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The Use of Different Methodological Approaches to Teaching Mathematics at Secondary Level

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***Abstract*—**The article describes methods of preparation of future teachers that includes the entire diversity of traditional and computer-oriented methodological approaches. The authors reveal how, in the specific educational environment, a teacher can choose the most effective combination of educational technologies based on the nature of the learning task. The key conditions that determine such a choice are that the methodological approach corresponds to the specificity of the problem being solved and that it is also responsive to the individual characteristics of the students. The article refers to the training of students in the proper use of mathematical electronic tools for educational purposes. The preparation of future mathematics teachers should be a step-by-step process, building on specific examples. At the first stage, students optimally solve problems aided by electronic means of teaching. At the second stage, the main emphasis is on modeling lessons. At the third stage, students develop and implement strategies in the study of one of the topics within a school mathematics curriculum. The article also recommended the implementation of this strategy in preparation of future teachers and stated the possible benefits.

***Keywords*—**Computer-oriented approach, traditional approach, future teachers, mathematics, lesson, students, education.

I. Introduction

THE transition to the new Federal State Educational Standard necessitates the creation of a modern information-educational environment (IEE) within an educational institution, which includes a whole range of information educational resources. The IEE is designed to provide, among other things: information - methodological support of the educational process; its planning and resource support; monitoring and recording progress and results. The establishment of an effective and creative environment largely depends on the competence of the staff of the educational institution in solving professional problems with the use of ICT.

Numerous fundamental and applied research in the field of computerization of education [1], [2], [12], [14] show that the introduction of information technology in the educational process can, properly structured, significantly contribute to improving the effectiveness of learning at all its levels and profiles (intensification and individualization of the learning process, expanding opportunities for visualization and dynamization of content). Nevertheless, a number of works have noted that the spontaneous use of such technologies without clear frameworks and objectives can have a significantly adverse effect on student performance and well-being. This is particularly pertinent to the process of teaching mathematics in secondary school. Pedagogical literature describes the potential advantages of electronic educational tools and software over traditional methods of teaching mathematics [5], [7]. However, in practice, for beginner mathematics teachers, the use of electronic tools in the study of this discipline often boils down to the irrational fragmentary application of individual programs, without a cohesive strategy of interaction with traditional teaching methods. This clearly demonstrates the need for purposeful work on the preparation of future mathematics teachers to ensure the realization of the best of both worlds.

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II. Methodological Approaches and Instrumentation

To solve this problem, it is necessary to clarify the ideas about the methods of training within the framework of our research to prevent dysfunction between traditional and computer-oriented methodological approaches [2], [13]. The features of training for teachers to ensure a rational combination of traditional and computer-oriented approaches that are acceptable in this particular learning situation can be presented in the form of an appropriate model (Fig. 1) [6]. The model is based on the joint activity of the teacher and students. In this model, each teaching method is represented in the form of an ordered triad of characteristics. In accordance with [9], [15], the teaching method is characterized by an ordered triad of characteristics: the dominant nature of goal-forming (external, mixed or internal - A_1, A_2, A_3); orientation toward a certain degree of correlation of the various forms of material representation corresponding to a particular cognitive substructure of thinking (minor, medium or high - I_1, I_2, I_3), and also to a certain level of generalization of the assimilated content (low, medium or high G_1, G_2, G_3). The specified parameters can be used as reference points for the description of various educational technologies at all levels of the educational process organization. Description of the characteristics considered is presented in Table I. We used this approach in [4], [10], [12] to describe motivationally oriented learning technologies for training, monitoring, information retrieval and reference, demonstration and modelling software.

As a result, this triad correlates ($A_1I_1G_1$, $A_2I_2G_2$ and $A_3I_3G_3$) with the typology of electronic educational tools, on the basis of which a two-dimensional representation of the teaching method is constructed, which includes all the diversity of traditional and computer-oriented methodological approaches.

The proposed classification is shown in Table II.

