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An Examination of the Effectiveness of Instruction in which Pre-Service Mathematics Teachers Use Technology to Overcome Student Difficulties

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Abstract
It is seen that students face certain difficulties when learning the concepts and the relationships between them in the mathematics education that aims at enabling students to learn on the highest level. Identifying and eliminating these difficulties, helping students in the learning process and guiding them are among teachers' tasks. Overcoming the difficulties experienced by students is considered one of the contributions of the technological use to the mathematics education. Yet, the efficient use of information and communication technologies in overcoming student difficulties is possible through bringing teachers and pre-service teachers in basic knowledge and skills. To this end, the effectiveness of the instruction in which pre-service teachers benefit from information and communication technologies to overcome the difficulties regarding a given concept was investigated. The participants were 32 third-year pre-service teachers attending at the elementary mathematics education of a state university. The effectiveness of pre-service teachers' micro-instructions and their opinions on the role and effect of technology in their instructions were analyzed within the framework of specified themes. The instructional plans, observation sheets, self-evaluations, and the inventory of the interviews performed in regard to self-evaluations which affected the change in the process were analyzed with the content analysis. Consequently, the findings obtained in the study showed how the pre-service teachers performed effective instructions and revealed the positive change in their perspectives, possible means that technologies can offer to students in the mathematics education, and their positive contributions to their own learning. As for the components and recommendations of this pre-service educational program, it will be effective in the planning of instructional process in future studies.
Keywords: student difficulties, technological integration, mathematics education, micro-instruction, pre-service teachers

1. Introduction

It is seen that students face certain difficulties when learning the concepts and the relationships between them in the mathematics education that aims at enabling students to learn on the highest level (Ben-Hur, 2006; Inzunza, 2006; Simon, Tzur, Heinz and Kinzel, 2004; Stacey and MacGregor, 1997; Tall and Razali, 1993; Thompson, 1994). These difficulties have been the subject of study and examination in the research of mathematics education for a long time (Bingölbali and Özmantar, 2009; Hart, Brown, Kerslake, Kuchemann, Johnson, Ruddock and McCartney, 1980; Karapür, 2002; Özmantar, Bingölbali and Akkoç, 2008; Özsoy and Kemankaslı, 2004; Tall and Vinner, 1981; Tatar and Dikici, 2008; Ubuz, 1999; Yenilmez and Avcu, 2009). Several terms are used to express difficulties experienced in mathematics education. Difficulty, misconception, and error are the most commonly used terms in expressing the difficulties experienced by students in mathematics education (Bingölbali & Özmantar, 2009). Difficulty is an extensive concept and a term that is used to express difficulties experience by students in mathematics education in a general sense (Bingölbali & Özmantar, 2009). It is stated that mathematical difficulties and misconceptions experienced by students may be due to three main reasons: epistemological, ontogenetic, genetic or psychological, and didactical reasons (Brousseau, 1976; Cornu, 1991). Epistemological reasons are associated with the difficulties due to very nature of the concept while didactical reasons refer to the difficulty experienced by students when learning a concept and how it is addressed within the scope of factors such as the type, concept and method of the instruction given (Cornu, 1991 *in* Bingölbali & Özmantar, 2009, p.11). Psychological problems include student's self-development, preparedness level, mathematical comprehension skill and ability (Cornu, 1991 *in* Bingölbali & Özmantar, 2009, p.11). It has been revealed in studies that students may acquire new information incorrectly or incompletely if errors or shortcomings in how they obtain basic concepts are not noticed to be corrected (CSMS, 1993; Macgregor & Stacey, 1997). Indeed, it cannot be expected from a student who have difficulty in learning a subject in mathematics despite having strong prerequisite relations to perform meaningful learning in later subjects (Baki, 1998; Ersoy and Ardahan, 2003). Hence, planning the instructional activities in consideration of these is important for the quality of instruction (Gilbert, Osborne and Fensham, 1982).

Overcoming the difficulties experienced by students is considered one of the contributions of the technological use to the mathematics education (Ministry of National Education [MNE], 2005). When considering other contributions such as supporting conceptual learning and mathematical learning positively and

contributing to the problem solving process (Selden, Dubinsky, Harel, & Hitt, 2003; Sierpinska, 1987 *in* Nwabueze, 2004; Tall, 1991 *in* Nwabueze, 2004), it is recommended to use technology in an efficient way to construct learning environments in which students can learn by trying and exploring the information. Therefore, it is thought that changes in learning experiences through the use of an appropriate technology can also overcome student difficulties if they make positive contributions to learning. Teacher's duties include identifying and eliminating student difficulties, helping and guiding student in the learning process (National Council of Teachers of Mathematics [NCTM], 2000). For a teacher, it should not just be about revealing student difficulties but also examining the perceptions that cause these difficulties in depth, analyzing them, and turning them into advantages for learning by developing appropriate instructions, methods, and techniques after making the necessary assumptions (Ben –Hur, 2006; Zembat, 2008). The component of student difficulties which is used for measuring teaching knowledge and skills of teachers or pre-service teachers is handled by several researchers as a component of pedagogical content knowledge in mathematics education (Park & Oliver, 2008). Especially with the technological integration in education, teachers' knowledge on the pedagogy of technology, or how a concept is learned and taught with technology, is defined as "Technological Pedagogical Content Knowledge (TPCK)" (Niess, 2005; Pierson, 1999). TPCK is defined as a type of knowledge which emerges by adding technological knowledge to the concept of pedagogical content knowledge (PCK) and is in interaction with technological knowledge, pedagogical knowledge, and content knowledge in the area of intersection of these three knowledge types (Koehler, Mishra and Yahya, 2007; Mishra and Koehler, 2006). Yet, how teachers try to overcome a difficulty regarding any concept by using these technologies and what kind of plans and practices they perform have not received the sufficient attention in the scope of Technological Pedagogical Content Knowledge literature. It is seen that several studies have mainly addressed to what extent teachers or pre-service teachers are aware of student difficulty regarding any mathematical concept and the methods of overcoming this difficulty itself (An, Kulm and Wu, 2004; Chick and Baker, 2005; Isıksal and Çakıroğlu, 2011; Misailidou, 2008).

