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PROFESSIONAL-ORIENTED CONTENT OF MATH TRAINING FOR FUTURE PRIMARY TEACHERS - PRESENTATION OF AN INTEGRATIVE TREND

Tashpulatova Mamura Ismailovna
PhD Tashkent State Pedagogical University
Content of the mathematical component of primary teacher training

ABSTRACT

The question of the content of the training of future primary teachers in mathematics, as well as in other subject areas, occupies a special place among the similar problems of teacher training in relevant areas. This is because the primary teacher in his professional activity is directly related to the teaching of completely different fields of knowledge: mathematics, Russian language, literature, natural science, etc. It is quite clear that primary teachers cannot be considered as a teacher - a subject with a reduced volume of subject training in all these areas. Firstly, there is no way to give the future teacher any acceptable broad training both in mathematics and in other fields, in the allotted number of study hours. Secondly, mathematics education in primary schools has a significant difference from mathematics education in secondary school, both in content and in terms of teaching methods. How has this problem been solved in the practice of training primary teachers in pedagogical universities of our country over the past decades?

INTRODUCTION, LITERATURE REVIEW AND DISCUSSSION

Analyzing the mathematics course programs for pedagogical institutes in the specialty “Pedagogy and methods of initial education,” two main approaches can be distinguished in solving this problem.

With the first approach, which we will conventionally call “general education,” the main thing is the achievement by the future primary school teacher during the training of a certain level of mathematical culture. This approach focuses on such components of mathematical education as understanding the general principles of constructing mathematical theories (intuitive and axiomatic), mastering the techniques of constructing correct conclusions and various methods of defining concepts, the ability to perform the most used mathematical transformations, including computational nature, etc. In other words, the essence of this approach can briefly be described as a kind of mathematical “liquor.” There is no doubt that it is very important for a school that a mathematically competent primary school teacher works in it. In this case, we can be sure that such a teacher will not make any serious errors in the mathematical plan in his work, will lay the correct formation of basic mathematical concepts among younger students, will be able to see and timely correct those inaccuracies and miscalculations, from which the newly created textbooks are not insured, which have recently appeared in large quantities, will finally be able to increase the level of its methodological and mathematical training independently. More information on the role of mathematical culture in the training of primary teachers can be found in the article with the corresponding title.

Taking into account the above-mentioned orientation of the “general education” approach, the selection of material for the mathematics course at the primary school teachers’ training faculties offered by the authors of the respective programs becomes quite understandable. An

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obligatory and central component of such a programme is the section devoted to the study of elements of mathematical logic and related issues, such as the general principles of axiomatic theories. Other sections of the course should introduce students to the basic mathematical concepts and their properties, which can be classified as "general education" by their mathematical significance, namely: the concept of derivative, integral, algebraic structure, geometric transformation, etc.

In the second approach, which, in contrast to the first one, we will call "applied", the task of maximizing the mathematical preparation of the future primary school teacher to the problems that he will face in the teaching of primary mathematics comes to the first place. In other words, in this approach, the main criterion for the inclusion of material in the mathematics curriculum of primary school teacher training faculties is its professional orientation. From this point of view, the central section of the curriculum should be the section devoted to the system of integers with non-negative numbers, since the concept of integers with non-negative numbers occupies the main place in primary mathematics. At the same time, the system of integers of non-negative numbers should be considered from different positions, which provides modern mathematics, and as much detail as possible.

Otherwise, the teacher will not be prepared to understand and correctly interpret the various concepts of the content of primary mathematics that he is bound to encounter in his professional life.

Other parts of the programme that are included by authors with an "applied" approach are usually of a support (service) nature. Such sections are, first of all, those dealing with elements of the theory of sets and correspondences, elements of mathematical logic. The obligatory component of such programs should be also the sections in which the expansion of the concept of number is given, integers, rational, real numbers are studied, though not so in details, but strictly enough. This situation is caused, first of all, by the natural logic of mathematics itself.

When implementing the "applied" approach, the software material can and should be expanded to include additional sections with professionally oriented content. Mainly it concerns the material of geometrical character. The peculiarity of such sections in the program is their isolation from other sections and, obligatory in this case, self-sufficient!

