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PROBLEMS OF EXPERT EVALUATION IN TERMS OF THE USE OF VARIATIVE MODELS OF A COMPUTER-ORIENTED LEARNING ENVIRONMENT OF MATHEMATICAL AND NATURAL SCIENCE DISCIPLINES IN SCHOOLS

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The article discusses the concept of mathematical education of pupils of a school and the results of pedagogical research. Being trained to solve the simplest tasks without a deep (thorough) understanding of the meaning of mathematical relationships is not conducive to the development of intellectual abilities and is quickly lost after completing the topic. It is experimentally confirmed that a student aspiring to attain a higher technical education, in addition to computational skills, needs to have an idea about mathematics and its methods, possess logical development, a graphic culture, develop a spatial imagination, independent work skills, the ability, if necessary, to use the appropriate directory to restore specific facts and obtain the necessary information. The research also looks into ways of solving problems with designing the learning environment and elaborating variable models of studying the natural and mathematical sciences with application of certain components of a computer-oriented learning system with the aim of upgrading pupils' performance (a mass model, the main model and the creative model – an advanced level). The structuring of knowledge and the correct correlation of the selected types of knowledge develop the content of profile education, taking into account significant differentiation and the possibility of building an individual educational curriculum for schoolchildren, and also contributes to the filling of the three most important components of the content of profile training: basic invariant, profile variational and additional ones.

Keywords: mathematics, modeling, variation models, computer-oriented learning environment, natural science, mathematics education, pedagogy of variations, engineering, evaluation, intellectual development, multifunctionality

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1. SPECIFICITY OF MATHEMATICAL EDUCATION IN GENERAL EDUCATION INSTITUTIONS IN THE CONTEXT OF REFORMING THE SYSTEM OF EDUCATION

The mathematical education of students in the technical profile classes of education is directed at obtaining sufficient mathematical knowledge by the pupils, the development of skills, abilities and corresponding forms of thinking which are sufficient for:

1) acceptance at the higher education institution chosen by the students;
2) successful studies at the higher education institution.

In addition, the general intellectual development of students is important, i.e., the formation of those cognitive qualities in the process of mathematics training that are necessary for the full-fledged functioning of a person in modern society, for the dynamic adaptation of a person to this society. The main task of mathematical education is to teach the student to learn, to instill the skill of independent work and to develop his/her intellect and creative abilities.

In the process of developing the concept of mathematical education for students of a technical profile, we will rely on its definition: "By mathematical education we will understand the educational process, which is carried out in the course of studying mathematics at all levels of continuous education, in which not only the assimilation of a certain set of mathematical knowledge, skills and abilities occurs, but also the development of students' thinking, the formation of their moral and spiritual culture" (Hrybiuk, 2014). This is directly related to teaching in technical classes oriented to higher technical education institutions, in which the graduate will receive the same set of mathematical knowledge and develop the intellectual abilities, which were discussed in the definition.

"The aim of the carried out research is to determine what knowledge, skills and abilities are sufficient to, on the one hand, allow the student who has come from the usual middle level of comprehensive school to solve the program at a minimum – to enter a university, and on the other hand, to ensure the success of subsequent training" (Hrybiuk, 2016).

The assimilation and development of the above-mentioned knowledge, skills, and abilities should ensure the appropriate development of the student's intellectual abilities. As noted by V.G. Boltyansky and G.L. Glazer (1988), concerning the problems of differentiation of school mathematical education, "there is no »compulsory« set of skills sufficient even for transferring students to the next class. The criteria of assimilation, in their opinion, should serve a certain level of culture and knowledge that ensure the formation of readiness to live and work in the conditions of the scientific and technological revolution, the computerization of modern industry". Verifying mathematical development should not be reduced to the skills and abilities of instructional solving of simple standard tasks.

Training to solve simple problems without a deep (thorough) understanding of the meaning of mathematical regularities does not contribute to the development of intellectual abilities and is quickly lost after the topic is completed (Rubinshtein, 1989). A student who wants to receive a higher technical education, besides computational skills (the ability to perform arithmetic operations with numbers and fractions, perform identical transformations of algebraic and trigonometric transformations), should have an idea about mathematics and its methods, should possess logical development, a graphic culture, a developed spatial imagination, independent work skills, the ability, if necessary, to use the appropriate directory in order to restore specific facts and obtain the necessary information (Hrybiuk, 2010).