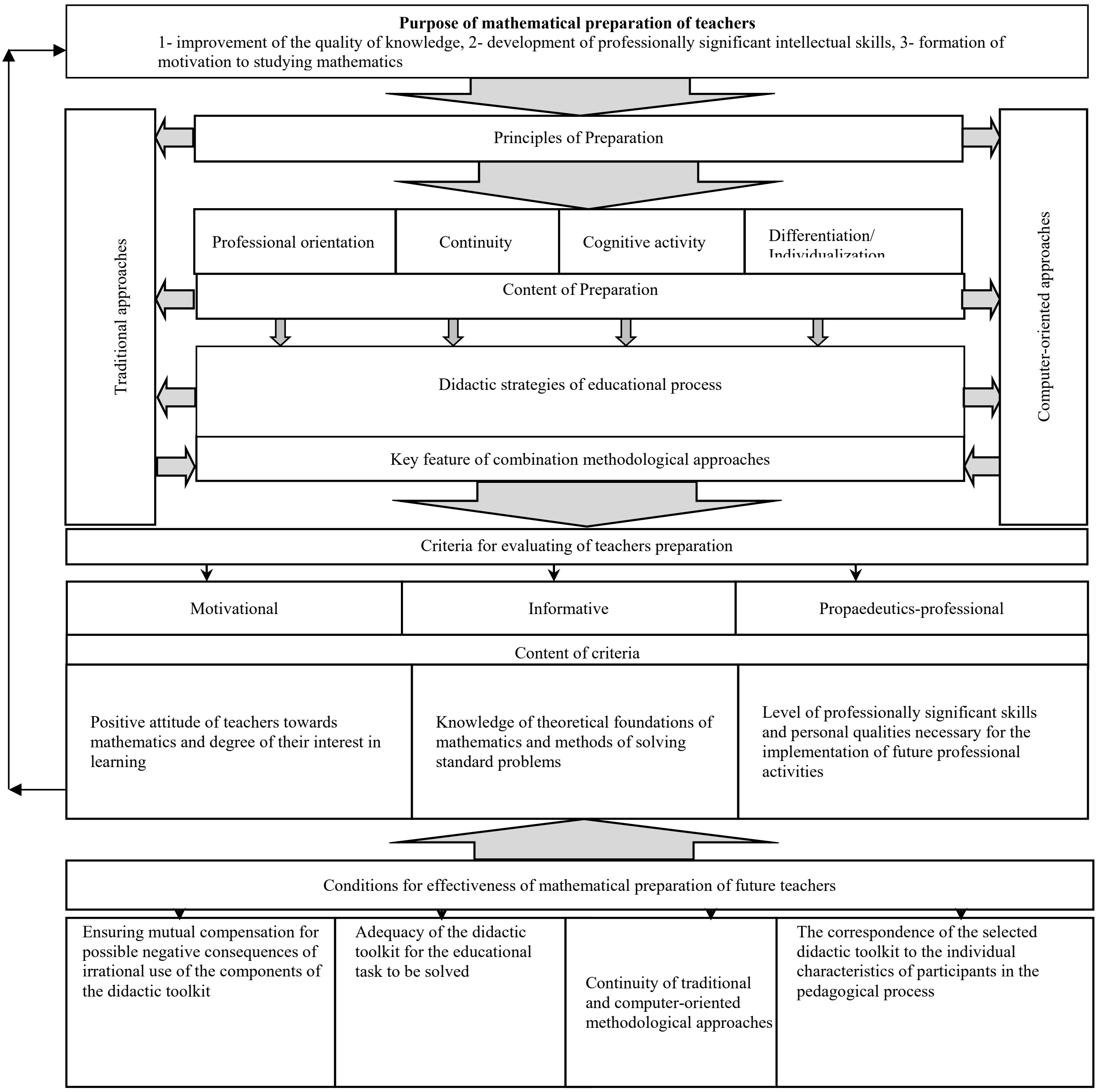

Fig. 1 Model of mathematical preparation of students based on a rational combination of traditional and computer-oriented approaches

TABLE I
THE TEACHING METHODS

	A	I	G
1	Direct instruction: the purpose "descends" from teacher"	Empirical/ visual approaches to study content	Performing actions using a template or a specific algorithm
2	Work is being done to adopt the purpose by students	Appropriate conversion of content within the available cognitive range	Orientation to the variation application of general algorithms, backed up by guiding questions and instructions from the teacher
3	The purpose is realized by students in the course of a partially independent solution of the problem situation	Organization of problem research on the basis of a multilateral analysis of the situation	Orientation on formed general and special skills of students

