NEW MATHEMATICS IN THE 9TH GRADE OF THE NEW UKRAINIAN SCHOOL*

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ABSTRACT: *In the article we consider a new approach to studying mathematics in the 9th grade within the framework of the educational reform project "New Ukrainian School". In particular, the methodological features of the mathematics textbook for the 9th grade of the author's team consisting of Oleksandr Shkolny, Yevhen Nelin, Andriy Mylyanyk, Yulia Prostakova are considered. The emphasis is on the fundamental differences of this textbook, which is based on the model educational program of the same authors, from traditional Ukrainian mathematics textbooks for the 9th grade of secondary school.*

KEYWORDS: *New Ukrainian School, competence approach, mathematics, elements of stochastic, financial literacy, combined study of plane and space geometry, geometric transformation.*

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1 Introduction.

The education reform “New Ukrainian School” (hereinafter - NUS) is currently underway in Ukraine [1]. This reform is based on a competence approach to learning and is aimed at turning the student’s face, so to speak, and following the learning process from the needs of his/her personal development. The first step in the implementation of NUS in Ukraine was the creation of State Education Standards for primary school (grades 1-4), basic secondary school (grades 5-9) and senior profiled school (grades 10-12) (see [2], [3], [4]). The next step of the reform is creation a basic educational plan and model programs for each educational field, particularly mathematics. Further, on the basis of model programs, author teams of experts in mathematics didactics create textbooks, manuals and other methodological support for the educational process in the NUS.

For mathematics education field, 2 model educational programs have been created in primary school and more than 10 model programs for basic secondary school, based on which more than 20 textbooks and manuals recommended by the Ministry of Education and Science of Ukraine (hereinafter – MES of Ukraine) have been written for use in the educational process. Our team of authors (Oleksandr Shkonyi, Yevhen Nelin, Andrii Mylianyk and Yulia Prostakova) also created model educational program in mathematics for grades 7-9, and also creates a set of textbooks and guides for this model program (see [5], [6], [7], [8]).

A common feature of the line of mathematics textbooks of the aforementioned author team for grades 7-9 [7], [8], [9] is an innovative style of presenting theoretical material. The basis of this presentation is the problem-based method: at the beginning of *every* paragraph, students (their names are Petryk and Tetianka) communicate with each other and consider a certain life situation that leads them to the need to study the material of the paragraph, and then teachers explain to them how mathematical knowledge and skills help to solve the problems set in the initial dialogue. This method motivates students well to study mathematics.

In addition, the content of textbooks [6], [7], [8] is also innovative, compared to other Ukrainian mathematics textbooks for grades 7-9. Our team of authors, in accordance with the model program [6], introduced the content line “Financial Literacy” into the mathematics course,

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which involves studying simple and compound interests, simple and compound discounts, dated amounts and equations of equivalence of payments in grade 8, as well as studying annuities and life annuities in grade 9. Also, the stochastic content line was strengthened in these textbooks. Previously, in grades 7-9 of the Ukrainian school, stochastics was studied mostly fragmentarily and not at the propaedeutic level. In our textbooks, this study is carried out systematically. In particular, during grades 7-9, students get acquainted with all the main approaches to calculating of random events probabilities (classical, statistical, geometric) and the main stages of statistical research, including the calculation of a system of statistical indicators.

However, even in the traditional content lines of the basic secondary school mathematics course (numbers and expressions, functions and their graphs, equations and inequalities, plane and space geometry), the study of the material is not traditional and has its own methodological peculiarities. This is especially clearly manifested in the 9th grade mathematics course, which we will discuss in more detail later in this article.

2 Research results

So, let's focus on the main methodological features of studying mathematics in the 9th grade of the NUS using the textbook of our author team.

Stochastics. According to the author's approach, in the 7th grade, the concepts of a random experiment, an elementary event, and a random event already known to students are repeated and generalized, as well as the classical approach to calculating the probability of a random event using the formula $P(A) = \frac{k}{n}$, where *n* is a total number of elementary events, *k* is a number of elementary events contributing to the event *A*. There, in the 7th grade, statistical research and its stages are studied (statistical observation, statistical summary, calculation of a system of statistical indicators, identification of patterns and decision-making), as well as a statistical approach to calculating the probabilities of random events. It consists in conducting a series of *n* experiments, in each of which an event *A* can occur. If in this series of experiments this event occurred *k* times, then we can find the relative frequency of event *A* by the formula $\omega_n(A) = \frac{k}{n}$, which is considered to be an approximate value of the probability of event *A* for sufficiently large values of *n*, i.e. we have the formula $P(A) \approx \omega_n(A)$.

