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INVESTIGATION OF ELEMENTARY PRE-SERVICE TEACHERS' ARITHMETICAL OPERATION SKILLS

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Abstract: In this research, it has been intended to describe pre-service elementary teachers' arithmetical operation skills by handling in learning environments. Case study method was accepted in the research. 80 pre-service elementary teachers studying at a state university in Turkey constituted the study group. The data were obtained through asking four questions to pre-service teachers and collecting answers in written. When analyzing the data, the error types of pre-service teachers were determined, and the interviews were analyzed through content analysis. It has been pointed out that the pre-service teachers make frequent errors in arithmetical operation process as a conclusion of the research. These errors intensify in multiplication and division. As a matter of fact, it has been figured out that there were some pre-service teachers who did not make any operations in multiplication and division. In the interviews, the pre-service teachers grounded their errors upon elementary education. They stated that they made continuous errors as they did not have a good elementary education and they did simple errors depending on four operations in university entrance exam. Once again, two pre-service teachers who did not make any errors grounded this upon good elementary and middle school education.

Key words: Arithmetic, Four operations, Pre-service teacher

1. Introduction

Arithmetic includes the numbers, inter-number relations and calculations through four operations (addition, subtraction, multiplication, division) (National Council of Teachers of Mathematics [NCTM], 1991). According to Mason (1996), all the operations depending on using four operations done to find the unknown moving from the known are arithmetic. Learning to calculate and using calculation skills to solve problems create a basis for arithmetic (Burns, 2000). Thus, it can be said that arithmetic covers the numbers and all the operations done via numbers.

Arithmetical skills create a basis for elementary mathematics (NCTM, 2000). Knowledge of four operations creates a basis for advanced level of mathematics (Campbell & Xue, 2001). Students construct algebra depending on the experiences they have in arithmetic (Kieran, 1992; Hersovics & Linchevski, 1994). Arithmetical deficiencies prevent students from algebraical thinking. Therefore, the students have trouble (Williams & Cooper, 2001). Arithmetical deficiencies affect problem solving skills of students in a negative way (Jordan, Hanich & Uberti, 2003).

Doing arithmetical operations fluently provides students with achieving advanced level of mathematical tasks (Wong & Evans, 2007). So, it can be said that the students should have operational fluency. Operational fluency is the ability of applying the operations in a flexible and correct way (Van de Walle, Karp & Bay-Williams, 2010). Operational fluency develops according to the speed of answering questions and using the correct strategy (Carr, Taasoobshirazi, Stroud & Royer, 2011).

In some cases of arithmetical operations, the students might have trouble in applying standard rules. The strategies produced (explored) by students in operational process might be more useful. Developing their own strategies when doing arithmetical operations can provide students with gaining operational fluency. The calculation operations done without comprehension are generally forgotten or misremembered. (Hiebert 1999; Kamii, Lewis & Livingston, 1993). This can hinder problem solving process (Thornton, 1990). Therefore, it can be said that teachers should present opportunities for students to understand the subject deeply and not restrict them by rules in the process of teaching four

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operations. When the opportunity is given, students will explore natural methods for calculating (Fuson, 2003). Additionally, it can be claimed that the teachers need to have arithmetical operation skills. It is because one of the factors affecting mathematical learning of students is teacher efficacy (NCTM, 2000). In mathematics teaching, how to teach is as important as the quality of the knowledge (NCTM, 1989). At this point, it can be said that the field knowledge and pedagogical knowledge of the teacher is affective. According to Shulman (1987), the skills providing a matter with being understood by others include pedagogical knowledge while the knowledge of the teacher on the concepts of his/her field is called as field knowledge. On this basis, the field knowledge and the ability to transfer this knowledge is in great importance in mathematics teaching.