One should not think that the presented approaches are mutually exclusive. Programs based on these two approaches can and do contain some common sections. Moreover, if one approach is implemented, whether we want it or not, the other will be implemented to some extent. Therefore, the approaches considered are closely interconnected and mutually permeating. Thus, the preference given to one approach will be expressed not in ignoring the other, but in prioritizing the given one. But which of these approaches should be considered the priority one?

In our opinion, the "applied" approach should be preferred, and there are several reasons for this. First, in the implementation of this approach, there is a very real possibility of two abovementioned tasks at once: to offer to study professionally oriented material, in the study of which students can reach the necessary level of mathematical culture. The "general education" approach has this possibility to a much lesser extent. Secondly, the "applied" approach makes it possible to establish a sufficiently close substantive connection between mathematics courses and primary school mathematics teaching methods. This, in turn, is of great help in the teaching of mathematics, for which the relevant sections of the mathematics course provide a sound basis for understanding. The "general education" approach provides little or no such opportunity, and the interrelationship of the courses is only sporadic. Thirdly, this approach allows for a rather convincing justification of the necessity to study this mathematics course, which will surely lead to more conscious assimilation of the offered material by students and increase their motivation to study. The "general" orientation of the studied material generates, as a rule, a lower level of motivation to study it than the "professional" orientation.

In conclusion to this paragraph, I would like to note that the proposed reflections on the content of the mathematical component of the training of primary school teachers will help teachers to answer a number of questions which, as teaching practice shows, especially in the part-time and correspondence sections, will necessarily put students before them. Above all, these are questions about what kind of mathematics we study and what we need it for.

Also, it is hoped that the thoughts and recommendations formulated in this paragraph will be useful to specialists engaged in training primary school teachers in other areas.

The author's many years of experience in developing and reading courses in mathematics at the psychological, legal and economic faculties of the University of Moscow allows us to assert that similar problems have to be solved when training specialists in a completely different field. At the same time, approaches to solving such problems have the same basis as in the described situation. Thus, we significantly expand the area to which these approaches are applicable in determining the content of training specialists in certain areas.

Integration of elements of mathematical theories into methodological approaches

When it comes to the relationship between mathematics and mathematics teaching methods in primary school, it is often possible to see only interaction at the level of content determination. In other words, in many cases relevant mathematical theories are only used to address one of the two main questions of mathematics teaching, namely, what to teach younger students in a given field of education. Such interaction is quite obvious and it is difficult to find any objections to its implementation. The nature and ways of such interaction lie on the surface and their analysis is the subject of the previous paragraph. As for another main methodological question (How to study this material?), mathematics is not always involved in its solution, although it can and should be done for several reasons. First, the study of one or another mathematical concept must necessarily correspond to the logic of introducing this concept in the corresponding mathematical theory, because the violation of this principle does not allow students to form the correct attitude to further study of mathematics. Secondly, and this is the main thing, analyzing fragments of the corresponding theories, the methodologist gets the most important information not only about the necessary propaedeutics work but also about those basic approaches that can be used in the process of studying this concept. Let us illustrate what was said by the example of studying one of the most important questions of any elementary mathematics course, which is formulated in the program as follows: natural numbers of the first ten.

It is well known that in mathematics for a long time, there was no strict definition of the natural number. Until the end of the XIX century, mathematicians were satisfied with the use of this concept on an intuitive level, considering it the original, undefined. After the German mathematician, H. Kantor managed to construct a quantitative theory of integers of non-negative numbers based on his theory of sets, this concept was defined accordingly. Almost at the same time, the Italian mathematician G. Peano created an axiomatic theory of integers of non-negative numbers, which was based on the idea of the ordinal approach. These two theories are the basic mathematical theories for constructing a system of non-negative integers. It is no coincidence that they are most often used as the basis for introducing the concept of integer non-negative numbers, including natural numbers of the first ten, in various initial courses of mathematics. This, of course, does not exclude the use of some other approaches. For example, the study of numbers in the system of D.B.Elkonin V.V.Davydov [6] is based on the corresponding theory of positive scalar values, which requires considering the number as a result of measuring this or that value.