Thus, after the 7th grade, students already have a fairly solid understanding of random events and their probabilities. Therefore, in the 9th grade, after studying the topic "Areas of polygons and the area of a circle", it seems quite natural to consider the third and last of the main approaches to determining the probability of a random event – the geometric approach. According to this approach, the probability of random event *A* is calculated by the formula $P(A) = \frac{m(A)}{m(\Omega)}$, where $m(A)$ is a length or area of the event *A*, $m(\Omega)$ is a length or area of the set of all elementary events. It is clear that the probabilities of random events can be calculated geometrically only if all elementary events are equal, and their entire set can be represented as part of a line or plane.

As a result, in the 9th grade of NUS, students who work with the textbooks of our author team receive a complete understanding of all the main methods of finding the probabilities of random events and are ready for further study of stochastics in the senior specialized school. This study, as it seems natural to us, should include information about discrete and continuous random variables, in particular, uniform discrete distribution, geometric distribution, binomial distribution, Poisson distribution, uniform continuous distribution and normal distribution. Also, in the classes of the natural science and physics & mathematical profile of NUS, it would be advisable to study

statistical hypothesis testing, construction of confidence intervals and elements of correlation and variance analysis.

Financial literacy. As already noted, in the 8th grade, in the mathematics course according to the author's program and textbook, students master the initial knowledge of financial mathematics, which complements the mainly humanitarian course "Fundamentals of Financial Literacy", which has been introduced into the educational process in Ukraine since the 2024-2025 academic year. This knowledge includes the classical formulas for simple interest and discounts: $S = P(1 + it)$ and $P = S(1 - dt)$, where P is the initial amount, S is the final amount, t is the time in years, i is the annual percentage rate, d is the annual discount rate. Students are offered mostly simple tasks for using these formulas in real-life situations, similar to those that arise in the lives of Petryk and Tetianka at the beginning of the corresponding paragraphs.

Also in grade 8, compound interest formulas $S = P(1 + i)^n$ are studied. Here P is the initial amount, S is the final amount, i is the interest rate for one conversion period and n is a number of conversion periods. This formula, written in the form $P = S(1 + i)^{-n}$ we also call the compound discount formula. Thus, the concept of a power with a negative exponent learned in the 8th grade finds its natural application in real practical problems of economic content. Further, this information becomes the basis for deriving equivalence equations of two dated sums and series of dated sums that also are studied in the 8th grade.

The 9th grade material summarizes information on financial mathematics in basic secondary school. The topic "Annuities and Lifetime Annuities" is very convenient for this, where both the equivalence equations considered in grade 8 and the formulas for the sum of the first n elements of a geometric progression are used. Thus, as for stochastics, after studying mathematics in grades 7-9 using the author's educational materials, students receive systematic basic knowledge and skills in financial mathematics and are ready for further study in a specialized senior school, especially in classes of economic and financial orientation.

Study of spatial geometry. Since in the 5th and 6th grades of NUS all model programs envisage the study of spatial geometric bodies (cube, rectangular parallelepiped, prism, cylinder, cone, sphere), it would be natural to continue their study in the grades 7-9 as well. However, unfortunately, in the vast majority of programs and textbooks for grades 7-9 of NUS, such study does not take place, which leads to a violation of the didactic principle of continuity and a gap in the knowledge and skills of students related to spatial geometry. As a result of such a gap in the senior professional school, students face significant difficulties during the systematic study of geometric objects in space using the axiomatic method.

To overcome the mentioned difficulties, we offer in our program and textbooks a parallel study of geometry on a plane and in space. At the same time, geometry on the plane is studied on the basis of the axiomatic method, and geometry in space is studied at the propaedeutic level using the students' intuition. We consider nets of polyhedrons and rotation bodies to be the main tool of such study. At the same time, we do not give a strict definition of both the spatial bodies themselves and their nets, relying on the students' intuition. However, since the elements of nets are already flat geometric figures, their properties can be used with a greater level of rigor and justification.

In grade 7, we consider the nets of a cube, a rectangular parallelepiped, a triangular and quadrangular pyramid. Students learn to make models of these geometric bodies from paper, wood and other materials, which contributes, among other things, to the development of their fine motor skills and has a positive effect on the development of their spatial imagination and spatial thinking. At this stage, students also get acquainted with the concepts of the lateral and total surface area of a polyhedron, which creates for them a good propaedeutic effect for studying these concepts in senior profiled school.