Consequently, it is obvious that there are limited number of studies handling which information and communication technology (ICT) teachers or pre-service teachers use to overcome a student difficulty that may be experienced in teaching any mathematical concept and how efficient these technologies are used to eliminate the difficulty (Akkaya, 2009). In accordance with the fact, the main purpose of this study is to investigate the effectiveness of the instruction in which pre-service teachers benefit from information and communication technologies to overcome the difficulties regarding a given concept.

2. Method

2.1 Participants

The participants of the study were 32 pre-service teachers attending at the elementary mathematics education of a state university. As for backgrounds of the participants, they were taught multiple representations of concept, student difficulties regarding concepts and misconceptions, conceptual assessment-evaluation, and aspects of teaching the concept learned in the instructional program within the scope of PCK. The pre-service teachers used the main functions of software such as Graphic Analysis, GeoGebra, Microsoft Mathematics, Excel, and Cabri 3D within the scope of Technological Knowledge in the content of a course In addition, the participants were taught technology and multiple representations of concept, technology and student difficulties regarding concepts and misconceptions, technology and conceptual assessment-evaluation, and aspects of teaching the concept learned with the help of technology in the instructional program, and they performed micro-instructions. Yet, they could not make enough progress in terms of being able to do planning by benefiting from information and communication technologies to overcome student difficulties regarding the given concept. Based on the finding, it was decided that the subject should be handled with a different pre-service training; and the design of this education is explained below.

2.2 Practical Process and Data Collection Instruments

In the content of the training conducted for 14 weeks in the scope of a course, preliminary knowledge of the participants was obtained with an interview sheet in which they could explain the concepts of error, misconception, and difficulty, their relationships and reasons and present the role of overcoming the difficulties in mathematics teaching, possible advantages and disadvantages of technology, the methods and techniques they can use, and difficulties they might face when using technology. The participants were asked to create groups of 4 or 5 people. It was requested from these groups to prefer a field of learning (numbers and operations, algebra, geometry and measurement, data processing, probability) in the instructional program of 5th to 8th grades (11-14 years old) to which they would teach in the future. The participants who preferred the same field of learning agreed to orientate towards different fields. Among seven groups, two of them preferred numbers and operations, two of them preferred geometry and measurement, and the remaining groups preferred algebra, data processing, and probability separately. The groups were asked to review the literature on student difficulties regarding

concepts in the fields of learning of their preference and prepare a report. Each pre-service teacher in the groups interviewed a different teacher face-to-face in regard to student difficulties regarding the concepts in the fields of learning of their preference and they were asked to create a presentation about the student difficulties expressed by the teachers in these concepts. The groups explained the student difficulties regarding the concepts in the fields of learning they had preferred and found the chance to discuss how these difficulties can be overcome using technology in their presentations. Next, the pre-service teachers associated the difficulties of concepts they had found in the group with the attainments in the instructional program to perform their micro-instructions. They delivered the instructional plans they had prepared on the concepts of preference before their instructions and performed their micro-instructions before other pre-service teachers for 10 to 20 minutes. The pre-service teacher who performed his/her micro-instruction was evaluated by his/her peers with an observation sheet prepared by the researchers. The observation sheet involves questions whether the pre-service teacher can exemplify and explain the student difficulty clearly with its reasons, his/her interventions to the instruction in which he/she used technology to overcome the student difficulty, the assessment-evaluation of the conceptual difficulty with technology, and whether he/she considered the student difficulties and questions requiring evaluation of means and restrictions that come along with the technology in lecturing in general. Micro-instructions of each pre-service teacher were recorded with two cameras, one focusing on the student-teacher communication and the other focusing on the teacher's lecture. The pre-service teachers examined the evaluations made by their peers in the observation sheet and the video records of their micro-instructions after the lecturing and wrote their self-evaluations under the frame in the observation sheet. In the meantime, semi-structured interviews were performed with the pre-service teachers on the self-evaluations of micro-instructions. The pre-service teachers revised and delivered their instructional plans in parallel with their self-evaluations after their micro-instructions. Finally, along with the content in the preliminary interview sheet, the participants were asked to complete an interview sheet in which they could present their opinions on the hardships when benefiting from information and communication technologies to overcome the student difficulties and how these hardships affected their instructions, whether there was a change in their perspective of benefiting from information and communication technologies to overcome the student difficulties, whether they would benefit from information and communication technologies to overcome the student difficulties when they would start teaching professionally and the means and restrictions for students that may come along with benefiting from information and communication technologies to overcome the student difficulties in mathematics education.

2.3 Data Analysis

The effectiveness of the instructions in which the pre-service teachers benefited from information and communication technologies to overcome the student difficulties regarding the given concept was evaluated within the framework of comprehension of error, misconception, and difficulty concepts, their relationships and reasons; identification of student difficulty in instructional plans and instructions; types of intervention with the instruction in which they used technology to overcome the student difficulty, selection of appropriate information and communication technologies; assessment-evaluation through technology for the conceptual difficulty; whether the student difficulties regarding the use of technology were taken into consideration; and means and restrictions that came along with technology in lecturing in general. Video records of the micro-instructions, the instructional plans, the observation sheets, the self-evaluations and the inventory of the interviews performed in regard to the self-evaluations were analyzed with the content analysis technique. The analysis included a circular process which was composed of rereading and reorganizing the data and deliberating the related sections within the framework of the components. The raw data obtained from the research were encoded by three experts individually to ensure the reliability of the process, and 86% of inter-rater dependability was reached. Next, the consistencies of the codes were checked to make necessary adjustments, and the themes were finalized.