In quantitative theory, the non-negative integer is introduced as an invariant of a class of finite equaled sets, or as a common property of all elements from a class of finite equaled sets. Such an approach to the definition of this notion requires relying on such notions as a finite set, equivalence ratio, equivalence class with respect to the equinox. In the initial course of mathematics, all these theoretical positions should find their methodical embodiment. It can be done in the following way.

At first, students should be introduced to various examples of finite sets. It is not necessary to use the term “finite set” at all. It makes sense to take examples of finite sets from the surrounding reality. The next step on the way of realization of the plan should be the work on the establishment of the identical mutual correspondence between concrete sets or their parts (subsets). This work is based on the use of the notions “more”, “less”, “as much”. No knowledge of numbers is required for its performance. In the method of teaching the mathematics of younger schoolchildren, this stage of the work is called “prehistoric”. The main result of this work should be the formation of the ability of younger students to clearly and accurately identify sets that belong to the same class. Since quantitative theory tells us that each class of finite non-empty sets contains infinitely many sets consisting of elements of different nature, and all of these sets are equal to each other, even when considering the relevant issues in the elementary mathematics course students should be invited to work with a variety of examples of sets with elements of different nature. In no case should students be limited to a set of constantly repeating examples of sets. This can lead to misconceptions that only these sets can be linked to the numbers. The next step in introducing the concept of a non-negative integer is to assign to each class a certain numeric symbol (number) and a term that will answer the question of how many elements in each set from that class. The order of studying numbers (we remind that we are talking about the numbers of the first ten) in this case does not play any role, because the obtained numbers are not yet related to each other by any relationship. Study of their properties, including their ordering, will be carried out at the next stage of the study of arithmetic material. In more detail, the described above approach to the study of numbers of the first ten can be seen on the example of the course we have implemented in the manual for preschoolers, or in the textbooks of I.I.Arginskaya [11-14] and N.B.Istomin [100-103].

The orderly approach to building a system of integers with non-negative numbers requires completely different methodological solutions. These decisions depend on that theory which is realized in a considered case. In mathematics, the ordinal approach to the construction of the system of integers of non-negative numbers is put in a basis of the corresponding axiomatic theory which author is J. Peano. According to the rules of construction of any axiomatic theories, there is a formulation of the axiomatic theory, which includes a list of primary terms of the given theory and a list of axioms, in which the essence of these primary terms is explained. After that, all other concepts are defined and all theorems are proved based on axioms or previously proved theorems. Peano’s axiomatics is constructed in such a way that the natural series of numbers is characterized by the presence of the beginning (number 1), the absence of the end (infinity of the series), the impossibility of a direct sequence of two different numbers after the same number and the same number after two different numbers, as well as the uniqueness of the series that satisfies all the properties listed earlier. Such features of the implementation of the ordinal approach in mathematical theory also lead to corresponding methodological solutions in the initial course of mathematics. In this case, the study of numbers should begin with the construction of some sequence in which each number takes its strictly defined place, starting with number 1. It is better to denote all these places by means of ordinal numerals (first, second, third, etc.), but it is possible to use quantitative numerals as well, while not putting any quantitative sense into them. In other words, students first memorize a sort of "count" from the number names in a certain order. This is followed by a specific arithmetic meaning based on the counting procedure of the subjects, as well as on the relationships and arithmetic actions to be introduced. In mathematics, it is well known that the strength of any axiomatic theory lies in its high degree of formalization and rigour. This is the reason why modern mathematics in almost all areas has moved to the construction of axiomatic theories, as opposed to intuitive theories. But these features of axiomatic theories, providing advantages from the point of view of mathematics, serve a negative service from the point of view of the method of primary education. The fact is that, for younger students, a high level of formalization is almost unacceptable. For younger schoolchildren, a high degree of content is required, which is better represented in quantitative theory.

Another possible approach to the introduction of the concept of natural number is an approach based on the theory of positive scalar sizes. In this approach, some positive scalar values are first studied (using length, mass, capacity, etc. as an example) and its properties using letter symbolism, and then the number appears as a result of measuring the value. In this case, all properties obtained earlier for the values are transferred to numbers. It is accepted to use such an approach in system of D.B.Elkonin-V.V.Davydov. Corresponding textbooks are written on this system (for example, E.I.Alexandrova's textbooks and S.F.Gorbov's textbooks, etc.). In them, this approach is realized and realized quite successfully.