McNamara (1991) has stated that the skills the teacher will exhibit in learning environment is related to the knowledge on subject and teaching skills. According to Ball (1990a) it is necessary to have mathematical knowledge and to understand mathematics for affective mathematics teaching. Fennema and Franke (1992) pointed out that teacher's content knowledge, pedagogical knowledge and students' knowledge towards learning are necessary for effective mathematics teaching. Similarly, Grossman (1990) stated that a teacher needs knowledge about subject, general pedagogical knowledge and pedagogical content knowledge for conducting effective teaching. On the basis of these knowledge, it can be said that the teachers should have comprehensive, flexible, applicable mathematical knowledge and teaching skills. The teachers with greater knowledge display originality in enriching the existing mathematics for learners (Fennema & Franke, 1992). It can be thereby stated that the teachers with larger field knowledge will create a difference in professional implementations and mathematics achievement of the students. In the literature, it has been stated that the field knowledge of teacher has a crucial role for an effective way of teaching mathematics and student achievement (Baumert et al., 2010; Hill, Rowan & Ball, 2005; Goulding, Rowland & Barber, 2002).

Goulding et al., (2002) has stated that deficient subject or field knowledge of pre-service teachers will affect their planning skills towards teaching. Teaching mathematics requires understanding comprehending different solutions and methods (Ball, Bass & Hill, 2004). The field knowledge of pre-service elementary teachers in mathematics and their perceptions of mathematics teaching will form their future teaching. In this research, it has been aimed to investigate arithmetical operation skills of pre-service elementary teachers. It is considered that the results of the research will provide an awareness for pre-service elementary teachers about the mathematical content knowledge related to the subject and present an opportunity to improve their knowledge. Additionally, it can be said that it will plant opinions to the teacher training institutions and authorities, elementary teachers and researchers.

2. Method

2. 1. Research Model

Case study has been accepted in the research. In case studies, a phenomenon is investigated by approaching in its real context. In this process the questions of what, how, and why are searched (Stake, 1995; Yin, 2003). The researchers can obtain detailed data related to the case. Generalization is not intended in case studies (Lichtman, 2006). A limited system (case, individuals, process, etc.) is investigated deeply by collecting extensive data (Creswell, 2007). In this research, it has been intended to define arithmetical operation skills of pre-service elementary teachers by approaching in learning environments.

2. 2. Study Group

The study group of the research was determined via criterion sampling from purposeful sampling methods. The purposeful sampling is used explore-intended or field researches and valuable for specific situations (Neuman, 2014). On the other hand, criterion sampling includes studying the cases meeting with some predetermined criteria. These criteria could either be created by the researchers or have been created beforehand (Yıldırım & Şimşek, 2011). The criteria when selecting the pre-service teachers in this research was determined as studying at the department of elementary teaching, still taking the class mathematics teaching I and that the subjects in the scope of operations teaching have not been instructed

yet. According to these criteria, the study group consisted of 80 pre-service elementary teachers studying at a state university in Turkey.

2. 3. Data Collection

Four questions were prepared in the research to reveal four operation skills of pre-service teachers. When the questions were prepared, including multiple-digit numbers was considered. The learning outcome in 4th grade mathematics course teaching curriculum "*reads and writes 4-, 5- and 6-digit natural numbers* (Ministry of National Education [MoNE], 2017, pp. 49)" was referred and the questions were prepared as including at least 4-digit numbers. In the questions prepared, maximum 9-digit for addition, maximum 8-digit for subtraction, 4-digit for multiplication and 9-digit numbers were selected for division operations. The possible errors in operational process were considered when preparing the questions. The prepared questions were asked to the pre-service teachers before starting the units of four operations teaching in mathematics teaching I class. The pre-service teachers asked to answer questions on a blank paper. Any time limitations were not stated for pre-service teachers to answer the questions during the class. The implementation was done under the supervision of two researchers and using mobile phones, calculators etc. and communicating with each other was not allowed for pre-service teachers. At the end of the time given, the papers of pre-service teachers were collected. Then ten pre-service teachers were selected for interviews among them according to their operation results as no errors, only one error, two errors, three errors and all the questions with errors. The papers including their operations were given to these pre-service teachers, they asked to examine their papers and the sources of errors were interviewed with them. The interviews were recorded in written.

