53 + 6.68x - 0.49x2$, with $x \in (2; 12)$. Graph this function and find the age at which the cow will give the most milk (Shvets & Prus, 2007);

The environmental problem as an example. In studying the ecological state of rivers, scientists have found the dependence of the river flow velocity y (in m/s) at different depths $y = 0.958 + 0.13x - 0.225 x 2$, where $x \in [0; n]$, n is the most significant channel depth (in m). Graph this dependence and determine at what depth the river velocity will be the highest (Shvets & Prus, 2007);

Historical task example. Find the data on global gold prices for the last century. Construct a graph of changes in world gold prices depending on the last century and determine if it defines a function. Determine whether there is a time interval that allows building a function.

The linguistic task is an example. Choose your favorite literary work and build a graph for it, which corresponds to Zipf's law of frequencies of words about the frequency of certain words.

Sports task as an example. Find data to predict the athletes' results in weightlifting. Draw a graph of the dependence between the result in the classical lifting of two weights and their weight. Determine the functional dependence. With the graph, determine the number of lifts of two kettlebells of 32 kg if the athlete performed this exercise 118 times with kettlebells weighing 26 kg.

After solving these tasks (optional), the teacher offers to make a notice about the historical information found that relates to the study of this topic. After that, there is communication between the teacher and students, where it is noted that the first steps in forming functions were developed in ancient Babylon (Bevz, 2005). During this period, tables of inverse numbers, their squares and cubes, sums of squares, and cubes of numbers developed. For example, these are tables of values of the functions y = 1/x; y = x2; y = x3; y = x2 + x3.

Different stages of mathematics lessons for non-mathematics pupils should be conducted with group division. For pupils of 1c, 2c, and 3c groups, it is advisable to determine the problem. Then, naming the lesson's topic, the teacher gives an epigraph to the topic, allowing pupils to focus more on the topic.

For example, when studying the topic "Elements of Probability Theory" (11th grade), teachers can take an excerpt from B. Pascal's letter to P. Fermat as an epigraph that shows that many people think that if they have limited knowledge about certain objects or phenomena, they know nothing about them at all. However, this opinion is mistaken. Partial knowledge is also knowledge, and not complete certainty also has some practical value, especially when it is possible to calculate the degree of certainty. The question is discussed whether it is possible to measure the degree of trust or confidence in numbers. The teacher explains that people who gamble professionally know the probability of winning (Bevz, 2005).

For students of groups 1b, 2b, 3a, and 3b, the plan of educational material is announced. In this case, it is formed as questions to which students receive answers during communication with the teacher. As a result, pupils are more actively involved in the process of solving problems that are clearly defined in the plan.

Elements of self-control and self-assessment were used for students of groups 1a and 2a. These students were offered different ways to control the mastering of new material. In addition, it developed the initiative of students to communicate with the teacher. In particular, they asked questions, clarified the material, and formed the skills of self-assessment and perception. When some lecture materials are familiar to students, the teacher allows them to present the material independently. The research has shown that the following methods and techniques were the most effective in geometry lessons, as shown in Table 3.

Table 3. Methods of Teaching Mathematics to Non-Mathematics Students

Group	*Teaching methods and techniques*
1a, 2a	- providing own examples and counterexamples;
	- geometric support for proving theorems;
	- formulation of converse of the theorems, checking their correctness,
	- providing examples and illustrating them;
	- replacement of certain properties in definitions or theorems with other properties and analysis of the obtained statements
1b, 2b, 3a, 3b	- illustration of the studied material in a foreign language;
	- creation of reference summaries;
	- providing drawings for theorems
1c, 2c, 3c	- illustration of the practical application of the studied material;
	- preparation of reports on historical topics;
	- search for connections between educational material and the environment

Description: grouped by the authors for the survey

In the 11th grade, after solving the problem "Determine the number of integer solutions of the inequality $log90(x\text{-}10)+log90(x\text{-}11)\leq 1$", students had the opportunity to analyze the acquired knowledge (Fig. 2) (Drushlyak, 2019). In particular, a hypothesis was put forward about the solutions of the inequality $log90x + log90x \leq 1$, after which it was tested analytically. Such knowledge caused a clear negative because of the student's inability to solve them. However, after the teacher conducted the associative series, the sequence of solving the tasks became clear. Thus, students could focus on their success and understand that even at first sight, complex tasks can be solved by humanities students.