TABLE II
TWO-DIMENSIONAL REPRESENTATION OF THE TEACHING METHODS

Traditional teaching methods	Electronic means for educational purpose				
	Training	Monitoring	Information retrieval and reference	Demonstration	Modeling
$A_1I_1G_1$ Direct instruction: the purpose "descends" from teacher". Empirical/ visual approaches to study content. Performing actions using a template or a specific algorithm.	Accumulation and systematization of necessary information, consolidation of new knowledge, skills.	Diagnosis of accumulated knowledge, skills, intermediate control.	Search and accumulation of necessary information.	Visualization of new material.	The construction of models for solving various tasks under the guidance of the teacher using the algorithms
$A_2I_2G_2$ Work is being done to adopt the purpose by students. Appropriate conversion of content within the available cognitive range. Orientation to the variation application of general algorithms, backed up by guiding questions and instructions from the teacher.	Perfection of creative abilities and skills, finding of non-standard ways of the solution of the given problems.	Final control the solution of non-standard tasks.	Finding information that is necessary for solving creative non-standard problems.	Visualization of new material, processes under consideration, solutions of problems posed, etc.	The accumulation of experience in the use of strategies and tactics of creative activity
$A_3I_3G_3$ The purpose is realized by students in the course of a partially independent solution of the problem situation. Organization of problem research on the basis of a multilateral analysis of the situation. Orientation on formed general and special skills of students	Perfection of creative abilities and skills, finding non-standard ways of solving the problems.	Final control of non-standard problems.	Finding information that is necessary for solving creative non-standard problems.	Visualization of new material, processes under consideration, solutions of problems posed, etc.	The accumulation of experience in the use of strategies and tactics of creative activity.

In the specific circumstances of the educational process, the teacher should, on the basis of the dominant learning task, be able to choose the most effective combinations from the whole spectrum of the methods and means. This is a difficult task and requires special, purposeful preparation of students for the implementation of this choice in future professional activity as a teacher of mathematics. To organize such training, it became necessary to develop certain selection criteria, as well as a set of measures to develop the ability and willingness to rationally select and combine traditional and computer-oriented methodological approaches in the process of teaching mathematics.

III. METHODS OF IMPLEMENTATION

We approach the preparation of future mathematics teachers to ensure a rational combination of traditional and computer-oriented methodological approaches within the framework of the course, "Methods of Teaching Mathematics". At the first stage, in the process of studying general questions of the methodology of teaching mathematics, acquaintance with various electronic educational resources and the principles of their use occurs. In particular, students get acquainted with the creative interactive environment "1C: Mathematical Designer" [3]. At the same time, in collective discussion we highlight a number of educational tasks which can be optimally achieved with the help of electronic teaching aids. These include:

1) Organization of research at the stage of opening "new" knowledge by schoolchildren;
2) Visualization and dynamization of the subject matter;
3) Optimization of calculations and constructions;
4) The use of mini-tests to update knowledge and their operational control;
5) The use of presentation materials to rationalize time in the mathematics class.

As a result, each student performs individual tasks of the following types:

- Using one of the mathematical constructors "1C: Mathematical Designer" to create an interactive model that ensures the research activity of schoolchildren at the stage of acquaintance with the new teaching material by the example of one of the concepts or one of the theorems.
- Preparing a mini-test on the basis of one of the test shells to update the necessary knowledge or test their primary assimilation.
- Developing a summary of the lesson and a presentation that supports it.
- Making use of a visual aid used in the study of mathematics in high school.

Here are some examples of completed tasks from algebra and geometry for eight class students.

Example 1. For The function $y = kx^2$ construct a graph and investigate its properties.

To study the position of the graph of a quadratic function, depending on the value of the coefficient k and clarifying its properties, students can be asked to perform a lab work using 1C: Mathematical Designer. In this situation, it will reduce the time needed for constructing the graphs of functions by points and increase the number of examples considered, which will increase the reliability of the resulting conclusions.

At the first acquaintance with the new function, it is advisable to build the graph by points "manually" for fixed values of k, since all students need to acquire skills in plotting the functions of the particular area of study. The task can be performed on variants with different parameter values. In this case, students come to the conclusion that the graph in all cases will be a parabola. It is advisable to study the character of the dependence of the parabola location on the values of k using special software.