The last approach considered is the one based on the algebraic idea of extending the numeric set to make some algebraic operation possible. In the initial course of mathematics, this approach is transformed into the idea of building "new" numbers based on the addition operation (action) over "old" numbers. In other words, the "new" number is obtained by adding the "old" numbers. This approach can be attributed to the traditional and very popular. Almost every teacher will answer the question of how to get a "new" number in the following way: by adding number 1 to the largest number studied earlier. This is the implementation of the idea of expanding the number set to be able to perform the corresponding operation. The positive aspects of this approach are quite obvious. First, each "new" number from the moment of its appearance is represented by a certain sum, which allows to easily proceed to consideration of the additive composition of the number. Secondly, the procedure of "counting by 1" is the basis of one of the computational methods of addition. Third, the addition of number 1 means the transition to the next number directly, which allows you to easily link the appearance of "new" numbers with their ordering. However, when implementing this approach one should not forget about some negative points that accompany it. The first such point is the fact that the application of this approach is possible only if there is a sufficient numerical base. In other words, this approach cannot be used to obtain the first few natural numbers. This is explained by the fact that the addition already requires a certain numerical base (recall that we are talking about the addition of numbers). Therefore, the first few natural numbers must be entered on some other basis. If this is not done, this approach cannot be recognized as "legitimate" logically. The second negative point is that in this approach, the appearance of "new" numbers is associated with the needs of solving a purely mathematical problem about the feasibility of addition, in contrast to other approaches, in which the appearance of new numbers is associated with the solution of practical problems of counting objects or measuring values. The practical necessity of numbers for younger schoolchildren is undoubtedly more convincing than a mathematical necessity.

Summing up the above, we will formulate our methodical approach to the introduction of natural numbers of the first ten, which is implemented in the author's training kit in mathematics in the framework of the project "Perspective primary school". [222]. This approach consists of two stages. The first stage is based on the quantitative theory of the integer non-negative number. At this stage, natural numbers from 1 to 5 and number 0 are defined. The second stage is based on the idea of additive (based on the addition) expansion of the already existing numerical set. At this stage, natural numbers from 6 to 10 are defined. Thus, when studying numbers of the first ten, we apply a combination of two approaches: quantitative and algebraic. At the same time, both these approaches in our variant undergo some changes in comparison with the way they are usually applied. Thus, the quantitative approach to introduce this number requires consideration of various equidistant sets, all of which are equal to each other. We propose to separate one from the class of equated sets, which will act as a reference representative of this class, and we will compare all other sets with this "reference". In our opinion, only such a set from a given class can claim to be a reference set, which, on the one hand, is rigidly related to the corresponding number, and on the other hand, is familiar to students with a set of subjects surrounding reality. We have chosen the following sets: for number 2 is a set of wings of a bird, for number 3 is a set of horses in "three", for number 4 is a set of paws of a cat, for number 5 is a set of fingers on one hand. As to number 1, we do not introduce a special "reference" set for it only because the appearance of this number is characterized, first of all, not by a desire to illustrate the quantitative aspect of this number, but by a desire to show the qualitative difference between the description of a situation without the use of numbers and the description of the corresponding situation using a number, in particular number 1. In other words, in this case, the most interesting for us is the qualitative transition from the pre-calculation stage to the numerical stage. And this is what we focus on. Number 0 also occupies a special position. To introduce it, we use an empty set, which we introduce to students on various examples of the corresponding characteristic properties. Since the class of finite equaled sets defining number 0 consists of only one set, in this case, there is no sense in talking about the equivalence of some sets from the class, but we should talk about the number of the empty set.

Once the first five natural numbers and number 0 have been entered, we propose to introduce an addition action on this numeric set. Although there are not so many numbers at our disposal yet, it is already possible to form a correct idea of the addition action by using these numbers as an example. It is very important to form a view of the addition as an action from the very beginning. This means that when we talk about adding up, we must necessarily emphasize the following two points. First, the addition must necessarily involve three numbers (components and result) which are reflected in the corresponding entry. Secondly, to illustrate the addition, we need to display the situation in the dynamics, which can be done by moving from a situation image before acting as a situation image after acting. Having introduced students to the additional action, we will now not only study the addition action but also use it to expand the studied numeric set.