According to the classification proposed by V.G. Boltyansky and G.L. Glazer, students of the technical profile can be assigned to the second and third groups, the so-called applied and creative groups. *The second group includes those for whom mathematics will be an important tool in their professional work.* For this category, not only knowledge of mathematical facts, logical thinking skills, spatial representations are important, but also strong skills in solving mathematical problems. *The third group includes those students who will choose mathematics (or related fields of knowledge) as the basis for their future activities.*

The content of existing textbooks does not solve the problem of the content of the school course of mathematics for technical classes, which makes it possible to ensure the fulfillment of the assigned tasks. Obviously, it should have some differences from the mathematical education of students of other profiles. The majority of graduates of technical classes will in the future receive an engineering education, different from a classical, university education. Mathematics classes should have *a more applied nature* and contribute to the development of appropriate types of thinking (*system, design, technical*).

This content of education should provide a systematic transition to a higher level of abstraction in the presentation of mathematical disciplines, sufficient for successful studies at a university. Unlike mathematical classes, the emphasis in teaching should be shifted to the applied direction – toward mathematical analysis and its applications, as well as parts of geometry.

As for the amount of mathematical knowledge, it really depends on the state of mathematical science at the moment. However, the content of school courses should not directly depend on this (Halperin, 1985). “The principle of reasonable conservatism should be shown – it is impossible to transfer directly and rectilinearly the results of the development of mathematical science in the field of school education”.

When formulating the content of the training of students of the technical profile, we will adhere to the general educational doctrine, according to which education should reproduce, in general terms, the development of science.

According to this doctrine, one cannot make sharp leaps in the historical sequence of the material presented. The history of the development of science in many ways determines the stages of the mathematical development of schoolchildren and students. *Let us single out this statement as the principle of historical determinism*, having in mind not the chronological order of mathematical discoveries, but the sequence of the fundamental stages in the development of mathematical disciplines.

It should be recognized that the school mathematics course, sufficient for understanding the first courses of technical universities, leaves schoolchildren (even graduates of classes with in-depth study of the subject) somewhere on the edge of the XVII-XVIII centuries. The course of teaching mathematics in the technical profile class should be built in such a way that during the allotted time of schooling the student can get a holistic view of mathematics and its methods. The basic concepts should be correctly formulated and learned by students so that in the future they are not subjected to radical breakage. It is necessary to reduce the existing "double gap" between school and university mathematics, which was written about back in 1924 by F. Klein.

"When constructing a concept, one should reckon with the fact that the school is not studying science and not even the "basis of science", but something completely different – the subject of "mathematics". In accordance with this, we will approach the formation of the content of the curriculum, the methodology and style of presentation of the teaching material".

The question of which sections should be included in the school course in technical classes is still open. On March 10, 1954, at a joint meeting of the Moscow Mathematical Society's sections on secondary school and technical colleges, a discussion of the proposed draft of a new curriculum on mathematics was held. A detailed draft of a new curriculum for the general comprehensive school was proposed by V.G. Boltyansky, N.Ya. Vilenkin, I.M. Yaglom.

In this project, new sections appeared: "Vectors. The Method of Coordinates" (VIII form) "Geometric transformations" (IX form). The section "Theory of functions" includes such new topics as "Inequalities", "Limits", "The concept of a derivative", "The concept of an integral", "Differentiation of functions", "Application of a derivative" (X form). The section "Complex numbers" was saved in the program.

The concept of the axiomatic method in mathematics was supposed to be given in the final section of the course of geometry. Many of these sections were later either deleted or significantly reduced, as it was considered that the submitted draft of the program does not meet the task of preparing students for technical college, and elements of higher mathematics in the school curriculum are not necessary for technical training. What is needed is developed logic and knowledge of the basic facts.

In accordance with the methodological letter of the Ministry of Education and Science, when creating the author's programs of technical, economic and other profiles, selecting the content of training for profile differentiation, it was recommended to create curricula in subjects that are studied in depth, not fundamentally different from the courses of these subjects in ordinary classes.

In such cases, it was recommended to adapt mathematics through the redistribution of the number of hours devoted to the study of certain topics, i.e. by varying, within certain limits, the depth of the material being studied, by the introduction of expedient additional sections of mathematics. Also, these goals can be achieved by increasing the number of tasks to be accomplished, by conducting individual homework assignments and practical work.