In the 8th grade, after studying the circle and their elements, we consider the nets of the rotation bodies – the cylinder and the cone. Students also make models of these geometric solids from paper and other materials and study the concepts of their lateral and full surface. It is clear that these spatial figures are already more complex than polyhedrons, and therefore, to make their models, more complex manipulations have to be performed. But the numerous applications of cones and cylinders in practical human activities and in everyday life well motivate students to such activities and do not usually raise questions about its feasibility.

Finally, the 9th grade becomes the culmination of the whole idea of parallel study of flat and spatial geometric figures. After studying the topic "Areas of polygons and the area of a circle", we consider the areas of the surfaces of the previously studied polyhedrons and rotation bodies – prisms, pyramids, cylinders and cones. In this case, the areas of their surfaces are interpreted as the areas of the nets of the surfaces of these geometric solids. This approach allows us to use strictly proven statements for flat geometric figures as well as for spatial geometric bodies. It is good to motivate students to study this material, since practical problems that require knowledge of formulas for the surface areas of geometric bodies often arise in everyday life. For example, in the textbook for grade 9, Petryk and Tetianka are finding the area of the film from which you can make a greenhouse cover for vegetables, which has the shape of a prism or half a cylinder. We also can find many other similar problems in our routine life, they are given in the system of problems of the author's textbook for grade 9.

Geometric transformations of the plane and their role in the study of functions. Geometric transformations of the plane according to the author's approach in grade 9 are studied at the beginning of the academic year and are important for further study of the material, unlike most Ukrainian mathematics programs, where they are mostly assigned a secondary and illustrative role at the end of the mathematics course. Indeed, since the main algebraic topics of the 9th grade mathematics course are the quadratic function and quadratic equations, the study of these topics should be carried out at the appropriate theoretical level. Currently, in most Ukrainian programs, the construction of a graph of a quadratic function $y = ax^2 + bx + c$ took place using intuitive representations: the graph of already known function $y = x^2$ is in a certain way "squeezed", "mirrored relative to the abscissa axis" and "shifted" to the right, left, up or down. At the same time, the content of the concepts given in quotes was not mathematically substantiated and relied solely on the intuitive ideas of students, supported by a certain number of specific examples. As a result, teachers constantly faced difficulties in students' understanding of the procedure for constructing a graph of a quadratic function.

According to our approach, before studying the quadratic function, it is worth mastering the topic "Geometric transformations" at the appropriate level, where it is shown how to construct images of points during compression or extension to a line, symmetry relative to a line, as well as parallel translation to a given vector. After that, it is natural to teach students to construct graphs of arbitrary functions of the form using geometric transformations $y = f(x) + A$, $y = f(x - a)$, $y = -f(x)$, $y = f(-x)$, $y = kf(x)$, $y = f(mx)$, when the graph of the function $y = f(x)$ has already drawn. It is clear that after such mastery, it is easy to construct a graph of a quadratic function, relying not on the students' intuitive ideas, but on the formed skills.

To achieve the above goal, our team of authors had to make adjustments to the study of topics not only in grade 9, but also in grade 8. Indeed, in order to properly study the topic "Geometric transformations of the plane" using the analytical representation of such transformations at the beginning of the school year in grade 9, it is necessary to master the topic "Coordinates and vectors" in grade 8, which according to other programs is studied in grade 9. Therefore, we replaced the topic "Areas of quadrilaterals and triangles", traditional for other

programs, which was studied at the end of grade 8, with the topic "Coordinates and vectors", and the study of areas of polygons was added to the topic "Area of a circle", traditional for grade 9. Such changes allowed us to implement the methodological approach to studying the quadratic function described above.

We also note that early and more fundamental analytical study of geometric transformations is useful not only for the subsequent mastering of algebraic material, but also in itself. Indeed, geometric transformations are a good tool that is widely used for solving problems in applied engineering, computer modeling of moving objects, in everyday life, etc. Therefore, the change in the role of geometric transformations in the mathematics course of basic secondary school that we propose seems natural and necessary for further applications in senior specialized schools and higher education.

3 Conclusions and prospects for further research

The approach proposed in the article to the study of mathematics in a basic secondary school within the framework of the New Ukrainian School project has passed due approval and was recognized as deserving of approval by the MES of Ukraine. The testing also showed that the students accept our proposed changes well and do not have significant difficulties in mastering mathematics according to our approach. However, the number of students working with our program and textbooks, as well as the short time of implementation of these materials, do not allow us to make a final conclusion about their effectiveness on a statistically significant sample. In the future, we plan to study in more detail the impact of the approaches described in the article on the formation of mathematical and other competences of Ukrainian students.

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