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ERRORS MADE BY STUDENTS FROM FIFTH GRADE IN MACEDONIA WHILE STUDYING MATHEMATICS*

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When students learn content, it is unavoidable that omissions occur and if they are not eliminated in a timely manner, they are multiplied further on in the course of education. Hence, one of the tasks of the mathematics instruction is to discover the errors made by the students and to eliminate them on time. In this paper we present the results of the research on some of the errors made by fifth grade students in the Republic of Macedonia. Also, an effort has been made to systemize and identify the causes for their occurrence and we have offered procedures for elimination of the errors identified.

1. Introduction. It is natural that the students make errors, when learning certain material. The detection of these errors and their timely correction, in order to eliminate them when learning new things, is a process which the teacher should constantly realize and it is vital in the process of acquiring permanent and usable knowledge and skills. As a result of this, the subject of this paper is the detection and correction of the errors made by the students from fifth grade in the primary education. The detection is made with direct research in the classroom. We carried out the research on a sample of 500 teachers, and teaching observation of the subject Methodology of mathematics education, realized by the students from the Faculty of Pedagogy in Skopje. For the purposes of our research, we used tests designed by school teachers. Thus the tests were made unbiased and independent of the various mathemtics textbooks used in our education system. Namely, although the same syllabus is in question, the results of the instruction are, among other things, influenced directly by the textual didactic means, i.e. the textbook which is used in the specific school. Further on, we made an effort to offer directions for correction of all identified errors, which can also be used as a method or a procedure to anticipate the occurrence of these or similar errors by the students of the future generations.

The syllabus for the subject Mathematics in the fifth grade of the primary education, for the arithmetic and algebraic parts, has three units, therefore, the errors which are made by the students can be divided in the following three characteristic groups:

1) errors made while learning material from the set theory unit,
2) errors made while learning material from the addition, subtraction, multiplication and division up to 1000000 unit,

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3) errors made while learning the fractions unit.

Further on, we will identify the cause for each group of errors and we will offer a method and a procedure for correction of the identified errors, which can be used to correct and anticipate the occurrence of these or similar errors by the students of the future generations. We can have an extensive discussion about the need to timely detect and correct mathematical errors made by the students, however, without scrutinizing these issues in detail, it is enough just to mention that the timely detection and correction of the omissions in the mathematical knowledge is important because of:

– the concentric circles, which mathematics instruction is realized in, in the initial education, the errors which are not corrected on time, are multiplied when learning new material, and
– the omissions in the mathematical knowledge are a great obstacle in the integration of the overall instruction in primary education, and especially the integration of the instruction of the technical and natural scientific instructional disciplines.

2. Errors made while learning material from the set theory unit. In fifth grade, students learn elements of the number theory in more detail. When learning material related to the Set theory, we almost did not identify errors related to union, intersection and difference of two sets. However, during the teaching observation, the students solved problems of the following type.

Example 1. *There are 50 teachers in the school, and 29 of them drink coffee, 28 drink tea, and 16 drink neither coffee, nor tea. How many teachers drink only coffee and how many of them, only tea?*

Some students solved this problem using a Venn diagram, intuitively using the following equation:

$$\delta(A \cap B) = \delta(A) + \delta(B) - \delta(A \cup B)$$

A is notation for the set of coffee drinking teachers, and B for tea drinking teachers:

a) $A \cup B$ are all teachers

b) $A \cap B$ are teachers who drink both coffee and tea

resulting in

$$\delta(A \cap B) = \delta(A) + \delta(B) - \delta(A \cup B) = 29 + 28 - 50 = 57 - 50 = 7.$$

Further on, they put it in a Venn diagram and gave the following answer: 22 *teachers drink only coffee, and* 21 *drink only tea.*