3. Findings

In this study examining the effectiveness of instructions in which the pre-service teachers benefit from information and communication technologies to overcome student difficulties regarding the given concept, the pre-service teachers were encoded as being PT1, PT2,...,PT32. The research findings are presented generally under the topics of effectiveness of micro-instructions and role and effects of technology in instruction.

3.1 Effectiveness of Micro- Instructions

The effectiveness of instructions in which the pre-service teachers benefit from information and communication technologies to overcome student difficulties regarding the given concept was examined under the themes of identification of the student difficulty, explanation of reason or reasons for this difficulty, methods used in the practice, activities developed for the student difficulty, assessment-evaluation, and difficulties regarding the use of technology.

According to pre-service teachers' preliminary knowledge on the error, misconceptions, and difficulty concepts, their relationships and reasons, 81% (26) of all the participants exemplified the concepts, their relationships and reasons and explained them in an accurate and clear way. The following are explanations of some pre-service teachers on the relationship between and reasons for the difficulty, misconception, and error concepts which were cited from the preliminary written-interview forms. In addition, the change in the preliminary knowledge on other subjects which were found out through the interview sheet was handled within the scope of micro-instructions and the final interview.

"When students can't do anything related to the subject, they say 'they have difficulty'. That is, the concept of difficulty becomes a general situation for students. A student having difficulty in the comparison of decimals mistakes 0.5798 for the bigger one in the comparison between 0.7 and 0.5798 because he/she thinks that the digits following the point are bigger. There emerges the misconception in the student. Then we can say that misconception underlies the errors made by students in the subjects in which they have difficulty."(PT18)

"Difficulty is the most general of these concepts. It refers to the difficulty that student has in a course. Error and misconception can be regarded as subsets of difficulty. For example, a student may solve a given problem incorrectly. If this incorrect solution is one-off, it's an error. However, if the student insists on this error, we can talk about misconception. (PT5)

"Error, misconception, and difficulty are interrelated concepts. Difficulty involves error and misconception. It is caused by the troubles experienced by students during the learning. One of the factors causing them to have experience those troubles is the present misconception. They make errors due to misconception. But the point in misconception is that it is systematical differently from error. It's not a simple error of operation. And correcting an error made by a student as a result of misconception and convincing that student is harder. He/she insists on his/her answer." (PT9)

69% (22) of the pre-service teachers reported that the interviews with the teachers were more effective than a literature review in identifying the student difficulties. They indicated the reason was that teachers could explain these difficulties and the perceptions underlying them in a clear way and by giving examples because they had had the chance to examine and analyze the perceptions that cause these difficulties for years. They also told how they discussed the reason or reasons for these difficulties with the groups before the micro-instruction allowed them to analyze those reasons in-depth and incubate possible activities for their instruction in the discussions on how the difficulties were to be overcome with technology. The case is supported by the opinions of the pre-service teachers in the interviews performed on their self-evaluations.

"[O]ur field of learning was 'data processing'. Before interviewing with the teacher I selected, there were several student difficulties regarding this subject [field of learning] we specified, but I did have trouble with understanding some of them, too. For example, it writes in the resources that students are interpreting the charts not by numerical values but formal sizes in the axes and this is an error made by them [students]. Actually, there was nothing I could think of this (this student error) until I interviewed with the teacher. The teacher explained very clearly that he/she asks students the comparative column charts first but takes the intervals of values in the y-axis even though these column charts are composed by the same numerical values. He/she increases one of them by 10 while increasing the other by 20; that being the case, as the columns of the y-axis which is increased by 20 in the column chart are shorter, all the students say that the other one [the column chart of the y-axis increasing by 10] has more, for example, fruits, cars, etc. But then, the students get shocked when the teacher says both charts show the same values. He/she also explained that this is a normal thing for them [students] to be confused in such way because they have always reviewed examples coinciding with this [in which numerical values are in direct proportion with formal sizes all the time in different numerical values]." (PT2)

"[W]e had very productive discussions when explaining to the other groups the things in our minds about how we can overcome the difficulties we had presented in groups before my micro-instruction. For example, we realized in a few difficulties we came up with that we used the technology just for the sake of it and then [the discussion among groups] I started to prepare my instructional plan with several points to consider in my mind." (PT24)

As for the types of intervention presented by the pre-service teachers in the preliminary interviews, they reported the methods and techniques of question-answers, discovery, presentation, problem solving and direct instruction. Yet, it was observed in pre-service teachers' instructional plans and micro-instructions that they used different intervention types when benefiting from information and communication technologies to overcome the student difficulty regarding the given concept. They also added different intervention types which they thought would be more effective in eliminating the difficulty to their second instructional plans after having reviewed their peers' evaluations and their self-evaluations. Table 1 shows the types of intervention and the distribution of the pre-service teachers who used those interventions.