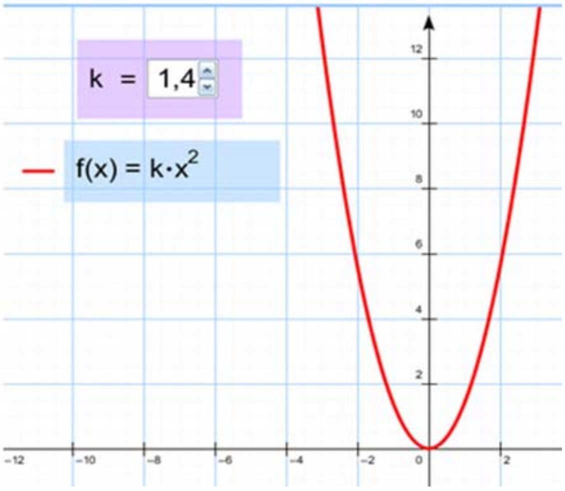

Fig. 2 The function $y = kx^2$

Fig. 2 shows an interactive model for students to work with. In the process of this work, students create a parameter on their own and build the desired function graph with this parameter. Changing the values of the parameter determine the dependence of the direction of the branches of the parabola, its axis, compression and stretching of the graph. In this case, visualization of the process of compression and stretching of the graph is of particular importance. As a conclusion, all the properties of the function in question must be obtained.

Example 2. Find the degree measures of the angles: B_1DN_1, $M_1K_1S_1$ and Q_1SE_1

In the lesson, after studying the theorem on the inscribed angle, students can be offered a small test of its application as a means to verify their answers. In this case, the main goal is not to test the assimilation of the acquired knowledge, but to improve the skills of applying the theorem being studied. In the lesson, students work individually on computers or on laptops and tablets. The students work independently, but can receive advice from the teacher if required. The problems are presented in Fig. 2. The teacher, by observation, receives information about the primary assimilation of the material studied. In the final lesson of this Unit, a mini-conference is held, during which there is a discussion of the proposed solutions.

At the second stage, in the process of studying specific methods, the main emphasis is on Units of lessons preparation by students, when it is necessary to combine both computer-oriented and traditional methodological approaches. For example, when studying a linear function to clarify the type of its graph, it is advisable to use the capabilities of the corresponding software tools to creation a table of function values and plot the points, to test the hypothesis put forward. However, later, students need to acquire the skill of plotting linear function on two points by traditional means. The students will have to, either by themselves or under the guidance of the lecturer, find the same situations in the mathematics course of the secondary school and develop a scenario for schoolchildren's activity. In this case, special attention should be paid to the justification of the methodological approaches used in the lesson.

At the third final stage of preparation in the process of a writing course or final qualification works, students develop a holistic methodology for studying one of the selected topics of the school course of mathematics and are able to justify the chosen teaching tools. Some of their methodologies were presented at the competition of diploma projects organized by 1C Company. Here are some examples of completed tasks.

Example 3. The topic was linear function. Within the framework of the project, a thematic plan for studying the topic on one of the textbooks is considered, and lessons are specially allocated to consider various options and software tools. Below is one of the possible options developed by students in Table 3. As the main software tools, we used "1C: School. Algebra 7 - 9" and "1C: Mathematical constructor".