2. 4. Data Analysis

When the data were analyzed, the solutions of pre-service teachers were separately investigated by two researchers, the true and false answers were determined according to the operational results. Then the error types were determined by considering the false answers of pre-service teachers. These error types were calculated for each of addition, subtraction, multiplication and division operations (total of errors made) numerically. Finally, content analysis technique was used to analyze the interviews on the errors and the sources of these errors. In content analysis similar data are presented to the audience in a meaningful way by combining in terms of determined themes and concepts (Fraenkel and Wallen, 2000). In the research, the written documents of the interviews were read by each researcher independently and the similar data were coded. The categories were created according to the codes. For providing coding reliability, the formula suggested by Miles and Huberman (1994), Agreement/(Agreement + Disagreement) x 100 was utilized. According to this formula, the codes are accepted reliable if the value calculated is above 70%. In this research, the calculated value was found 89% and it was regarded reliable for the research. When the categorization was done, the pre-service teachers were numbered from 1 to 10 (e.g. T1, T2, … T9, T10). The categories reflecting the reasons of pre-service teacher errors are presented in tables. In that table, the error expressions are presented according to each of addition, subtraction, multiplication and division or errorless one.

3. Findings

Presenting the findings, the types of errors related to four operations by pre-service teachers are given in numbers initially. Afterwards, the samples of four operations from the errors of pre-service teachers are given. Finally, the categories reflecting the reasons of errors of pre-service teachers who were interviewed about them are presented in tables.

Table 1. *Distribution of Pre-service Elementary Teachers According to Their Errors in Four Operation Process*

Error Types	Addition	Subtraction	Multiplication	Division
Calculation Error	27	29	41	46
Digit Error	1	-	6	-
Inattention*	3	5	-	2
No Operation	-	-	3	11
Total	31	34	50	59

*The errors made by pre-service teachers (missing information, incorrect information, incomplete question etc.) were evaluated within this context.

Investigating Table 1, it is seen that the errors of four operations are grouped under four headings as calculation error, digit error, inattention and no operation. Calculation error was most commonly made in the operations of multiplication and division. On the other hand, digit error was made dominantly in multiplication. It has been seen that errors were made as a consequence of inattention in all three operations. The most outstanding point here is that three pre-service teachers in multiplication and eleven in division did not perform any operations.

When the errors made in addition by pre-service elementary teachers are investigated, it is seen that specifically calculation errors (27 pre-service teachers) were made. Calculation errors sometimes stem from calculating carry while they stem from wrong operations in some cases. Three pre-service teachers made errors because of inattention while one pre-service teacher dislocated the digits in operation process. Some errors made by the pre-service teachers during addition are as follow.

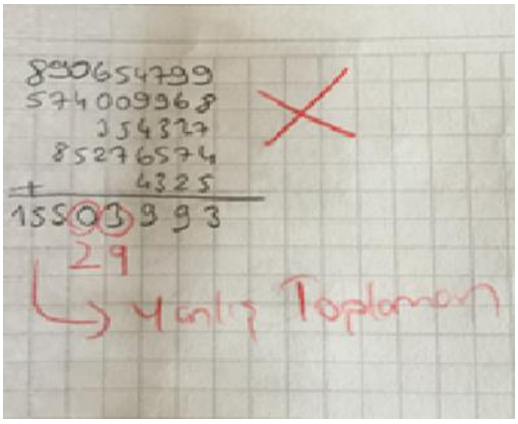

Figure 1

In Figure 1, it can be seen that pre-service teacher made a calculation error. The calculation errors next to each other suggest that the pre-service teacher has a problem with addition.

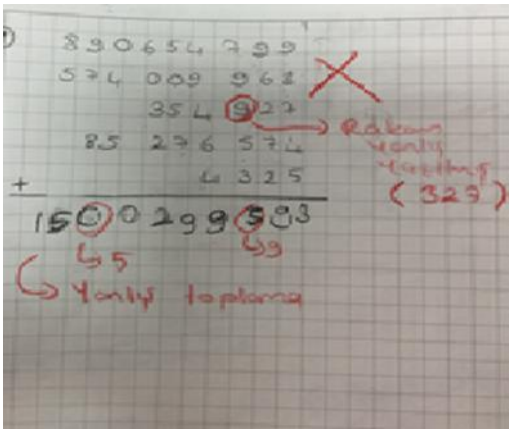

Figure 2

In Figure 2, it can be seen that the pre-service teacher made both a calculation and inattention-related errors by writing the operation wrong.