Table 1. Types and distribution of interventions used by the pre-service teachers when using information and communication technologies to overcome the student difficulty regarding the given concept

Types of Intervention	**Number of Pre-Service Teachers**	
	f	**%***
Taking the opinions of all students on the conceptual difficulty	24	75
Confronting the students with the inconsistencies and contradictions in their solutions, thoughts or interpretations regarding the questions asked, explanations made, and the concept itself	26	81
Referring the students to discussion with their peers	21	66
Specifying important points about the concept	15	47
Exemplification	17	53
Referring the students to the activity prepared	28	88
Giving the correct answer and the explanation after telling the students that their explanations and answers are wrong	12	38
Telling the students query the conceptual difficulty with questions	27	84

*: *Percentage values may exceed 100% because the intervention types of some of the pre-service teachers were placed under multiple codes.*

According to the table, the intervention types preferred by the pre-service teachers the most were "taking the opinions of all students on the conceptual difficulty; confronting the students with the inconsistencies and contradictions in their solutions, thoughts or interpretations regarding the questions asked, explanations made, and the concept itself; exemplification; giving the correct answer and the explanation after telling the students that their explanations and answers are wrong; referring the students towards discussion with their peers; referring the students towards the activity prepared; and telling the students query the conceptual difficulty with questions." These intervention types are exemplified below as they are in the instructional plan of one of the pre-service teachers (Figure 1.)

INSTRUCTIONAL PLAN

Grade: 6
Field of learning: Geometry and Measurement
Sub-Field of Learning Circle
Attainment: The students determines that the ratio of a circle's circumference to its diameter is a constant by taking a measurement.

- It is emphasized that this constant is called π (pi). When giving problems about π, the approximate value to be used is specified with statements such as "please take π as 3, 22/7, 3.14" every time.

Student Difficulty: Since pi is an irrational number, it can never be expressed in a finite integer order and it involves infinitely many nonrepetitive numbers following the point. It is therefore hard for students to apprehend and demonstrate its exact value. The reason for this student difficulty may be psychological and didactical because teachers generally tell students that it involves infinitely many nonrepetitive numbers but they should take its value 3.14 in short. Students find it difficult to think about the value of a number involving infinitely many nonrepetitive numbers and its equivalent on the number line. Those who are cognitively prepared may not struggle but many of them do. In addition, many teachers say that the value is 3.14 or 22/7 when it comes to pi and talks about how we need to take it as approximately 3. They do not make students do any additional activity; so it cannot be expected from students to comprehend it only on the basis of its approximate value and definition and show its value on the number line.

Overcoming the Student Difficulty with the Help of Information and Communication Technologies:
First, the students are asked whether they have heard about pi. Next, it is said that it involves infinitely many nonrepetitive numbers following the point after asking if they have any idea about its value. It is brought up for discussion among the students whether it is possible to show such a number on the number line. It is asked after the discussion whether there is a relationship between pi and circle. The point here is that students discuss how the rate of circumferences of different circles to their diameters turn out to be a constant and how the equivalent of this value can be found on the number line. Then, students are referred to the activity prepared in GeoGebra. In the activity, it is expected from them to understand the relationship between pi and circle and how it is placed on the number line. It is ensured that the students who are confused about these concepts confront the inconsistencies in their minds through questions to be asked during the activity.

STEP 1:
It is asked students to create circles with different radiuses in GeoGebra and divide circumferences of these circles by their diameters. It is therefore ensured that they realize the ratio of different circles' circumference to their diameters is a constant.

STEP 2:
The dynamic structure mentioned below is established with students. The point here is to ensure that students observe how to find the equivalent of π on the number line and make them discover that it can involve infinitely many numbers following the point even though it corresponds to a value on the number line as it gets closer to that value.
We draw a circle.