Taking into consideration the fact that during several centuries the methodology of teaching mathematics has accumulated a large number of tasks that have passed the test of time, it is possible to select for each topic a sufficient number of examples and tasks of different difficulty levels, the solution of which will allow each student (according to the level of his/her preparation) to move towards the stated goal – maximal intellectual development (Hrybiuk, 2014).

Personal experience in teaching at the university made it possible to identify a number of topics that are not included in the general school curriculum, but which are appropriate for students studying in the technical profile due to their role in secondary education, studying and applying them in the process of further education at the university and considering the age of students. The following topics were highlighted (Hrybiuk, 2007):

1) “The Method of mathematical induction” as one of the most important methods of proof, is quite often used in university courses on “Mathematical Analysis,” “Analytical Geometry,” “Linear Algebra” etc.
2) Newton's binomial formula and polynomial formula, elements of combinatorics are quite useful in the university courses of “Mathematical Analysis” and “Probability Theory”.
3) In the process of investigating functions, it is necessary to teach schoolchildren to draw sketches of graphs, both with the use of a derivative and without using it. In particular, in the mass model it is sufficient to restrict oneself to the method of elementary transformations of graphs of functions, and in the rest models it is useful to justify the method of constructing sketches of graphs by adding, subtracting, multiplying and dividing the ordinates of the points of the graphs of the original functions.
4) “Elements of mathematical logic.” Within this topic it is desirable to acquaint students with the methods of constructing the negation of utterances and basic operations on utterances, with the concepts of direct, inverse, opposite direct, and opposite inverse theorems.
5) “The Limit of a Sequence” and “The Limit of a Function”. It is necessary to state that in the first of these topics, the properties of the limit of a sequence (arithmetic properties, uniqueness of the limit in a convergent sequence and its limitations) can be proved strictly by using the definition of infinitely small sequences. When discussing “The Limit of a Function” with the technical profile students (within the framework of the mass and basic model) the proof of

arithmetic properties of the limit of a function need not be done strictly, instead it is recommended to draw analogy with the topic of "The Limit of a Function." Within the framework of the advanced model, the topic can be studied in its entirety using the mathematics of logic.

6) When studying "Integral calculus," it is sufficient to give examples which do not require a thorough mastery of the methods of substitution and integration by parts (within the framework of the mass model these questions should not be touched upon at all) since they are not used widely enough in geometry and physics courses at schools, while in the courses at higher institutions they are allotted a sufficient amount of time for better understanding by students.
7) The topic "Polynomials" requires a greater amount of knowledge. Accordingly, it requires knowledge of the roots of a polynomial, knowledge of the Viet's generalized theorem. Additionally, within the framework of the advanced model knowledge of Cardano's and Ferrari's formulas is useful as well.
8) The topic "Complex numbers" (within the framework of the basic model and advanced model) finds wide application in all higher education courses in mathematics and physics beginning from the first course.
9) The topic "Differential equations," which is of an applied nature, develops mathematical modelling skills.
10) "Sections of Polyhedrons," "Geometrical constructions in the plane and in space," "Loci in the plane and in space" are important for the development of spatial imagination.
11) "Trihedral angle" with the derivation of the cosine theorem and theorem of sinuses for a trihedral angle.
12) "Cross and mixed product of vectors" (within the framework of the basic and advanced model) and the related topic "definers of the second order".

In addition, within the framework of the advanced model, when there are available teachers with an appropriate level of training, it is possible to study such topics as elements of higher algebra (modular arithmetic, binary relations, groups, rings, fields); stricter study of the parts of mathematical analysis; in Geometry – Hilbert axiomatics, elements of projective, spherical and non-Euclidean geometry.

It is necessary to state that in the letter of the Ministry of Education and Science it is recommended, in accordance with the overall objectives of teaching mathematics, to include in the curriculum of all teaching profiles the following parts: real and complex numbers; elementary functions; derivative and integral; arrangement of straight lines and planes in space; polyhedrons and solids of revolution; volumes.

The above material is imposing additional requirements to the field-specific pre-training of technical students, to their computation skill levels, inadmissibility of systematic decline in the requirements, imposed to the knowledge and skills of the students (Hrybiuk, 2015). Counting skills are also required in the process of teaching and during entrance examinations and finally for the engineer. As far back as the 19th century, the Swiss teacher J.H. Pestalozzi pointed out the great importance of arithmetic and all the branches of mathematical knowledge for the mastery of other school subjects, the interconnection of school subjects, including inside the mathematic disciplines. For instance, ignorance of arithmetic will lead to difficulties in learning geometry, drawing and other subjects.