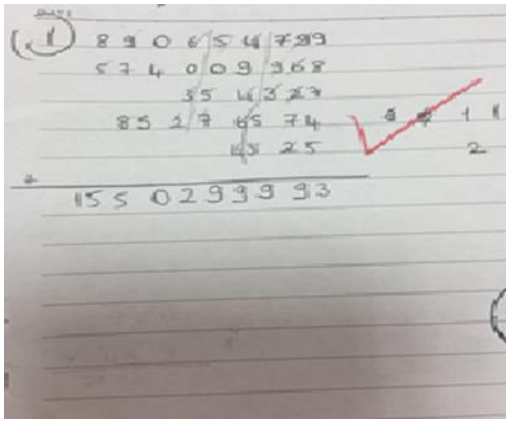

Figure 3

In Figure 3, it is seen that the pre-service teacher did not consider the digits while doing operation and dislocated the digits. This suggests that the pre-service teacher is in trouble with addition.

When the errors made by pre-service teachers in subtraction are investigated, it is seen that 29 of them made calculation errors and 5 made error because of inattention. It has been determined that the errors of subtraction derive from carrying over. The errors were made in the parts depending on breaking 5th, 6th and 7th digits. The samples of errors made by pre-service teachers in subtraction are as follow.

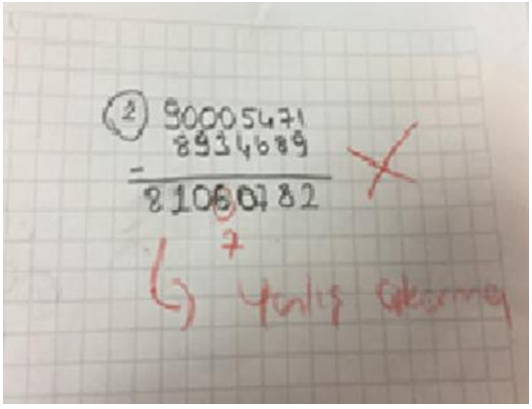

Figure 4

In Figure 4, the pre-service teacher made a calculation error depending carrying over.

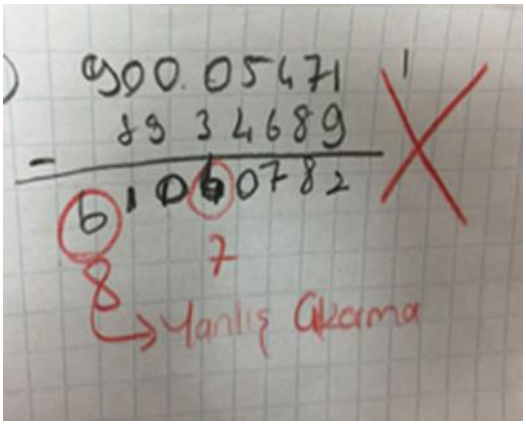

Figure 5

In Figure 5, an error of carrying over was made.

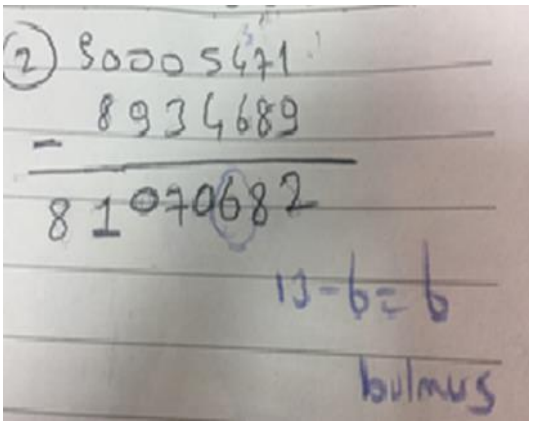

Figure 6

In Figure 6, the pre-service teacher made a calculation error in the subtraction given.