So, let's move on to the introduction of the remaining numbers in the top ten. Number 6 first appears as a result of adding numbers 5 and 1. In this case, the sum of 5 + 1 is treated not from the position of transition to the next number directly, but from the position of "account on the fingers". From our point of view, "the count on the fingers" is that natural arithmetic basis, which should not pass by at all when studying numbers of the first ten. After number 6 is introduced on the additive basis, we necessarily introduce students to the quantitative meaning of this number, using the familiar idea of the reference set. For number 6, we have chosen the beetle's leg set as a reference set. The number of this set can only be equal to number 6. To introduce numbers from 7 to 10, we use a very similar method. At first, these numbers appear as a result of adding the number 5 to the numbers 2, 3, 4 and 5 respectively. After that, each of the numbers is illustrated with a corresponding reference set. For number 7 such a set is a set of days of the week, for number 8 - a set of paws at the spider, for number 9 - a set of training months of the year, for number 10 - a set of fingers. Thus, the introduction of numbers in the first ten can be considered complete. The approach we have implemented has some advantages. First of all, it is legitimate from a mathematical point of view. Secondly, the additive basis of numbers from 5 to 10 allows us to expand the list of computational methods of addition. Thirdly, the construction of numbers from 6 to 10 on the principle of 5+p allows us to build reasoning by analogy when introducing numbers of the second ten.

Another striking example of the integration of mathematical theory into the corresponding methodological approach is the method of studying questions related to written algorithms of arithmetic action, in particular, with the algorithm of multiplication "column". At first glance, and many teachers, as a rule, are limited to such consideration, the logic of studying the written algorithm of "column" multiplication is dictated only by the implementation of the principles of availability and strength of the formed skills, and the principle of scientificity and the corresponding theoretical validity in this case is in the background. This is not the case at all. If we analyze the algorithm of multiplication by "column" from the point of view of what provisions of theoretical arithmetic are at its basis, we will see the following. First of all, this algorithm is based on the ability to multiply single-digit numbers (based on knowledge of the multiplication table). It is based on the distribution (distribution) property of multiplication relative to addition (both on the right and the left), the property of multiplication by digit summands, and the ability to add multi-digit numbers by a "column", and in cases when the summands are more than two. A competent methodological approach to studying the algorithm of multiplication by a "column" in the initial course of mathematics should take into account all these provisions and consistently rely on them. Let's consider how we propose to study this issue in the elementary mathematics course, which we have developed in the framework of the project "Promising Primary School". [233, 236].

The first stage (preparatory) in the study of this issue is connected with the development at the proper level of the algorithm of adding multi-digit numbers "column" and tabular cases of multiplication. This work is subject to its logic and is carried out, taking into account its methodological peculiarities, which in this case, we will not discuss, as this is the subject of a separate conversation. After the specified base is prepared, you can proceed to the second stage - the stage of building an algorithm of interest to us for the case of multiplication by an unambiguous number. For this purpose, we propose first to consider the cases of multiplication of the "round" number by an unambiguous number, and after that the rule of multiplication of the sum by a number (the right distributive law of multiplication with respect to addition). These two mathematical facts allow us to justify the digit method of multiplication of a multi-digit number by a univocal number, while we are still using the line entry of the calculation. The end of this step is the transition from recording multiplication by row to column. Column-writing, at this stage, does not yet offer any particular computational advantage, so we do not suggest that students compare the two forms of recording from this point of view. The next step in the study of the column multiplication algorithm is to consider the case of two-digit multiplication. For this purpose, we suggest that we first consider multiplication by number 10, then multiplication by a "round" two-digit number (by a digit sum of tens), and finally, the rule of multiplication by sum (the left distributive law of multiplication concerning addition). All the facts just listed allow us to justify the digit method of multiplication by a two-digit number and go on to write this case of multiplication into a column. At this stage, it already makes sense to talk about the advantages of column-writing, because with this form of recording it is convenient to add the obtained intermediate results of multiplication to each of the two-bit summations. The last stage in the study of the "column" multiplication algorithm is connected with the transition from the two-digit number multiplication to the three- and more-digit numbers. This transition is carried out by the principle of analogy with the preliminary consideration of cases of multiplication by number 100 and by number 1000 (special consideration of other digit units is not required, because the corresponding multiplication cases, as a rule, are not found in the calculation tasks). The result of all this work is the formation of the ability to perform "column" multiplication of multi-digit numbers and the formulation of a "column" multiplication algorithm by students while answering questions that they are asked in the text of the corresponding task. This is the form of mastering the algorithm, we believe, is sufficient. We do not consider it necessary to ensure that students learn to give the full wording of the algorithm themselves. The main thing is that they are able to perform this algorithm and give explanations for their actions, answering the questions asked of them.