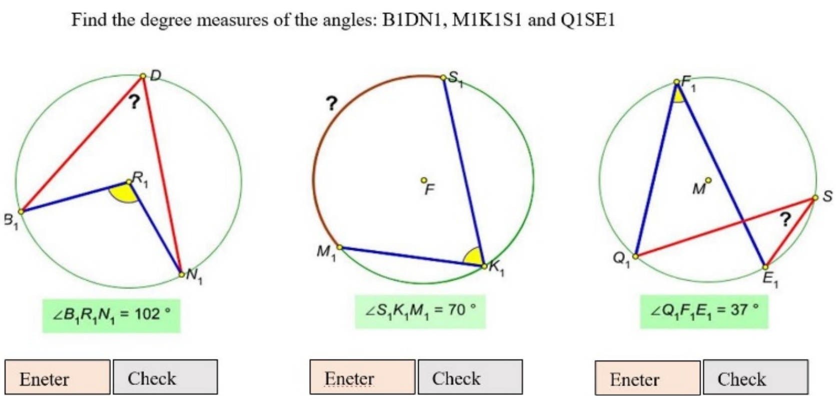

Fig. 3 The Angles: B_1DN_1, $M_1K_1S_1$and Q_1SE_1

TABLE III
THE UNIT PLAN

№	Topic	Period	Type of lesson	Characteristics
1	What is a function?	1	Studying the new material	Independent work with the verification of answers to the formation of skills to find the values of the function according to the graph and the table.
2	Calculation of the values of functions by the formula	1	Studying the new material	Performing a test with the verification of answers to the formation of skills to calculate the values of functions by the formula.
3	The graph of a function	2	Studying the new material	Demonstration model for obtaining a function graph from the function value table.
4	A Directly Proportional Graph	2	Studying the new material. Consolidation of knowledge and skills	Laboratory work on establishing the type of the graph of direct proportionality. Independent work aimed at testing the ability to determine the slope coefficient by direct proportionality graph.
5	The linear function and its graph	3	Studying the new material Consolidation of knowledge and skills	Laboratory work on establishing the type of graph of a linear function and its connection with a graph of direct proportionality. Performing independent work on establishing the correspondence of graphs of linear functions and their formulas with verification of the answers.
6	Multiple representations of linear functions	2	Systematization and generalization of students' knowledge	Independent work on determining the properties of the graph of linear functions given by formulas.
7	Summative assessment	1	Monitoring and controlling knowledge and skills	

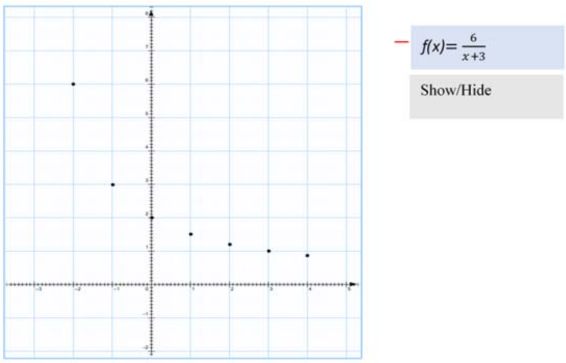

Fig. 4 (a) Graph of the function *f(x) = 6/ x+3*

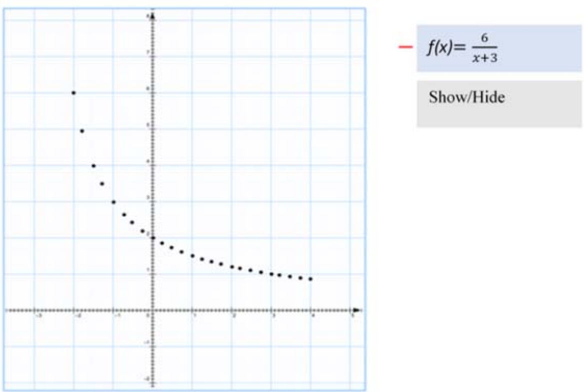

Fig. 4 (b) Graph of the function *f(x) = 6/ x+3*

Let us consider the description of lesson 3 and lesson 6, in which electronic educational resources were used. In lesson 3, the concept of graph of a function is introduced. In most cases, this is done through the task of constructing points whose abscissas are equal to the argument of the function, and the ordinates are equal to the values of the function. In this case, as a rule, a table of the values of the function is created at a given interval in steps of 1 unit. Creating a table of values of a function with a smaller step and building points takes a lot of time in the lesson, so in this case special software can be used. We developed an interactive model within the framework of "1C: Mathematical Designer". The function value table is created by students at the stage of knowledge actualization. The construction of points with step one unit from the first table takes place in the traditional way. The construction of points on the basis of tables with a smaller step is illustrated by our model. Figs. 4 (a) and (b) show the results of the work.

At the conclusion of the demonstration, the function graph is constructed. Thus, within the framework of the model, the process of obtaining the function graph is illustrated. In lesson 6, one of the tasks that should be performed is to determine the properties of the graph of a linear function as given by the formula. During the execution of the task, the students fill out a table of a special type, which lists the formulas that define the functions and some of their properties. Students need to demonstrate a correspondence between them.

As a result of the training described above, future mathematics teachers acquire the sequence of procedures, which together make up the algorithm for preparing for the lesson, based on a rational combination of traditional and computer-oriented approaches. This preparation includes developing skills of future teachers:

1) Defining the specific objectives and outcomes for the lesson.
2) Analyzing educational and mathematical content.
3) Identifying pre-knowledge in mathematics and the level of preparedness of work prepared by computer.
4) Predicting the possible results of the impact of the electronic teaching tools, the style of thinking and behavior of all participants in the educational process.
5) Determining the structure of the lesson.
6) Adjusting the Unit of lessons.