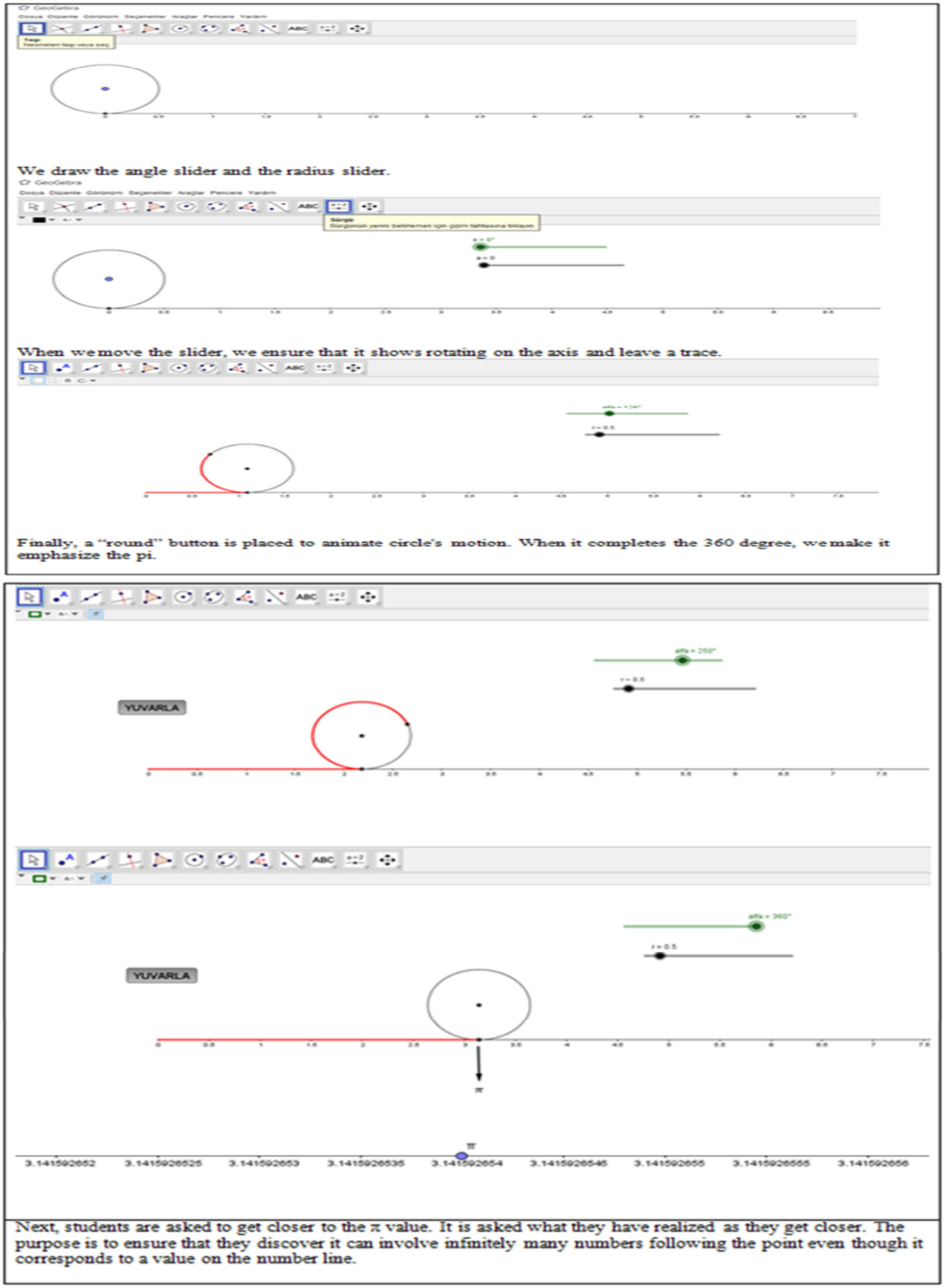


Figure 1. Example of the Most Used Intervention Types in the Micro-Instructions as in the Instructional Plan of the Pre-Service Teacher (PT11)

Most of the participants reported in the interviews performed on their self-evaluations that students are less likely to experience the difficulty later when they are confronted with the inconsistencies and misunderstandings in their own solutions and thoughts about the concept and when they are made discover why it is not true. The following are the statements of PT15 and PT28 on the case:

"[I]n the pi activity, I'm sure many students face the dilemma how a number involving infinitely many numbers following the point can be shown in the number line. According to the teachers, many of them think it cannot be on the number line. But with the activity performed by our friend [Figure 4], students will face these wrong thoughts of theirs and certainly will never forget them…" (PT15)

"Take the example of me. When I face something disproving my thought about the difficulties I have, and if that disproof is argued in such a beautiful way, believe me when I say it comes to my mind how my thought was disproven as soon as that difficulty is in question. I find it to be striking. When I look at the activities prepared my friends, some of them explains first, and then wants students to see and look at it, but I think that method is not exactly striking. When students discover the incorrectness of their thoughts as they go on with the correctness of their thought, it comes as striking, then. I think confronting is the best. That way, student won't do the same error again." (PT28)

Actually, the section that is mentioned as "Referring the students to the activity prepared" in the types of intervention and constituted the mainframe of participants' micro-instructions is the body of activities created using the information and communication technologies. These activities were created using software including GeoGebra, Microsoft Mathematics, Excel, and Cabri 3D. They involve visual and dynamic properties that allow for exploring concepts, making observations and assumptions, and analyzing in general. The pre-service teachers used general types of intervention within the framework of these activities. The activities were evaluated in accordance with the goals of the pre-service teachers. It was examined whether the pre-service teachers just used the activities to change the environment or to help do some operations in a rapid way, or to contribute to students' conceptual and deep understanding in the elimination of given conceptual difficulties. Whereas one of the pre-service teachers used the ICT tool to change the environment for the operations that could be done on the board, three of them used it only to run certain mathematical operations more rapidly. Yet, the remaining 28 pre-service teachers used the activities to create learning environments that would allow for conceptual and deep understanding for overcoming the given conceptual difficulty. Although short-term and small sections were used within these activities to do rapid operations or achieve visuality, it was focused on the means that would allow for conceptual and deep understanding throughout the activities. A part of the 28 pre-service teachers confronted the students with the conceptual difficulty first, then allowed them to explore the correct conceptual construct through the activity while others explained the conceptual difficulty first, then emphasized the important points on the concept and helped reinforce the correct conceptual construct. The pre-service teachers designed activities that would enable them to identify the appropriate software and use the intervention types in a way that they could overcome the difficulty in the elimination of the difficulties regarding the concept they had specified. Examples of the activities created using different information and communication technologies are presented along with short explanations of contents (Figures 2-6) below.