2. THE PARAMETERS OF THE DIAGNOSTIC TASK OF THE TEACHING AIM

To characterize the requirements for the students' level of knowledge and the evaluation of the curricula of mathematical education in the conditions of profile teaching the suggested by V.P. Bespalko parameters of describing the experience of learners' activity will be used (Bespalko, 2002).

We will use the following parameters (Table 1): "the level of mastery, the scientific contents (the stage of abstraction, the awareness of learning, the stage of mastery (automatization))" (Hrybiuk, 2013).

Table 1. The Parameters of the Diagnostic Task of the Teaching Aim

1. The level of learning (α)	The 1st level (α=1)	*Activity of recognition*. The goal is given in the task together with the situation and actions for solving it. The student must make a conclusion about the conformity of all three components of the task.
	The 2nd level (α=2)	*Reproductive algorithmic action*. The goal and the situation are given in the task. The student is required to apply the previously learned action to solve it.
	The 3rd level (α=3)	*Action of heuristic type*. The goal is given in the task, but the situation is not clear. The student is required to add (or define more precisely) the situation and to apply the previously learned action for solving the given non-typical task.
	The 4th level (α=4)	*Action of creative type*. The goal of activity is given in the task in general form. The student is required to define the situation and action, which leads to its achievement.
	The quality of mastery $K_\alpha = \frac{\alpha}{p}$, *where p is the number of the essential actions, leading to the solution of the test and α is the number of correctly performed operations.*	

2. The scientific level of the subject (the stage of abstraction (β)	The phenomenological stage (β=1)	A descriptive statement of facts and phenomena; making a catalogue of objects, a statement of peculiarities and qualities; the use of everyday natural language.
	The analytical synthetic stage (β=2)	A qualified explanation of nature and the peculiarities of objects. The possibilities for the prediction of further development and possible results of the watching phenomenon are created. Scientific language with its notions, symbols and definitions is created too.
	The prognostic stage (β=3)	The explanation of the phenomena of the given sphere with creating the theory of quantity, modeling of main processes, analytical presentation of laws and properties with possible prognosis of terms and quantity of the results of the phenomena. The developed language of this science is created.
	The axiom stage (β=4)	The explanation of the phenomena with the help of the usage of an alliance of high level. An exact and long-term prognosis and explanation is possible. The intersubjective language of science is created.
	The coefficient of scientific character $K_\beta = \frac{\beta_ф}{\beta_m}$, where $\beta_ф$ is the real stage of abstraction with the help of which the process of teaching is held, β_m is the stage of abstraction achieved in the branch of science, which leads to the appearance of the educational subject.	
3. Degree of automation of learning(τ)	***Coefficient of mastery*** $K_t = \frac{t_{cp}}{t_{уч}}$, where t_{cp} is the control time given for performing the test, $t_{уч}$ is time spent by the students on performing the test.	
4. Quality of learning– "awareness" (Υ)	First degree *(Υ=1)*	For argumentation of the orienting basis of actions, information from the studied subject is used within which the problem arises.
	Second degree *(Υ=2)*	For argumentation of the orienting basis of actions, information from one or some disciplines close to the subject under study is used.
	Third degree *(Υ=3)*	For argumentation of the orienting basis of actions, broad subject connections from different disciplines are used.
	Coefficient of awareness $K_\gamma = \frac{\gamma_{уч}}{\gamma_ц}$, where $\Upsilon_{уч}$ – degree of awareness of learning of the material by students, $\Upsilon_ц$ – degree of awareness of the purpose of learning.	
5. Durability of assimilation (T_p)	***Parameter of strength of learning*** T_p is identified as the duration of preserving in memory the learned images from the end of training to the moment of their reproduction with the quality indicators (α and β).	

Source: own work.

The taxonomy of educational objectives is essentially a realization of the idea of a diagnostic formulation of goals. All of them tend to avoid instructions about the content of training. Many of them, specifying the goals of education, highlight levels of mastering the educational material that can be achieved by the student as knowledge is acquired.

It is known that in the cognitive field there are quite a lot of approaches to the allocation of levels of mastering the educational material. A comparison of the levels of assimilation described by different authors is given below (Table 2).