IV. CRITERIA FOR CHOOSING A PARTICULAR COMBINATION OF METHODOLOGICAL APPROACHES

We identify a number of general conditions that can serve as criteria for choosing a particular combination of methodological approaches to the implementation of the educational process.

1. Mutual compensation of possible negative consequences

of using traditional and computer-oriented approaches in the educational process.

As is known, the use of software in the pedagogical community has a twofold relationship. Many scientists speak only about the advantages of using electronic tools in teaching compared to traditional methods of teaching, while others point to "new" problems that are not typical of traditional learning: passivity of trainees, low level of communicative skills and independence, the problem of student orientation in the flow of information, fragmentation of knowledge, algorithmization of thinking and medical and other problems of well being such "carpal tunnel syndrome", "computer visual syndrome", Internet addiction and cognitive dissociation [8], [9]. Accordingly, the teacher, before deciding on the necessity or type of electronic means to be used in any given lesson, must always carefully balance benefits and potential risks. In other words, their choice and degree of use should be always be consciously justified. For example, in practice, it became clear that schoolchildren who performed the task in a traditional (manual) way, often incorrectly plotted a graph. Schoolchildren, who are working on similar tasks using 1C: Mathematical Designer, encountered difficulties, both technical in nature, and connected with the inability to "read" the schedule and to compare it with the research data.

Moreover, students could not always transfer the acquired knowledge and algorithms to a similar educational material. The combination of both approaches allowed for compensation of difficulties compensate for difficulties encountered by schoolchildren who performed the task of graphic interpretation of data in a traditional way and also contributed to the realization of a general algorithm for working with functions by students who performed the task with the help of computer program.

2. Correspondence of the chosen combination of approaches to the specificity of the educational task and individual characteristics of subjects of the educational process.

Teachers of mathematics may have complex choices in the use of didactic tools. So, for example, above we represented the structure of the teaching method in the form of an ordered triad of signs: the dominant nature of goal-forming; the degree of correlation of various forms of material representation to particular cognitive substructure; and also the level of generalization of the assimilated content. It is evident that the use of any particular method in the specific circumstances of the learning process must be guided by the corresponding individual characteristics of the students: the nature of their motivation, the dominant structure of their thinking and the level of their training and attainment [3], [11]. In addition, it is necessary to take into account the ecological specifics of the overall organization of the schoolchildren's educational activity.

3. The organizational and procedural compatibility of traditional and computer-oriented methodological approaches.

The need for this condition is closely related to the previous one. Each approach must have a clear and internally consistent ideology with an explicit understanding of its strengths and limitations. It must also allow for and where necessary seek compatibility with other approaches.

The combination of traditional teaching methods and electronic educational tools in the structure and content of teaching the school course of mathematics is a necessary condition that ensures continuity, consistency, planning and progressive development of teaching this course at all stages of the learning process. It can be considered in two directions, which are also taken into account in our research in procedure and organizational aspects. The procedural aspect determines the choice of means, and methods of teaching; provides communication for purposes, forms of training and allows for spontaneity but not ad hoc deviation. The organizational aspect determines the sequence of stages of the learning process and ensures cooperation of all participants in the pedagogical process.

V. Conclusion

The analysis of pedagogical literature and our observations on the course of the educational process attest to the need for special training of future mathematics teachers to ensure a rational combination of traditional and computer-oriented methodological approaches in the teaching of mathematics. This requires a step-by-step approach within the framework of the course "Theory and methodology of teaching mathematics".

In the first stage, in the process of studying general questions of the methodology of teaching mathematics, teachers consider and solve various educational tasks including how their implementation can be optimized with the help of electronic educational tools; the organization of educational research at the stage of opening "new" knowledge by schoolchildren; visualization and dynamization of the subject content and constructs; the use of tests for the actualization of knowledge and their operational control and the use of presentation materials for rational action time on a math lesson.

In the second stage, in the process of studying specific methodological questions, students relatively independently design, substantiate and represent a holistic structure of the lesson, in which both methodological approaches are effectively combined.

In the third and final stage, and in preparation for passing final practice and written qualifying exams, the future teachers of mathematics develop an integrated methodology for assessing and applying the school mathematics curriculum.

We tested the feasibility and quality of the proposed methodology and demonstrated positive results. The concept of preparing students to be able to adaptively utilize an effective combination of traditional and computer-oriented methodological approaches in the lessons of mathematics is an approach which also has much wider applicability for teaching mathematics generally - and indeed for other disciplines [8], [9].

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