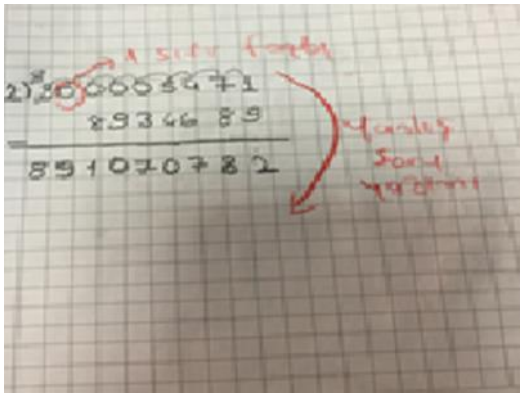

Figure 7

Investigating Figure 7, it is seen that the pre-service teacher made an error while writing the question.

In multiplication, the largest number of errors were made depending on multiplying the numbers. Additionally, some errors deriving from dislocating digits and miscalculation in adding carry were made in operation process. It has been seen that three pre-service elementary teachers did not make any operations. These pre-service teachers were asked for doing the operation, but the pre-service teachers pointed out that they could not do it. Some errors the pre-service teachers made for multiplication are as follow.

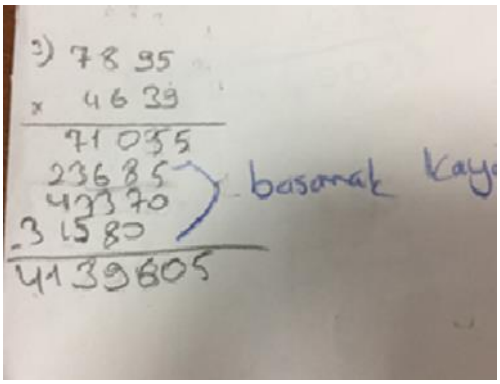

Figure 8

In Figure 8, the pre-service teacher made an error in multiplication when carrying over. This can be interpreted as an indicator of trouble experienced in operation.

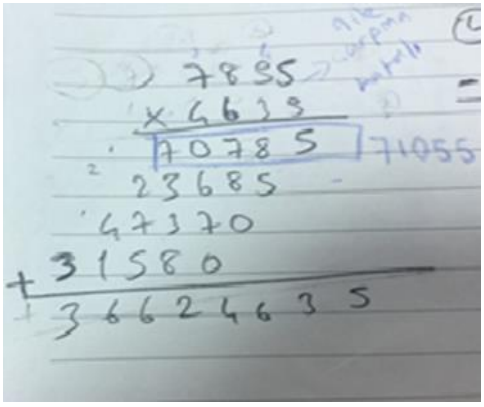

Figure 9

In Figure 9, the pre-service teacher made a calculation error in multiplication. This can be considered as the lack of knowledge about multiplication table.

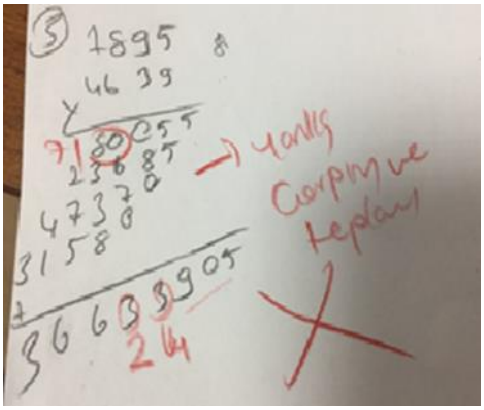

Figure 10

In Figure 10, it can be seen that the pre-service teacher made an error in multiplying by 9 when the result and process examined. An addition error was also made when finding the total.