An important example of the integration of theoretical provisions in the relevant methodological approaches can also be the consideration of the question of the interpretation of the concept of "problem solving", which we propose to apply in our course. This interpretation differs from the traditionally accepted one when the solution of a problem is considered as a procedure, the result of which is the obligatory obtaining an answer to the problem requirement. We consider it necessary to clearly distinguish two sides of this procedure: describing the sequence of actions, by means of which it is possible to get an answer to the task requirement, and implementing this procedure with the fulfillment of the corresponding calculations up to get a numerical answer to the task requirement. This questioning is consistent with the need, in learning and in evaluating actions, to distinguish between skills such as problem solving and computing. Besides, this point of view is consistent with the accepted in mathematics interpretation of the concept of "problem solving", which can be interpreted from algorithmic positions. Indeed, if the task solution is interpreted as an algorithm, then the ability to solve the task should be understood as the ability to construct (find) the corresponding algorithm, and the ability to obtain a concrete numerical answer to the task's requirement is the ability to implement this algorithm, which, as a rule, has an arithmetic character. When it comes to the algorithm, the question of the fulfillment of all the basic properties of this concept necessarily arises. With respect to the solution of the problem, practically all such properties are fulfilled. There is no doubt that the solution of the problem, in whatever form of record it is presented, meets the requirement of unambiguousness and sequence: the actions specified in the solution are strictly consistent and are understood unambiguously. The same is true of the requirement of practicability, finiteness and efficiency: the actions indicated in the solution are necessarily achievable and their number is of course, as is the finite procedure they describe (infinite cyclic repeatability is excluded here), and the execution of this procedure necessarily leads to a concrete result. The property of mass requires special attention. At first glance, this property is not executed when considering the solution of a concrete arithmetic plot problem. Indeed, what kind of mass can we talk about if we consider the sum 8+5 as the solution of the next problem: "How many apples lay in two vases, if one vase contained 8 apples and the other 5 apples? In fact, even in this case, the mass is present. First, it is quite clear that this algorithm as a solution to a problem corresponds to other problems with a similar plot. For example, it is possible to consider not apples but oranges, not vases, but plates, etc. Thus, it is possible to consider any number of problems corresponding to this solution. But this is a manifestation of mass, which, if I may say so, lies on the surface. A deeper manifestation of mass is that the solution recorded for specific numerical data can be generalized for any numerical data. Pupils will easily agree that changing numerical data does not change anything fundamentally in the solution of the problem, since the defining element of the solution to the problem is the choice of action, not the specific numbers over which the action is performed. Therefore, a similar problem, but with other numerical data, may well be considered as a problem corresponding to the specified algorithm, only the algorithm, in this case, should be understood as a procedure for adding the number of apples in one vase with the number of apples in another vase. This interpretation brings us to a higher level of generalizations, but it is quite accessible to students. Finally, we can consider a combination of these types of generalizations, when the plot and numerical data change, but the choice of action is preserved.

In this case, the algorithm should be understood as a procedure for adding the number of subjects in one set with the number of subjects in another set, provided that the sets do not intersect. It is not necessary to go to this level of generalization with all students, but the teacher should be aware of the existence of this possibility and use this possibility in favorable situations.

We have provided examples of the use of different mathematical theories in the study of various questions in the basic course of mathematics. There are many other examples of the use of mathematical theories as a basis for the appropriate methodological approach. But it is already clear from these examples that mathematical theories can be so deeply integrated into methodological approaches that it is already difficult to separate one from another, and vice versa, the mathematical theory and methodological approach become one. One can even say that the logic itself and the corresponding content of mathematical theory become a methodical approach.

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