Table 2. Levels of assimilation of learning material

B. Blum	**Simonov V.P.**	**Koroleva V.G.**	**Bespalko V.P.**	**Maksimova V.N.**	**Skatkin M.N.**
1. Meaning	1. Differentiation	1. Reproductive self-reproduction	1. Student (recognition activity)	1. Recognition	1. Reproduction of concepts
2. Understanding	2. Memorization	2. Reproductive algorithmic action	2. Algorithmic (solution of typical tasks)	2. Memorization	2. Recognition of concepts
3. Application	3. Understanding	3. Productive heuristic action (or application level)	3. Heuristic (action choice)	3. Understanding	3. Application of concepts
4. Analysis	4. Elementary skills	4. Productive creative action	4. Creative (action search)	4. Application 4.1. Thematic generalization 4.2. Subject generalization 4.3. Interdisciplinary generalization	4. Concept system reproduction
5. Synthesis	5. Transferring				5. Concept system application
6. Evaluation					

Source: own work.

3. PRINCIPLES OF FORMATION OF THE CONTENT OF MATHEMATICAL EDUCATION IN THE CONTEXT OF PROFILE LEARNING

In the formation of the content of learning and in its implementation in practice, one should start from the goals of teaching mathematics and the conditions under which it can play its significant role in solving the problems of general education. The whole structure of mathematical education should be based on ideas and methods of modern mathematics, which are desirable to acquaint students with, based on the goals and objectives of teaching mathematics in the context of profile learning (Hrybiuk, 2015). At the same time, these ideas and methods should be included explicitly in the content of instruction and their assimilation should become a direct goal of the students' learning activities. As students progress in learning, ideas and methods are unfolded, enriched, filled with new content.

These ideas and methods form the core of the whole content of teaching mathematics. The remaining contents of the school course should act as a concretization and application of these ideas and methods.

Let us study the content of mathematical education in profile learning, which is the most important component of all pedagogical systems, and the principles of its formation.

In practice, several basic principles of the developed concept are singled out, which are also relevant for the formation of the content of mathematical education in profile learning (Hrybiuk, 2013).

- Principle of priority. Issues related to the content of general secondary education have an undoubted priority in the system of general education, since it is the content that sets the activity of students and fully states the goals, the structure of the school, the training of teachers, etc.
- Principle of goal setting. The goal of general secondary education is the upbringing of students on humanistic culture (promoting the full disclosure of the natural potential of students taking into account their personal qualities, inclinations and abilities, etc.). For the first time in the history of national education, priority is given to the interests of the individual, rather than to the interests of the state.
- The principle of uncertainty. Human education is a random process that is influenced by two main factors: individuality (defined by natural inclinations and gradually formed growth) and the educational environment. The results of education cannot be guaranteed; we can only increase the probability of their achievement due to the improvement of the educational environment.
- The principle of completeness. The content of general secondary education should create a complete system that allows the graduate of the school to begin

an independent, dignified and confident life in accordance to the system of the modern world and the norms of society.

- The principle of minimum. The core of the content of general secondary education contains only necessary elements of culture.
- Principle of activity. The content of general secondary education is formed on the basis of analysis of the leading types and methods of human activity.

In the case of profile learning, one can hardly agree with the principle of uncertainty. In the case of profile learning, the problem is that education should not be an accidental process, but the very process that guarantees the planned result.

The principles of formation of the content of the profile of mathematical education are set out below:

- the principle of lifelong education;
- the principle of continuity;
- the principle of differentiation (individual, allowing students to obtain mathematical training of different levels in accordance with their individual features, and profile, i.e., the choice of mathematical education in the senior classes);
- the principle of reasonable conservatism;
- the principle of the target (the content includes material that meets the goals and objectives of the society);
- the principle of a minimum (the core of a general secondary education contains the most necessary elements of culture);
- the principle of systematic and systematicity;
- the principle of concentricity (it underlies the possibility of examining substantive questions at different levels of rigor and returning to them, taking into account the change in the level of motivation of students, determined by their age characteristics and capabilities, the content of sensitive periods of development of intellectual qualities, the definition of the "zone of proximal development");
- the fundamental principle of the choice of content;
- the principle of completeness (it assumes the inclusion of additional education on the content, apart from mathematical and methodological knowledge);
- principle of visibility.