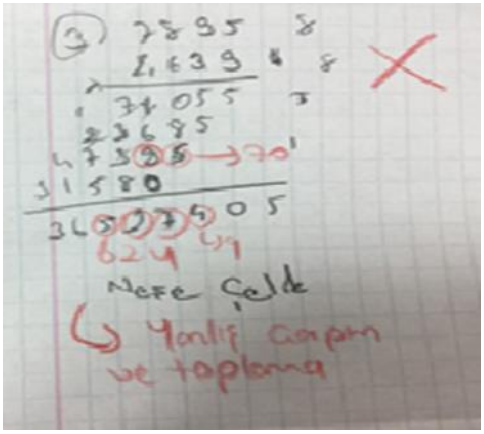

Figure 11

In Figure 11, the pre-service teacher made an error both when multiplying and when finding the total.

Most of the errors were made because of calculation in division. For example, subtraction errors were made in operation process. In addition to this, some errors like disregarding the digit that cannot be divided or doing operations with wrong digits were made. It has been determined that most errors derived from the error made in first subtraction at the beginning of the operation and not writing the number 0 to quotient for undivided digit. Eleven pre-service teachers did not do any operations and they stated that they could not when they were asked to do. Some division-related errors of pre-service teachers are as follow.

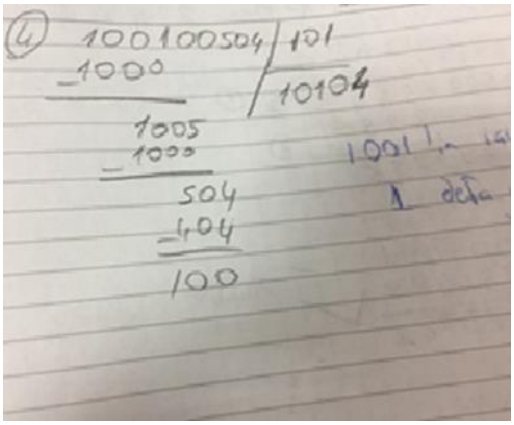

Figure 12

Investigating the operation in Figure 12, it is considered that the pre-service teacher has trouble in all stages of the operation process. An error was made in grouping the numbers of divided number that should have been done at the beginning and relating this to the dividing number.

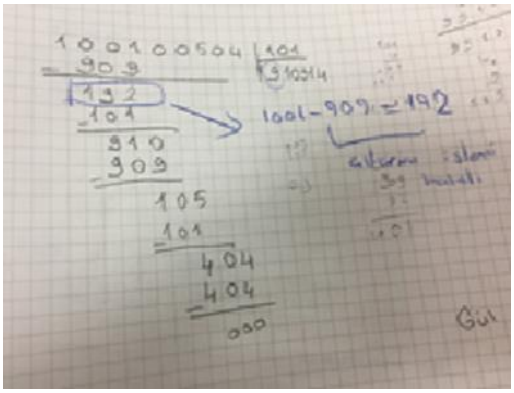

Figure 13

In Figure 13, errors were made in whole process because of subtraction error made in initial stages of the operations.

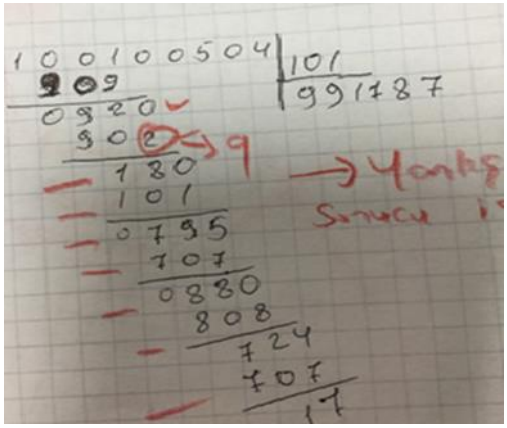

Figure 14

In Figure 14, the pre-service teacher made an error in total because of the multiplication error in initial stages of the operation.