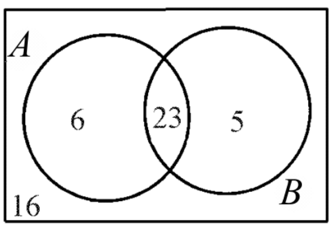


Fig. 1

Clearly, in this case, the students made an error, which was a result of the poorly learned methodology for solving problems, i.e. of the fact that the students have not understood the problem, namely they have not seen the basic, specific and unessential information presented in the formulation of the problem, according to which 16 teachers drink neither coffee, nor tea. The solution of this problem is (Figure 1):

Since 16 teachers drink neither coffee, nor tea, we get that

$$\delta(A\cup B) = 50-16 = 34,\ \ \delta(A\cap B) = \delta(A)+\delta(B)-\delta(A\cup B) = 29+28-34 = 57-34 = 23,$$

23 teachers drink both coffee and tea. $29 - 23 = 6$ teachers drink only coffee, and $28 - 23 = 5$ teachers drink only tea.

As we previously stated, the elimination of this type of errors is possible only through the complete use of the methodology for solving problems. The elementary school teachers should be trained to use this methodology in the course of their education, and this methodology should also be used when creating textual didactic tools (textbooks, workbooks and problem collections), which is not the case in most of them.

During the teaching observation, while revising the lesson *Set difference,* the teacher gave the problem reviewed in Example 2, which according to the difficulty, can be classified as a problem for advanced students.

Example 2. *Let* $A = \{1, 2, 3, 4, 5\}$ *and* $B = \{4, 5, 6, 7, 8\}$. *Determine the set* X *such that* $X \subseteq A \cup B,\ X \cap A = A\backslash B,\ X \cap B = B\backslash A$

Most of the students used the condition that $X \subseteq A\cup B$ and correctly concluded that $X \subseteq \{1, 2, 3, 4, 5, 6, 7, 8\}$. Further on, these students correctly determined that: $A\backslash B = \{1, 2, 3\}$ and $B\backslash A = \{6, 7, 8\}$ nevertheless, they stated that $X = \{1, 2, 3, 4, 5, 6, 7, 8\}$, which is not correct.

It can be said that this problem is not adequate for all fifth grade students, since if we are talking about a problem which aims to review the learned material, then, it should be solved as follows:

We have, $X \cap A = A\backslash B = \{1, 2, 3\},\ X \cap B = B\backslash A = \{6, 7, 8\}$, therefore

$$X = X \cap (A \cup B) = (X \cap A) \cup (X \cap B) = (A\backslash B) \cup (B\backslash A) = \{1, 2, 3\} \cup \{6, 7, 8\} = \{1, 2, 3, 6, 7, 8\}.$$

Clearly, we cannot expect this solution from fifth grade students, since they have not yet learned the distributive law of intersection over union. Consequently, we can say that in this specific case, the error is not made by the students, *the error is made by the teacher while planning the lesson.* The explanation that the problem can be solved in the following way does not hold. We have: $X \cap A = A\backslash B = \{1, 2, 3\},\ X \cap B = B\backslash A = \{6, 7, 8\}$. Further on, $X \cap A \subseteq X$ and $X \cap B \subseteq X$, and therefore

$$\{1, 2, 3, 6, 7, 8\} = \{1, 2, 3\} \cup \{6, 7, 8\} = (A\backslash B) \cup (B\backslash A) = (X \cap A) \cup (X \cap B) \subseteq X$$

However, $X \subseteq A \cup B$ implies that every element of X belongs to $X \cap A$ or to $X \cap B$, and therefore

$$X \subseteq (X \cap A) \cup (X \cap B) = (A\backslash B) \cup (B\backslash A) = \{1, 2, 3\} \cup \{6, 7, 8\} = \{1, 2, 3, 6, 7, 8\}$$

The last allows us to conclude that $X = \{1, 2, 3, 6, 7, 8\}$.

3. Errors made while learning material from the addition, subtraction, multiplication and division up to 1000000 units. While learning the units Addition and subtraction up to 1000000 and Multiplication and division up to 1000000, we detected a great number of errors, which we will try to correct by presenting several examples.