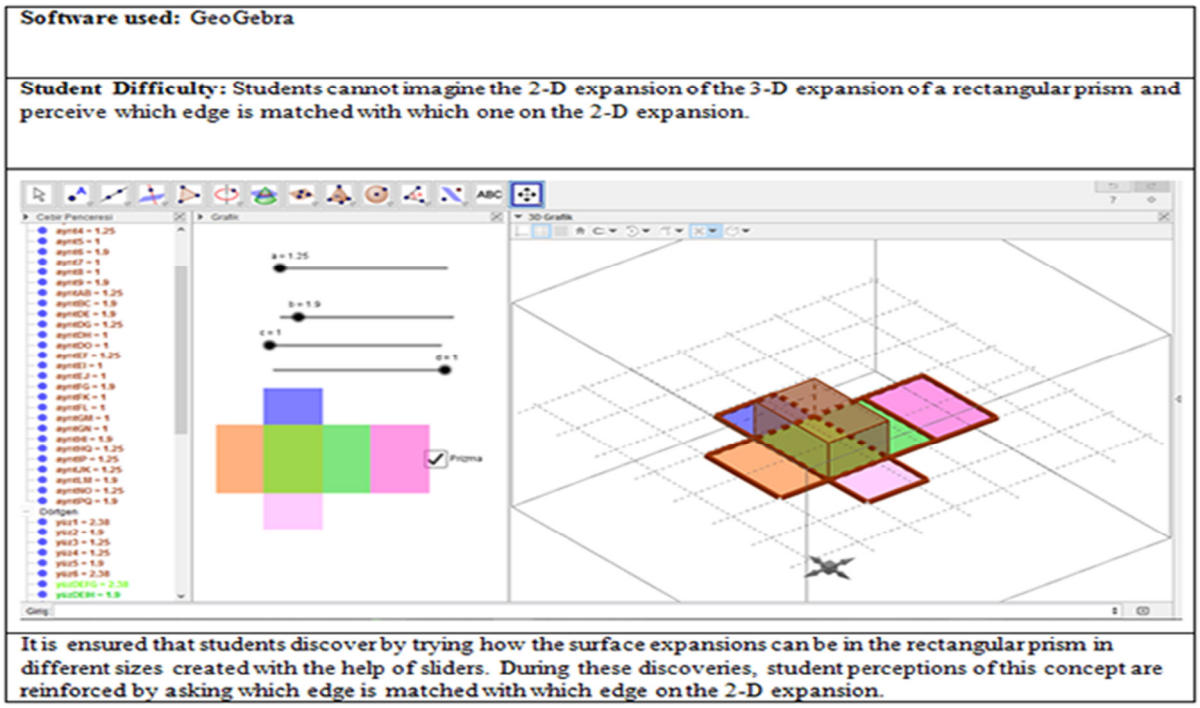
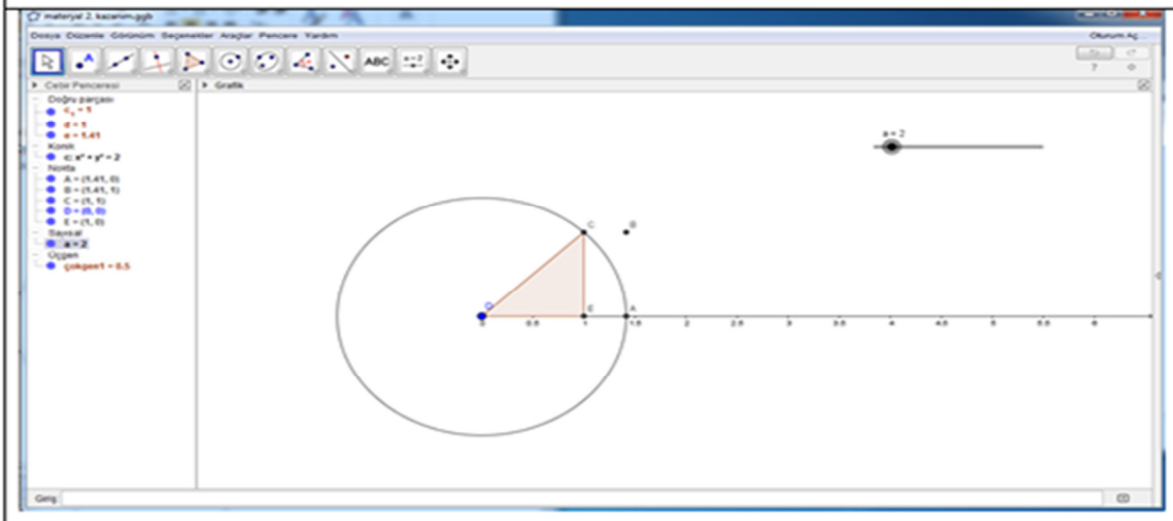


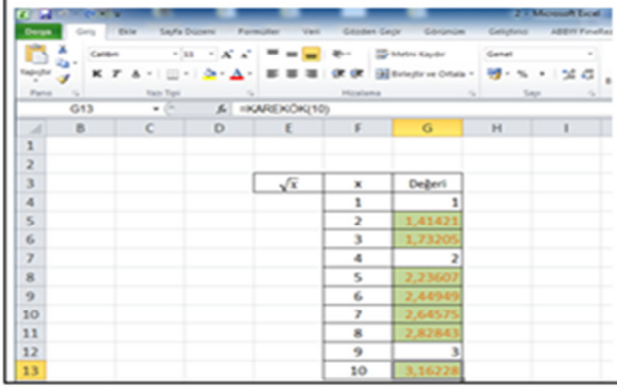
Figure 2. Example of Activity Prepared in Geogebra and a Short Explanation of Content

Software used: GeoGebra, Excel

Student Difficulty: Students cannot comprehend that irrational numbers have a corresponding value on the real number line and distinguish the value of square roots rationally or irrationally.



The first objective is to ensure that they discover that square roots have values on the real number line. Next, it is aimed to overcome the student difficulty by separating values of square roots as being rational and irrational. Moreover, another difficulty is in question in the second part, which is distinguishing irrational and rational numbers.



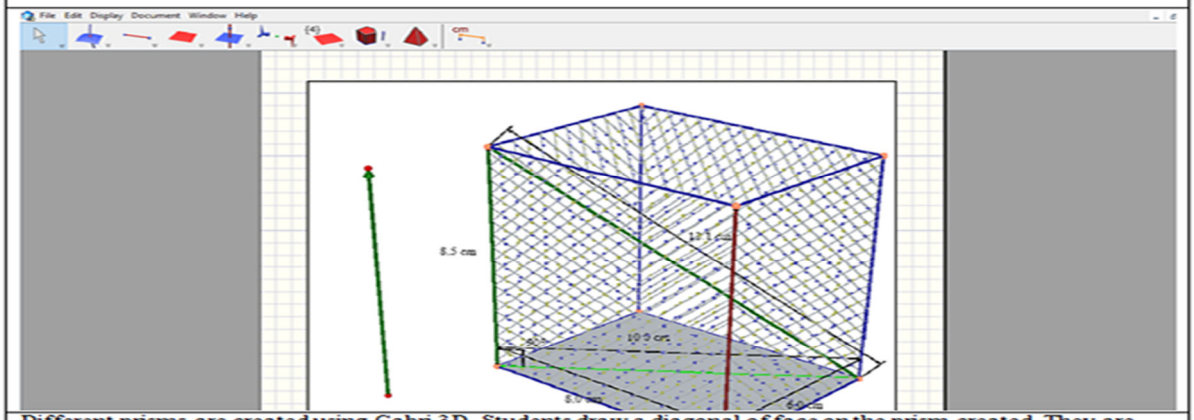
√x	x	Değeri
	1	1
	2	1,41421
	3	1,73205
	4	2
	5	2,23607
	6	2,44949
	7	2,64575
	8	2,82843
	9	3
	10	3,16228