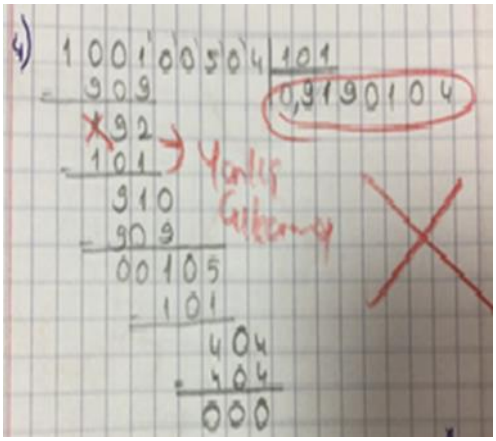

Figure 15

In Figure 15, the pre-service teacher added a 0 and made quotient a decimal. Therefore, it can be considered that the pre-service teacher does not know what to do with undivided digits and has trouble.

Among eighty pre-service elementary teachers, only six did the operations successfully. Among the pre-service teachers, ten pre-service teachers were interviewed according to their operation results as no errors, only one error, two errors, three errors and all the questions with errors. The pre-service teachers were asked about the sources of their errors and the categories of errors were created according to their answers.

Table 2. *The Reasons for Errors of Pre-service Elementary Teachers in Four Operation Processes*

Operation	Category
Addition	-Carry T2, T4 -Elementary education T4, T7 -Inattention T5, T6, T7 -Rush T8 -Tension T8
Subtraction	-Problem in carrying over T2, T4 -Elementary education T2, T4, T7 -Inattention T6
Multiplication	-Classroom environment T1, T3 -Order (digit) T1, T8 -Rarely doing operations T1, T4 -Rush T3, T4 -Dislike T6 -Inattention T6 -Number of digits T7 -Elementary education T1, T6, T7, T8
Division	-Dislike T1 -Number of digits T1, T4 -Rarely doing operations T1, T8, T9 -Elementary education T1, T2, T3, T4, T8, T9 -No knowledge T2 -Problem in undivided digit T5, T8 -Error stemming from another operation T6
Operation with no errors	-Middle school and secondary education T1 -Study T1

	-Elementary education T2

Investigating Table 2, the errors of pre-service teachers in addition are categorized under the titles of carry, elementary education, inattention, rush and tension. Two elementary pre-service teachers stated that they made errors as they did not understand the conception of carry properly. Two pre-service teachers based their errors on their elementary education. These pre-service teachers stated that they had been making errors in addition and they could miss some questions in university entrance exams because of operation errors. Whereas three pre-service teachers stated that they made errors because of inattention, one said that it was because of rush and tension.

The errors of pre-service teachers were categorized as problem in carrying over, elementary education and inattention in subtraction. Two pre-service teachers stated that they made errors because of their problem in carrying over. Three of them stated that it was because of elementary education and they encountered deficient teachers in primary school. On the other hand, one pre-service teacher expressed that the errors were made because of inattention.

The errors of pre-teachers in multiplication were categorized in the titles as classroom environment, rank(digit), rare practice of operations, rush, dislike, inattention, number of digits, elementary education. The pre-service teachers that they were distracted by the noise during the operations in the class, they forgot how to do operations in multiplication and they had been having problems in carrying over since elementary school years. Once again in multiplication, the pre-service teachers expressed that they did not have a good education in elementary school, so they have trouble in multiplication.

The errors of pre-service teachers in division were categorized in the titles as dislike, number of digits, rare practice of operation, elementary education, having no knowledge, problem in undivided digit and error deriving from another operation. The remarkable point here is that one pre-service teacher stated that he cannot do division because of his elementary education. Once again, six pre-service teachers basing their errors on elementary education might be accepted as an important finding. The pre-service teachers stated that they made errors because of they did not know how to cope with a digit that cannot be divided.

One of the pre-service teachers who did not make any errors explained this with the quality of his elementary education and studying well. One other pre-service teacher stated that he did not get a good elementary education bot had a good mathematics education in middle school and high school and became successful. When the pre-service teachers with and without errors are investigated in terms of their excuses, the common point is seen as the elementary education. Additionally, inattention and rush also outstand. Furthermore, it has been determined that errors were made in adding a carry, carrying over, dislocating the digits and undivided digit.