Example 1. a) When solving the problem:

Compute the value of the expression: $245 - 45 : 5 + 764$
an astonishingly great number of students wrote:

$245 - 45 : 5 + 764 = (245 - 45) : (5 + 764) = 200 : 769$ or $245 - 45 : 5 + 764 = 200 : 769$
instead of

$$245 - 45 : 5 + 764 = 245 - 9 + 764 = 1000$$

b) When solving the problem:

Compute the value of the expression: $345 : 5 \cdot 3 - 15$
some students wrote:

$$345 : 5 \cdot 3 - 15 = 345 : 15 - 15 = 23 - 15 = 8$$

instead of

$$345 : 5 \cdot 3 - 15 = 69 \cdot 3 - 15 = 207 - 15 = 192$$

Obviously, in both cases there is an error, which stems from the fact that the students have not learned the order of the operations multiplication, division, subtraction and addition of natural numbers.

The correction of this type of errors can be accomplished by solving many problems, which will emphasize which arithmetic operation and, in what case, has the priority over another arithmetic operation. However, textbook [5], which is used by the majority of teachers, does not pay attention to this essential question. Namely, the analysis of this textbook shows that it does not offer a completely solved example, and there is a lack of problems that would allow the students to learn the order of arithmetic operations. Apart from this, the textbook states the following on p. 92:

If any expression includes the operations addition, multiplication, division and subtraction, first the operations multiplication and division are carried out and then addition and subtraction.

Although at first glance this rule seems to be correct, it is not. Namely, while formulating this rule, the authors did not mention that the operations are performed from left to right at a given order in an expression. The absence of this important fact is actually the reason for the error made in the problem in b).

Example 2. When solving the problem:

What number is gained if the sum of 58432 *and* 36295 *is divided by* 100?
most of the respondents wrote: $(58432 + 36295) : 100 = 94727 : 100 = 947$ and answered that it was the number 947. Clearly, this is an error, but in this case, the error is made by the teacher, who gave an imprecise formulation of the problem. Namely, if the objective is to check the algorithm for division with a remainder, then the task should be formulated in the following way: *Find the quotient and remainder when the sum of the numbers* 58432 *and* 36295 *is divided by* 100.

Example 3. When solving the problem:

Calculate:

a) $(456721 - 243121) : 25$ b) $(456721 + 243104) : 25$
some students applied the distributive law and wrote:

a) $(456721 - 243121) : 25 = 456721 : 25 - 243121 : 25 = 18268 - 9724 = 8544$
instead of

$$(456721 - 243121) : 25 = 213600 : 25 = 8544$$

b) $(456721+243104):25 = 456721:25+243104:25 = 18268+9724 = 27992$ instead of

$$(456721+243104):25 = 699825:25 = 27993$$

and they were convinced that they had solved the given problem correctly. Clearly, in the problem a) the same result is produced but in a wrong way, and in the case b) both the procedure and the result are wrong. We notice that in this case there is a repetition of the errors we detected in the fourth grade students, and as we have previously mentioned, the reason for these errors is the use of the distributive law in a case when the operation division is not possible in the set of natural numbers and it is due to patterned instruction, which is unfortunately also encouraged by the authors of the existing textbooks. Hence, in [5], p. 127, the following problem is presented:

Calculate: $(136+40):8 = \_\_$ *in two ways*

and the following solution is offered:

First way: $(136+40):8 = 136:8+40:8 = 17+5 = 22$

Second way: $(136+40):8 = 176:8 = 22$

followed by the formulation of the distributive law:

A sum is divided by a given number in two ways:
all addends are divided by the given number and the quotients are added;
the sum of the numbers is calculated and then divided by the given number.

Clearly, we do not have remarks regarding the two ways of solving the problem and the formulation of the distributive law, but we will note that the authors did not pay attention that the distributive law of addition over division in the set of natural numbers, i.e. the equation $(a+b):c = a:c+b:c$, can be applied if and only if the two addends are divisible (a and b are both divisible) by the number c.