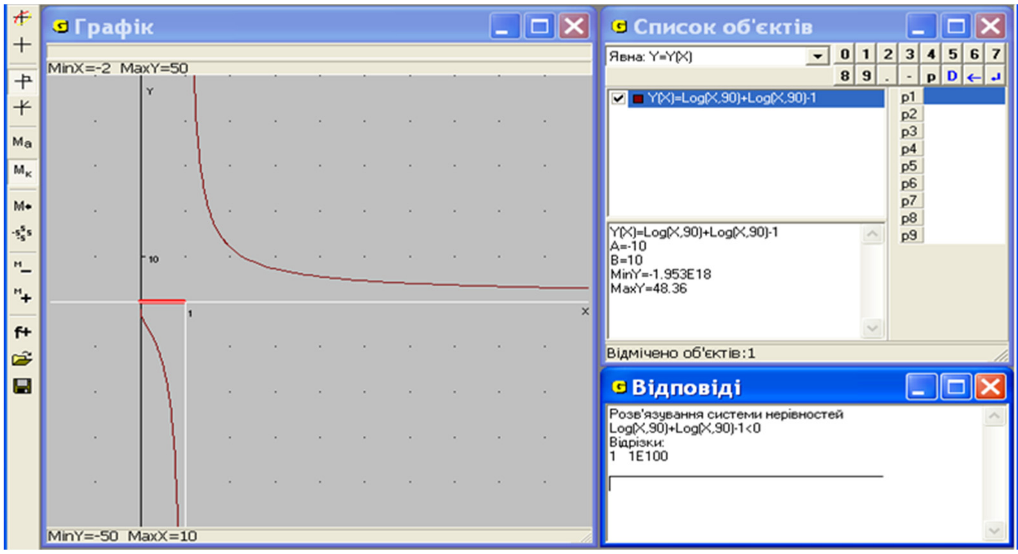

Figure 2. Illustration of the Task

Description: created by the authors

In the process of studying the topic "Derivative and its application" (11th grade), students solved the problem "Find the derivative of the function y = 2x2 - 4x. Based on the results, graphs of both functions were constructed". It allowed them to develop their own task with a non-standard formulation: "In the figure (Fig. 4), graph the functions that are derivatives of quadratic functions, the graphs of which (I, II, III) show the fish in the figure (Fig. 3)".

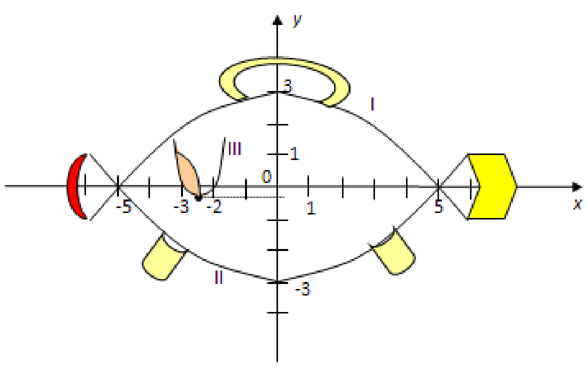

Figure 3. Illustration to the Task

Description: created by the authors

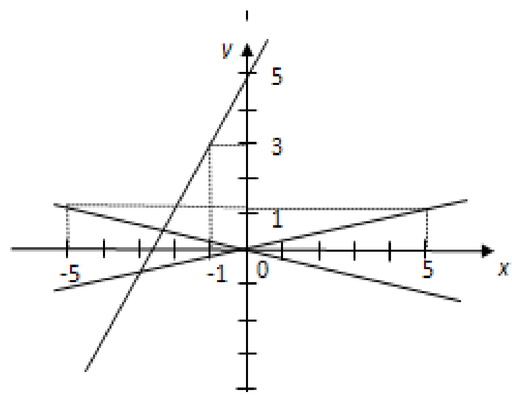

Figure 4. Illustration to the Task

Description: created by the authors

Activation of cognitive skills of non-mathematical students during the study of mathematics should create conditions for forming practical competencies. The main feature of studying mathematics at this stage is the possibility of obtaining knowledge and skills for solving problems and having basic knowledge of the topic. Therefore, it is advisable to use the following techniques in the lesson: filling in the gaps in the problem, which is carried out by filling in the table, giving own examples and searching for errors in the proposed examples, giving counter-examples to the problems presented in textbooks, organizing didactic games, etc.

According to the experiment results, it was found that lessons in skills formation, generalization, and systematization should be conducted in different forms. For example, psychological training lessons, integrated lessons, laboratory, practical lessons, and lessons-conferences are effective. Also, a competition called "Mathematics for All" was held among students.

The study showed the requirements for mathematical tasks for students taking into account the specifics of their learning. In particular, the teacher provided for the variability of conditions and ways of solving problems and determined the role of mathematics in everyday life, where examples from the specialties planned by students were used (Shvets & Prus, 2007; Sokolenko et al., 2010). The proposal of such tasks and their collective discussion prepared the group for the solution and helped them to make the right decision.

The main feature of the control evaluation of the teacher's work is to consider the level of specific mathematical knowledge and the motivation to study the topic. The study proposes a three-level structure of the system of subject control for each topic. Such methods as mathematical dictation, didactic games, and silent questioning ar

The motivation of students to learn should be considered a joint activity of mathematics teachers and students. Their joint work is aimed at overcoming negative attitudes and psychological barriers to mathematics learning, which is determined by the increased activity of students and stimulation of the cognitive process (Shyshenko, 2019).