The content of teaching math should provide:

- maximum opportunities for organizing high-grade mathematical activity of students (intellectual capacity);
- the realizability of learning the curriculum knowledge by all students in conditions of a developed level and profile differentiation and the limited amount of academic time due to a combination of external factors (differentiated realizability);
- maximum opportunities for the formation, maintenance and development of interest to the study of mathematics at each stage of learning (cognitive capacity);

- identification of mathematical and general intellectual abilities of students with the purpose of their reasonable orientation to the profile of learning and the choice of specialty (diagnostic and prognostic capacity);
- the possibility of studying other school subjects at the modern level of development of the relevant sciences and teaching methods.

In accordance with the emphasized above structural units in the system of educational institutions, we will consider how they can fulfill the contents of a mathematical education.

In the educational curriculum of the secondary school an increase in the level of mastery of the material is expected, the content is supplemented by sections or individual topics of the course of elementary mathematics that do not require the presentation of a transition to a higher stage of abstraction, the presentation of the basic material at a higher stage of abstraction, the inclusion of new sections, step abstraction in comparison with the traditional course of school mathematics (this approach is traditionally called "in-depth"),

In the educational curriculum of profile classes with in-depth study, an increase in the level of mastery of the material, replenishment of content at the expense of sections or individual topics of the course of elementary mathematics that do not require the presentation of a transition to a higher stage of abstraction is expected (this approach is traditionally called "expansion"). The use of an extensive approach to content formation mainly aims at the following goal: to achieve continuity of the educational curricula of the school and universities, both in content and in ideology.

The mathematics curriculum for secondary schools and profile classes should be designed so that schoolchildren have a holistic view on mathematics as a science, so that algebra, mathematical analysis, geometry and its elementary sections are not perceived by students as disjointed subjects, so that their inseparable connection and interpenetration is visible.

4. VARIATION AS A PEDAGOGICAL PERSPECTIVE FOR CLASSROOM INSTRUCTION. FOUR TYPES OF KNOWLEDGE TO DETERMINE THE PROFILE OF STUDY

In the educational curriculum of the pedagogical system of the third type, the content elements are indicated by the basic curriculum, additional time is devoted to mastering the experience of solving heuristic problems, acquiring skills, increasing the level of awareness of possession of the material.

The strategy for the implementation of profile training presupposes the allocation of general education and profile levels (Fig. 1). The first is to ensure the formation of general functional literacy and culture of students, their socialization, the creation of a solid base for profile education (Hrybiuk, 2006).

The didactic problem of determining the correct correlation between the profile and the general educational level requires a solution.

One way to solve this problem is to define the characteristic structural units in the content of the school course of mathematics and to associate them with the corresponding level of study profile (Fig. 1). A comparative analysis of the programs of all the above-mentioned types of classes was carried out for this purpose, which allowed us to define "knowledge" as structural units and to distinguish among them the following types:

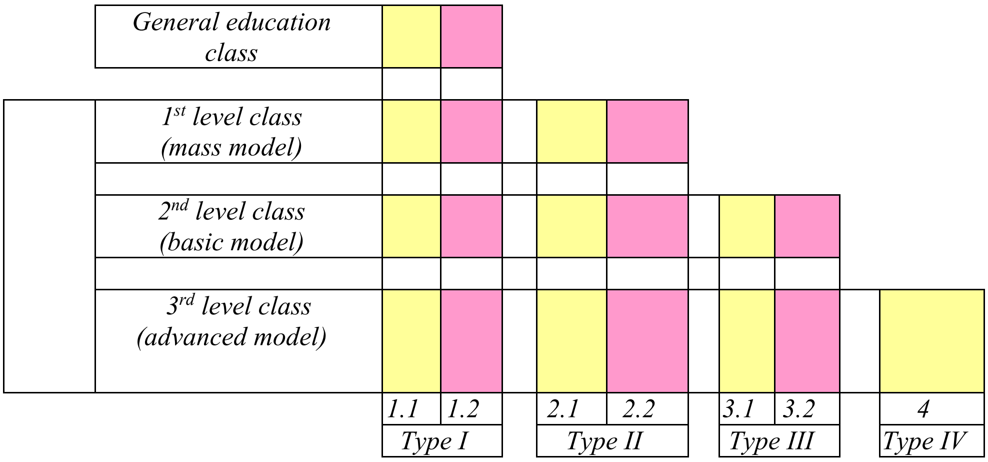

Fig. 1. Four types of knowledge to determine the profile of study. Source: own work

1. Knowledge that includes the obligatory minimum content of secondary (full) general education, which can be subdivided into two subtypes.