In this case as well, the elimination of the mentioned errors is possible only by solving a great number of similar examples, respecting the methodology for solving problems and learning the commutative, associative and distributive laws.

Example 4. a) When solving the equation $x-2165 = 412\cdot 195$ some students wrote:

$$\begin{array}{lcl} x = 412\cdot 195 - 2165 & & x = 412\cdot 195 + 2165 \\ x = 80340 - 2165 & \text{instead of} & x = 80340 + 2165 \\ x = 78175, & & x = 82505. \end{array}$$

b) When solving the equation $500:x = 10$ some students wrote:

$$\begin{array}{lcl} x = 500\cdot 10 & \text{instead of} & x = 500:10 \\ x = 5000 & & x = 50, \end{array}$$

And when solving the equation $5800:x = 10$ some students wrote:

$$\begin{array}{lcl} x = 5800\cdot 10 & \text{instead of} & x = 5800:10 \\ x = 58000 & & x = 580. \end{array}$$

Clearly, it is difficult to identify the source of the error in all three cases. However, it is important to mention that the textbook, which was used by this group of students, does not present a solved example of this type of equations, so if we take into consideration that these types of equations were learned by the students in the previous grades, then, even if they had learned them correctly, given the long period of time, it is possible that the errors are a result of forgetting the knowledge attained previously. This view is supported by the undeniable fact that the teachers fully abide by the methodology presented in the textbooks, which they use, and can be noticed by the texts they use.

Example 5. a) When solving the problem:

480 *passengers are travelling in* 10 *wagons in a train. How many passengers are there in each wagon if all wagons have the same number of passengers?*

Some students gave "the solution": $480 - 10 = 470$ passengers, and the others wrote: $10 : 480 = \dots$, instead of $480 : 10 = 48$ passengers.

Clearly, in this case, the students did not understand the problem, which is a result of the insufficient coverage of the methodology for solving problems, i.e. the absence of learning the four stages for solving mathematical problems, which we addressed earlier.

b) When solving the problem:

A car passes 1250 *meters in a minute. How many meters will the car pass in* 2 *hours and* 15 *minutes?*

some students gave "the solution":

$$1250 \cdot (15 + 2) = 1250 \cdot 17 = 21250 \text{ meters},$$

and the others:

$$1250 \cdot (15 \cdot 2) = 1250 \cdot 30 = 37500 \text{ meters},$$

instead of

$$2 \text{ h } 15 \text{ min} = (120 + 15) \text{ min} = 135 \text{ min}$$

therefore, the car will pass

$$1250 \cdot 135 = 168750 \text{ meters}.$$

Clearly, in both cases we have an error, which in the first case is due to the poor learning of the time measurement units, and in the second case it is due to the fact that the students did not understand the problem.

One of the objectives, when learning the material of this unit, is for the students to get introduced to the elementary structural knowledge about the sets of numbers. In order to attain this objective, many teachers ask the so-called "theoretical questions" to check the level of attainment of the elementary structural knowledge. However, we cannot understand the reason that some of the questions, which are used, are not formulated correctly, therefore, rendering it impossible to carry out the desired check. We will mention one such question in the following example.

Example 6. When checking the knowledge related to multiplication of numbers up to a million, the following question is frequently used:

If the product of two numbers is 1*, then at least one of the multipliers is equal to* ______ .

Clearly, the question is correct, however it is adequate to ask this question in second or third grade. Apart from this, taking into consideration the fact that the product of two natural numbers equals one, if and only if the two numbers equal one, better idea is to formulate that question in the following way:

If the product of two numbers is 1*, then both multipliers are equal to* ______

4. Errors made while learning material from the unit Fractions. While learning the unit Fractions, during our research, we detected certain errors, which will be stated in the text below.