4. Discussions, Results, and Recommendations

As a result of the study, it has been seen that pre-service teachers make very frequent errors in four operation processes. These errors get intense in multiplication and division. Furthermore, there are some pre-service teachers who did not do any operations in multiplication and division. So, it can be saied that the pre-service teachers experience problems in four operations.

In addition, the errors are mostly related to the calculations like wrong carrying over and wrong operation. In subtraction, the most common error type can be seen in carrying over. Therefore, it can be stated that the pre-service elementary teachers have lack of knowledge in addition and subtraction. Similarly, Turnuklu and Yesildere (2007) concluded in their study that the pre-service teachers do not have enough field knowledge of mathematics and they have problem in understanding the relationships between addition and subtraction.

The errors in multiplication are mostly related to wrong multiplying the numbers, dislocating the digits and calculations in carrying. Thus, it can be said that the knowledge of elementary teachers towards multiplication is deficient. This result shows similarity with the literature. Yenilmez and Uygan (2015) stated in their research that pre-service elementary teachers have limited knowledge of multiplication. In addition, Toluk Uçar (2011) the pre-service elementary teacher do not have enough conceptual comprehension through multiplication and division.

In division, there are errors in mechanical process of the operation and deriving from not adding a zero (0) into quotient for the digits that cannot be divided. According to the research of Ball (1990b), most of the pre-service teachers could explain division by quite partial terms. The knowledge of the pre-service teachers mostly depends on memorizing. Most of the could not remember rules as they did not have conceptual comprehension. In teaching multiplication and division, the opportunities for exploring various representations and reasoning towards the relationships between these representations should be provided to the students. In order to do that, it is require that the pre-service teachers should be able to think operationally and conceptually in division and multiplication. Thus, the operational and conceptual comprehension of the pre-service teachers should be focused during their mathematics education. The knowledge of the pre-service teachers thereby can be more permanent.

In the interviews, most pre-service teachers base their errors on elementary education. They stated that they made continuous errors because they did not get a proper elementary education and they did errors deriving from four operations even in university entrance exam. Also, two pre-service teachers who made no errors based their status on their elementary and middle school education. Similarly, Ball (1990b) discussed in a research that the rules of division given by pre-service teachers are the same rules of their own teachers. So, it can be claimed that elementary level learning creates a basis for future learning and will affect following educational stages in a positive way.

The pre-service teachers stated that they made errors in multiplication and division as they did not make frequent operational practices. The errors of teachers can be used as a positive learning experience (Ryan & McCrae, 2005/2006), they can reorganize and strengthen their knowledge reviewing their errors. Additionally, it can be said that the knowledge of the pre-service teachers is insufficient. Kinach (2002) points out that the classes towards developing pedagogical field knowledge of pre-service teachers like methodology if affective in the transformation from operational instructional explanations to conceptual instructional explanations. However, in this transformation, it is also stated that the past experiences and beliefs of pre-service teachers are effective as well.

The studies indicate that the mathematical comprehension of pre-service teachers from pre-college and college classes is not enough for them to instruct at elementary level (Ball, 1990b; Ma, 1999; Toluk Uçar, 2011). This might have been directed the pre-service teachers towards explaining the matter with their past experiences. Therefore, it can be pointed out that the pre-service teachers are in need of the activities for developing their field knowledge about four operations. Similarly, Livy and Vale (2011) stated in their research that a majority of the pre-service teachers are in need of developing their understanding of mathematical structure and making connections between mathematical conceptions.

In this study which has been carried out for investigating arithmetical skills of pre-service elementary teachers, it has been concluded that the field knowledge of pre-service teachers needs to be improved. The instruction provided by elementary teacher in mathematics education is relatively effective in their future learning. Because elementary mathematics is a basis for further learning. Hence, it can be claimed that the quality and importance of classes given pre-service elementary teachers in undergraduate education for mathematics teaching should be improved. For further researches, activities can be practiced towards examining the knowledge of pre-service elementary teachers in all subjects of mathematics teaching class and filing the insufficiencies.

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