1.1. Knowledge common for all dedicated classes, the learning degree which doesn't depend on the class level. This is general mathematical knowledge (main terms and definitions, notions and mathematical methods) that every senior student should obtain at secondary school.

1.2. Knowledge common for all dedicated classes, the learning degree which increases with the profile degree of the class. It can be reached due to expansion – solving more math problems using different methods and it belongs to the elementary branches of mathematics (Geometry, Algebra, and Trigonometry).

2. Knowledge that takes into consideration the profile of the class, there is no need for in-depth learning of the subject. Among it we also distinguish 2 types.

2.1. Knowledge that every student should have to successfully pass the entrance exam at a university. It is obtained by the mathematics curriculum for prospective students.

2.2. Knowledge necessary for further studying at a technical university, which provides the continuity of education at school and university. It means the right formation of basic mathematical concepts at school, the awareness of formulas and different methods of elementary mathematics. The learning degree of this type of knowledge increases with the level of the profile of the class due to expansion, i.e., solving lots of math problems by means of different methods, systematization and generalization of the material, including the logic of its courses, material of an applied and multilevel nature which creates the conditions for the differentiation of work and the development of interest in mathematics.

3. Knowledge oriented to the profound learning of mathematics and detailed consideration of some issues which are beyond the curriculum of general education, which logically complete and clarify the study of the main material.

3.1. Knowledge necessary for the right formation of basic mathematical concepts and mastering additional areas and methods of mathematics. As a rule, the curriculum at university doesn't provide much time to this problem, but students have to obtain such knowledge (e.g. method of mathematical induction, Newton's binomial theorem, etc.). In general, we deal with knowledge requiring no mathematical preparation.

3.2. Knowledge oriented to the expanded learning of basic mathematical concepts, mastering additional areas and methods of mathematics, and learning some issues which probably won't be studied at university, but they obviously promote the development of mathematical culture.

4. Knowledge oriented to in-depth study of mathematics, contributing to professional mathematical training, studying additional sections of geometry and methods of mathematical analysis and solving research problems. This knowledge reflects the particularity of mathematical activity and the requirements for a specialist in mathematics in various fields of activity.

The structuring of knowledge and the correct correlation of the selected types of knowledge develop the content of profile education, taking into account significant differentiation and the possibility of building an individual educational curriculum for schoolchildren, and also contributes to the filling of the three most important components of the content of profile training: basic invariant, profile variational and additional ones. During the last ten years, various models of (extended and advanced) mathematical education have been developed and implemented in practice according to the profile classes of several types of general education institutions.

Statistical analysis, the results of which are presented in the study, gives grounds to insist on the need to increase the number of natural-mathematical profile classes. To preserve and strengthen the level of engineering education, higher education institutions need to increase the quality of trained specialists and the number of professionally-oriented entrants in the context of today's realities. In the process of formation of the content of training and its implementation in practical activities, it is necessary to take into account that students who choose a natural-mathematical profile are significantly different in their level of intellectual development.

The research uses methods for conducting experiments in school diagnostic practice on the definition of students' intellectual abilities, including the results of the experiment which are analyzed on the basis of L. Termen's experimental studies. Based on the results of the experiments mentioned above, it can be stated that the number of gifted students in any field of activity is 10-15%, while 15-20% is a group of schoolchildren who are slow-learners and have a low level of knowledge. Concerning engineering mathematical training, it is necessary to focus on the average group of students, which can also be divided into several levels: above average, normal or average.

Obviously, within these groups the content of the proposed mathematical education should vary significantly. The knowledge that some children learn with difficulty, for others – is insufficient. Undoubtedly, the motivation decreases when the learning process is too complicated, that is, in cases when the intellectual abilities do not allow us to overcome the proposed training content, or vice versa. In the latter case, the child's development process slows down. As a result, there is a need to develop variational models of mathematical education for students of natural-mathematical, technical profiles that differ in content, methods of teaching, etc. The testing of students, which was conducted for several years in the process of teaching students to monitor their quality of knowledge, lets us distinguish several groups of students (Hrybiuk, 2018).

The first group consists of students (15.7% of the total number of students enrolled in profile classes), who scored less than 10 points on the test. Based on the results of practical exercises, the students of this group have difficulties in the process of mastering the curriculum, most of them eventually continue their education in ordinary classes and after graduating they enter higher education institutions.