In determining the cognitive activity level of students, the teacher should rely on such indicators of activity as a positive attitude to the subject, energy, initiative, intensity, emotionality, and success rate. The proposed classification of students' activity levels of non-mathematical specialties contains three levels: low, medium, and high. The main provisions of motivation for cognitive activity were tested experimentally. According to the section analysis results, it was shown that in the experimental classes after the implemented methodology, the activity level increased significantly, as shown in Table 4.

The study used statistical methods of analysis and interpretation. Pearson's criterion estimates the representativeness of the sample. Activity levels in two groups of pupils were compared using Student's t-test in two stages.

At each stage, the sample variance values in the two groups were compared. The following relationship was obtained:

$F = S12 / S22 = 35{,}66 / 30{,}90 = 1{,}154 < F0 = 2{,}014$

The value of Fisher's criterion is lower than the critical level. It allows us to conclude that the dispersion is equal at the significance level of 0.05 Estimated variances have numerical differences due to random coincidences or causes that suggest significant differences in distributions or variances.

Table 4. Non-Mathematics Students' Activity Levels at Mathematics Lessons

Level of activity	At the beginning of experiment				At the end of experiment			
	experimental group		control group		experimental group		control group	
	Number	%	Number	%	Number	%	Number	%
High	8	4.68	12	7.40	54	31.58	9	5.56
Medium	80	46.78	79	48.77	98	57.31	87	53.70
Low	83	48.54	71	43.83	19	11.11	66	40.74
Total	171	100	162	100	171	100	162	100

Description: calculated by the authors

At the next level, the discrepancy between the sample means was assessed. The calculated value of the t-criterion in our case is $t = 2.014 > t0 = 1.96$.

Thus, the significance level is 0.05, so we consider that the alternative hypothesis of a significant difference between the sample results is valid. The difference in total score is not due to chance alone. In the course of the experiment, we confirmed the following pattern: the level of activity in teaching mathematics to non-mathematical students significantly affects the level of cognitive activity. The experiment showed a significantly higher indicator than that obtained by the traditional method.

4. Conclusions

Mathematical education of students of non-mathematical specialties has certain features. For 2/3 of teachers, teaching mathematics to non-mathematical students is traditional and does not pose any difficulties. However, problems with teaching mathematics were noted by teachers who work in the following directions (from worst to best): sports and aesthetic profile; humanitarian profile; economic profile; natural sciences. The problem is compounded for teaching mathematics to high school students. Teachers note students' lack of interest in mathematics for the following reasons: modern mathematics material is difficult for students, modern textbooks do not reflect the mathematical aspects of students' future professional activities; the difficulty of presenting lesson topics to students in a simple and accessible language.

The biggest problem in learning mathematics is the lack of a motivational aspect. Therefore, the vast majority of students study mathematics with the aim of obtaining a certificate with good grades. Almost half of the students note that studying mathematics is a means of avoiding punishments for failure from both parents and teachers. Regarding awareness of the importance and role of mathematics in professional activity and life, only a third of students understand it. The general interest in the subject of mathematics is the lowest among other subjects (2%). In addition, successful mastering of mathematics for students does not bring them personal authority among classmates. Therefore, the study of mathematics in the fields of humanitarian education is carried out exclusively at the expense of the possibility of obtaining additional points.

This situation was complicated by the Covid-19 pandemic due to the fact that the direct possibility of communication between the student and the teacher, which is a determining factor in the study of mathematics, was lost. That is, independent study of this subject for students of non-mathematical fields is problematic and requires considerable time and mental abilities.

The conducted research made it possible to point out the problematic moments in the organization of mathematics education. First, the time limitation (3 hours per week) regarding the saturation of the subject. Accordingly, students are unable to solve practical and non-standard mathematical tasks. Limited time leads to the fact that teachers are forced to reduce the informative content of the subject. At the same time, the professional motive of teachers is to increase the overall success of the class. And this worsens the element of independent mastery of mathematics by students. Secondly, the students' psychological barrier to the subject was formed, which is manifested in the performance of homework and written works. This circumstance was further complicated by the introduction of quarantine measures of the Covid-19 pandemic and led to a decrease in the independent work of students.

The conducted research indicated that students' non-acceptance of non-mathematical classes of mathematics is a consequence of their psychological and pedagogical component, namely, against the background of the development of figurative thinking, a low level of abstract thinking, and pedagogical approaches in teaching mathematics do not ensure the development of abstract thinking. That is why self-organization and motivational aspects in the study of mathematics are so low. Therefore, students of non-mathematical classes need a broader and more in-depth explanation from teachers during lessons.

In general, it should be noted that mathematics teachers should pay attention to accessible teaching in the process of conducting mathematics classes, at the same time, emphasize the use of figurative thinking in understanding mathematical problems and examples, thereby activating the development of abstract thinking. The Covid-19 pandemic has further complicated the problem of teaching mathematics to students in non-mathematics classes. Therefore, the solution to the problem is the adaptation of the developed requirements in mathematics by specialists who have developed imaginative thinking.

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