Example 1. When solving problems of the type: $\frac{2}{10} + \frac{4}{10} = \cdots$, some students wrote:

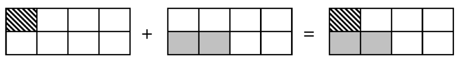
$$\frac{2}{10} + \frac{4}{10} = \frac{2+4}{10+10} = \frac{6}{20}, \text{ instead of } \frac{2}{10} + \frac{4}{10} = \frac{2+4}{10} = \frac{6}{10}.$$

At first glance, we cannot find a logical reason for this type of errors, since the authors of textbook [5] have offered an adequate illustration for *adding fractions with a common denominator.* Hence, apart from the fact that the textbook offers an "unusual" illustration, it is accompanied by the following correct explanation:

$$+\begin{array}{c} \text{3 sixth} \\ \underline{\text{2 sixth}} \\ \text{5 sixth} \end{array}, \quad \text{hence,} \quad \frac{3}{6} + \frac{2}{6} = \frac{5}{6}.$$

When adding two fractions with a common denominator, the numerators are added and the denominator remains the same.

Nevertheless, we may say that this approach does not sufficiently explain how to add fractions with equal denominators, hence, this type of errors can be corrected if the students learn well how to add fractions with common denominators. It would be best if the initial examples were clearly illustrated and the teachers used standard procedures, which do not seem "interesting" but are very effective. For example, the following illustration can be used to add the fractions $\frac{1}{8}$ and $\frac{2}{8}$



which can be accompanied by the following explanation: $\frac{1}{8}$ is marked in the first rectangle on the left, and $\frac{2}{8}$ in the second rectangle. $\frac{3}{8}$ are marked in the third rectangle in the same way, which makes us conclude that $\frac{1}{8} + \frac{2}{8} = \frac{3}{8}$. Finally, after reviewing several examples like this one, we may offer the following formulation about adding fractions with common denominators.

The sum *of two fractions with common denominators is a fraction with the same denominator like the one of the added fractions, and a numerator equal to the sum of the numerators of the added fractions, i.e.* $\frac{a}{c} + \frac{b}{c} = \frac{a+b}{c}$, $c \neq 0$.

Example 2. When solving problem of the type: $\frac{20}{25} - \frac{7}{25} = \cdots$, some students wrote:

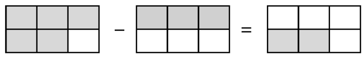
$$\frac{20}{25} - \frac{7}{25} = \frac{20-7}{25-25} = \frac{13}{0}, \text{ instead of } \frac{20}{25} - \frac{7}{25} = \frac{20-7}{25} = \frac{13}{25}.$$

At first glance, we cannot find a logical reason for this type of errors, since although the authors of textbook [5] have not illustrated the *subtraction of fractions with a common denominator*, they have "adequately" explained the subtraction of fractions with a common denominator in the following way:

$$-\begin{array}{r} \text{8 eighth} \\ \text{5 eighth} \\ \hline \text{3 eighth} \end{array}, \quad \text{hence,} \quad \frac{8}{8}-\frac{5}{8}=\frac{3}{8}.$$

When subtracting fractions with common denominators, the numerators are subtracted and the denominator remains the same.

Nevertheless, we are safe to say that this approach does not explain the subtraction of fractions with a common denominator, therefore, this type of errors can be corrected if the students learn it well. We believe that it is best to use the following standard procedure. For example, the following illustration can be used to subtract the fractions $\frac{5}{6}$ and $\frac{3}{6}$.



which can be accompanied by the following explanation: $\frac{5}{6}$ are marked in the first rectangle on the left, and $\frac{3}{6}$ in the second rectangle. $\frac{2}{6}$ are marked in the third rectangle in the same way, which leads us to conclude that $\frac{5}{6}-\frac{3}{6}=\frac{2}{6}$. Finally, after reviewing several examples like this one, we may offer the following formulation of the rule about subtracting fractions with common denominators.

The difference *of two fractions with common denominators is a fraction with the same denominator like the subtracted fractions, and a numerator equal to the difference of the numerators of the subtracted fractions, i.e.* $\frac{a}{c}-\frac{b}{c}=\frac{a-b}{c}$, $a, b > 0$, $c \neq 0$.