The second group consists of students (42.3%), who scored from 10 to 15 points on the test. Students of this group do not have well-formed computing skills, do not outstand with singularity of thinking, but in the process of systematic and gradual training they were able to master the basic level curriculum and an additional specific component part. They are able to work well if their actions are algorithmic. In the future, about 70% of the graduates of this group enter technical higher education institutions.

The third group consists of students (24.6%), who scored from 16 to 18 points in the testing process. These students have mastered the curriculum of secondary school fairly well, but for their further development it is necessary to develop their logical and creative thinking. Mostly all of them enter the chosen higher education institutions.

The fourth group consists of students (17.2%), who scored more than 18% during testing. This group represents the most prepared section of students who have come to profile classes. They show considerable interest in mathematics. All of them (100%) enter the chosen leading higher education institutions.

5. CONCLUSION

On the basis of the analysis given above, three models that represent various options of mathematical education for students in high school of the natural sciences, mathematics, and technical profile are considered and levels of immersion in the subject are suggested: a mass model (for students in the second group), the main model (for students in the third group) and the creative model – an advanced level (for students in the fourth group).

It should be noted that one of the ways and methods of solving the problem of increasing the level of schools' natural and mathematical education is the formation of a new list of facilities and equipment for biology, chemistry, physics, mathematics and computer science studies, and providing these classrooms with modern educational equipment. Undoubtedly, the interest of students in engineering research activities, the synergistic combination of engineering knowledge with fundamental interdisciplinarity, the development of new scientific and technical ideas will help create the necessary conditions for increasing the motivation of young people. This includes pedagogically-balanced applications of information-cognitive technologies and updated pedagogical approaches in the teaching and education process. Our children will enter a world with various problems, so a synergistic combination of science, education and technology is needed to solve vital problems.

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PROBLEMY EWALUACJI EKSPERCKIEJ W ZAKRESIE WYKORZYSTANIA W SZKOŁACH WARIATYWNYCH MODELI KOMPUTEROWEGO ZORIENTOWANEGO ŚRODOWISKA UCZENIA SIĘ MATEMATYKI ORAZ PRZEDMIOTÓW ŚCISŁYCH I PRZYRODNICZYCH

Streszczenie

Omówiono koncepcję edukacji matematycznej uczniów szkoły oraz wyniki pedagogicznych badań naukowych. Wyćwiczenie w rozwiązywaniu najprostszych zadań bez głębszego (świadomego) rozumienia sensu zasad matematycznych nie sprzyja rozwojowi zdolności intelektualnych i jest szybko zapominane po zakończeniu przerobionego tematu. Uczeń zamierzający uzyskać wyższe wykształcenie techniczne oprócz nawyków obliczeniowych powinien zdobyć wiedzę o matematyce i jej metodach, osiągnąć rozwój logiczny, kulturę graficzną, rozwiniętą wyobraźnię przestrzenną, nawyki samodzielnej pracy, umiejętność pozwalającą, w koniecznym przypadku, skorzystać z odpowiedniego źródła w celu ustalenia konkretnych faktów i otrzymać niezbędne informacje. Strategia realizacji nauczania profilowanego przewiduje oddzielenie poziomu ogólnokształcącego od poziomu profilowanego. W badaniu zostały również omówione sposoby rozwiązania zadań projektowania środowiska uczenia się i tworzenia modeli z zastosowaniem poszczególnych składników komputerowo-zorientowanego systemu kształcenia w celu poprawy wyników uczniów. Przeprowadzona strukturyzacja wiedzy i prawidłowe zestawienie wydzielonych typów wiadomości pozwalają na opracowanie treści nauczania profilowego, zakładającego znaczne zróżnicowanie i możliwość ułożenia dla uczniów indywidualnego programu nauczania (model masowy, model podstawowy i model twórczy – wyższy). W badaniu biorą udział metodycy w celu przeprowadzenia eksperymentów w szkolnej praktyce dla określenia zdolności intelektualnych, rezultaty są również analizowane na podstawie badań eksperymentalnych.

Słowa kluczowe: matematyka, modelowanie, wariatywne modele, inżynieria, edukacja matematyczna, komputerowo zorientowany system kształcenia, nauki przyrodnicze, pedagogika, rozwój intelektualny, ewaluacja, wielofunkcyjność