Teacher has students examine the values of the square roots found and transferred to the table using Excel in terms of being rational and irrational. During the examination, students' discovering steps are supported by the following questions: "Is every square root is a real number? Why? Do irrational numbers have an equivalent of integer? Why? Are repeating decimal numbers, irrational numbers? Why?"

Figure 3. Example of Activity Prepared in Geogebra and Excel and a Short Explanation of Content

Software used: Cabri 3D

Student Difficulty: Students cannot comprehend, materialize and mistake the space diagonal with face diagonal in prisms.

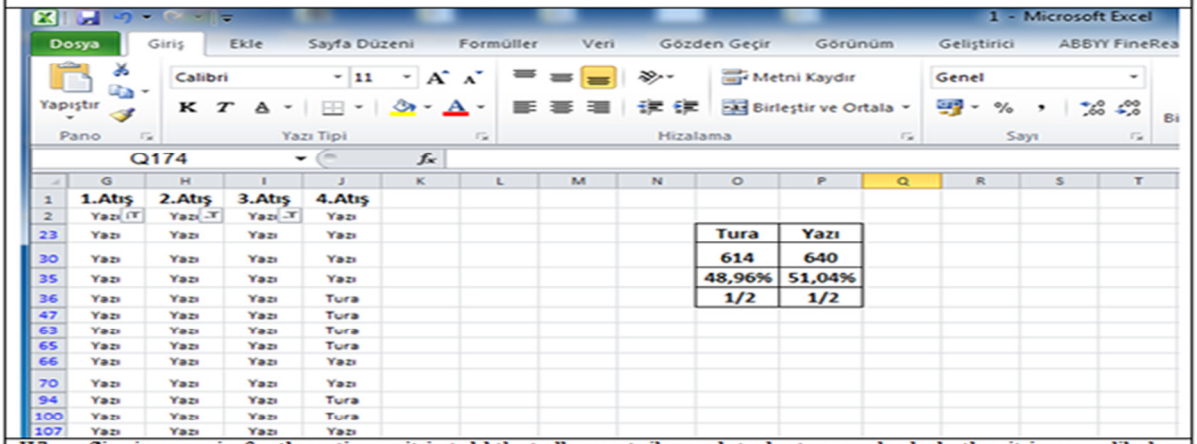


Different prisms are created using Cabri 3D. Students draw a diagonal of face on the prism created. They are asked how to calculate the length of this diagonal, and after they have given answers, it is showed how to calculate it with Pythagorean theorem. Next, a diagonal of space is drawn and it is asked how to calculate its length. After the answers given, it is shown how to calculate it with the Pythagorean theorem. Students are asked to draw diagonals of face and space diagonal in different prisms and calculate their length. Finally, it is opened up for discussion among students what the differences are between the diagonals of face and space diagonal.

Figure 4. Example of Activity Prepared in Cabri 3D and a Short Explanation of Content

Software used: Excel

Student Difficulty: Students tend to make predictions in the favor of output that has not occurred in previous trials on the basis of successive same results in the next one in the experiments of prediction. This shows that students have difficulty in perceiving that successive outputs of a random process are independent.



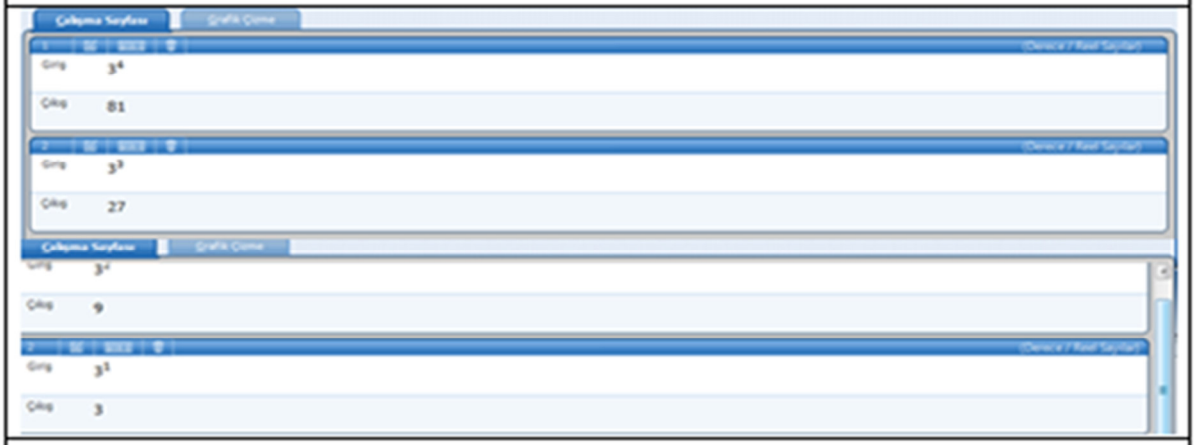
When flipping a coin for three times, it is told that all were tails, and students are asked whether it is more likely to be tails or heads in the next flip. After receiving answers of all the students, a coin is flipped for 4 times with the help of Excel, and then teacher has students examine an Excel spreadsheet in which a coin is flipped for 10.000 times. The cases where the first three flips are tails are selected and students examine what it is in the 4th flip in the spreadsheet and calculate the number, percentage and probabilities of heads and tails in the 4th flip. Through an experimental probability using Excel, students discover that successive outputs of a random process are independent.