Note. At the end of this part we would like to note that apart from the fact that the authors in textbook [6] have adequately introduced the comparison of fractions with common denominators, the authors of textbook [5] have not used this for revising the material, and then, they ask the students to compare fractions $\frac{1}{2}$ and $\frac{1}{3}$ on p. 130, which is something that is not planned in the syllabus. Apart from this, this action of the authors of textbook [5] can lead to serious difficulties in the future attaining of structural knowledge about the sets of rational numbers, data processing, percentages and ratios, material which is planned in the syllabus for fifth grade. Namely, the explanation that *it is clear from the illustration*, which accompanies the task, is not a good one, since it renders the statement wrong and denies the students the possibility to learn that every statement needs to be proved. This explanation is in collision with the algorithm for comparing the areas of plane figures, which is used by the authors further on in the textbook.

5. Conclusion. In the above text we paid our attention to the omissions in the knowledge and skills of the students in fifth grade, which are detected with the research. We listed the reasons why these errors occur and also suggested appropriate procedures to eliminate them. As we have seen, there are many objective reasons for the occurrence of errors, and they need to be located outside the classroom. The analysis of the overall position of the education system and the school course in mathematics within the system shows that:

– although the syllabus for fifth grade has been reduced in order to "unburden" the students, there are no visible effects of this action, which is a result of the constant changes of the syllabi, without prior analysis and answer to the questions what, why and how to change the syllabi, as well as how these changes should be implemented in the didactic means;
– the syllabi, created in this way, and the effort to make a universal concept for a textbook, which applies both for mathematics and PE, resulting from the so-called pedagogization of the education process, has an extremely negative influence on the mathematics textbooks, which are currently used and planned for use in the Macedonian education system. Some of them do not cover well the curriculum;
– there is a tendency to compensate the shortcomings of the textbooks with the so-called workbooks, which are not only of bad quality, but slowly and surely replace the textbooks and rapidly cement the already wrong view that mathematics is just solving tasks and nothing more, and
– the current partial changes in the education system resulted in a drastic decrease of the fund of classes for realizing mathematics instruction, and the "extra classes" are now used to realize the new ideological subjects, such as Civic education, Ethics, etc.

Consequently, we can conclude that the reasons for the omissions in the knowledge and skills of the students are not just a result of the work of teachers and students, which is why it is not fair to hold the teachers responsible for the poor results and their alleged continuing mathematical education, which is carried out through different seminars and training. The latter is especially indicative, since in the past two decades there are continuous seminars for modernizing education (step by step, interactive instruction – active learning, use of assessment standards, etc.), while the results of the previous have had a negative trend for almost two decades.

Taking into consideration the previously mentioned, it is necessary to carry out a thorough analysis of the syllabi and the textual didactic means, as well as the segments of the education system, in which the future teachers for initial education are produced before approaching any further changes. This means that the future changes need to be coordinated with the results gathered from the mentioned analyses.

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ГРЕШКИ, ДОПУСКАНИ ОТ ПЕТОКЛАСНИЦИТЕ В МАКЕДОНИЯ, ПРИ ИЗУЧАВАНЕ НА МАТЕМАТИКА

Методи Главче, Ристо Малчески, Катерина Аневска

Когато учениците изучават учебното съдържание, е неизбежно да допускат грешки, но ако тези грешки не бъдат отстранявани своевременно, те се умножават при по-нататъшното обучение. Ето защо една от задачите на образованието по математика е да открива грешките, допускани от учениците, и да ги отстранява навреме. В тази статия представяме резултатите от изследването на някои от грешките, допускани от петокласници в Република Македония. Също така правим опит да систематизираме и идентифицираме причините за тяхната поява и предлагаме процедури за отстраняване на откритите грешки.

2010 Mathematics Subject Classification: 97D70.

Ключови думи: грешки, откриване, коригиране, множество, данни, дроб.