Figure 5. Example of Activity Prepared in Excel and a Short Explanation of Content

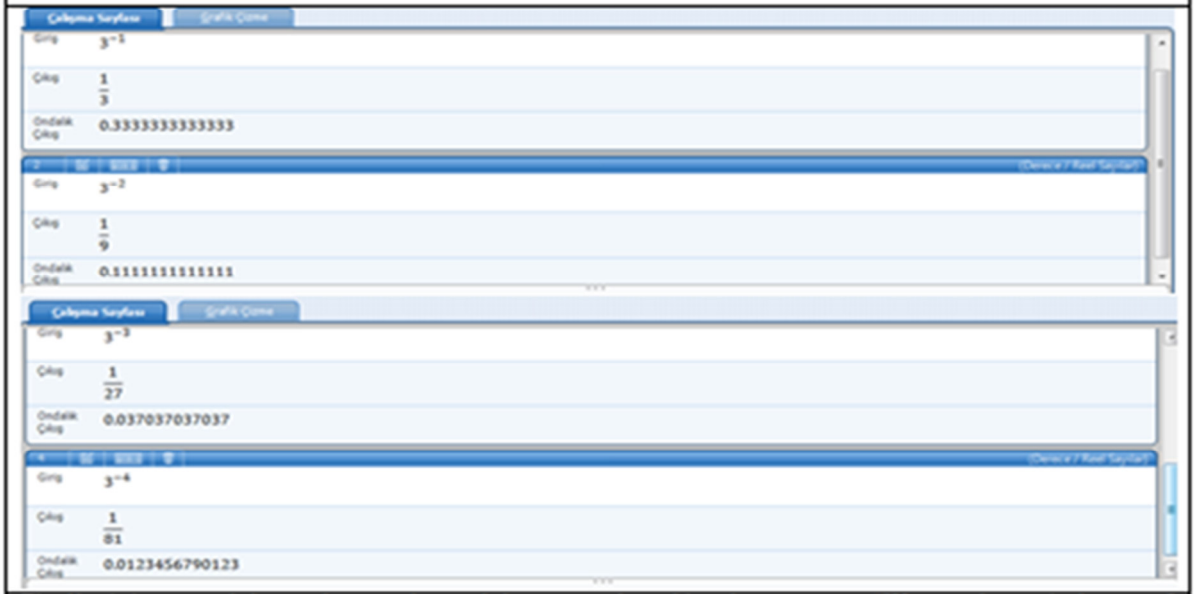
Software used: Microsoft Mathematics

Student Difficulty: Students have problems in perceiving the value of a negative exponent and perceive it as if $3^4 = 81$, $3^{-4} = -81$.

Before the instructional part, the operation $3^{-4} = -81$ is written on the board and it is asked students to raise hand if they think the result is correct and explain the reason and vice versa so that an environment of discussion is established in the classroom. Next, students are asked to find the values 3^4, 3^3, 3^2, and 3^1 in Microsoft Mathematics.



It is asked what the pattern is, depending on these values. It is expected from students here to discover that numbers given are divided by 3 and exponents decrease by 1 every time in the progress of the pattern. By this means, students predict $3^0 = 1$. Next, it is asked them what the values of 3^{-1}, 3^{-2}, 3^{-3} and 3^{-4} can be and to find and check the values they say on Microsoft Mathematics.



Finally, it is ensured that students understand the concept by asking the statements "We saw the equivalences of the numbers given. What is the difference between them in your opinion? Did those numbers increase or decrease?" because they saw the values both in rational numbers and decimals.

Figure 6. Example of Activity Prepared in Microsoft Mathematics and a Short Explanation of Content

The pre-service teachers addressed whether the students overcame difficulties regarding the concept specified with different assessment-evaluation techniques in their micro-instructions. 59% (19) of the pre-service teachers emphasized that they thought their instructions were effective in overcoming the given student difficulties, maybe the students could make correct explanations in the discussions and investigations in their instructions, in other words, they might think the difficulty was overcome but this should be reviewed in the classroom environment from time to time. The reason reported by the participants was that even though it is

thought that the conceptual difficulty has been overcome, students may interpret another related concept incorrectly. The pre-service teachers used the assessment-evaluation tools to test whether the difficulty was overcome and monitor the progress of the students. The technological and non-technological assessment-evaluation tools used by the pre-service teachers are classified in Table 2. It was seen that the pre-service teachers mainly used technological assessment-evaluation tools and an assessment-evaluation tool used by a pre-service teacher was exemplified.

Table 2. Distribution of the Technological and Non-Technological Assessment-Evaluation Tools Used by The Pre-Service Teachers

Assessment-Evaluation Tool	f	%*
Investigating questions	27	84
Example question	11	34
Homework	6	19
Technological Assessment-Evaluation Tools		
Computer-Aided Worksheet	26	81
Computer-Aided Homework	19	59
Computer-Aided Activity	28	88

*: *Percentage values may exceed 100% because some of the pre-service teachers used multiple tools for different purposes of usage.*

Thinking that the examples presented in the findings in the previous section represent the investigating questions, example questions, computer-aided worksheet and activity, the computer-aided homework prepared by one of the pre-service teachers (see Figure 7) is exemplified below. The pre-service teacher (PT26) expects students to examine the files prepared dynamically in GeoGebra and write their assumptions down. The files allow for examining the properties of types of quadrilateral and associating them with other types of quadrilateral. These files are shown along with the screenshots and their objectives below.

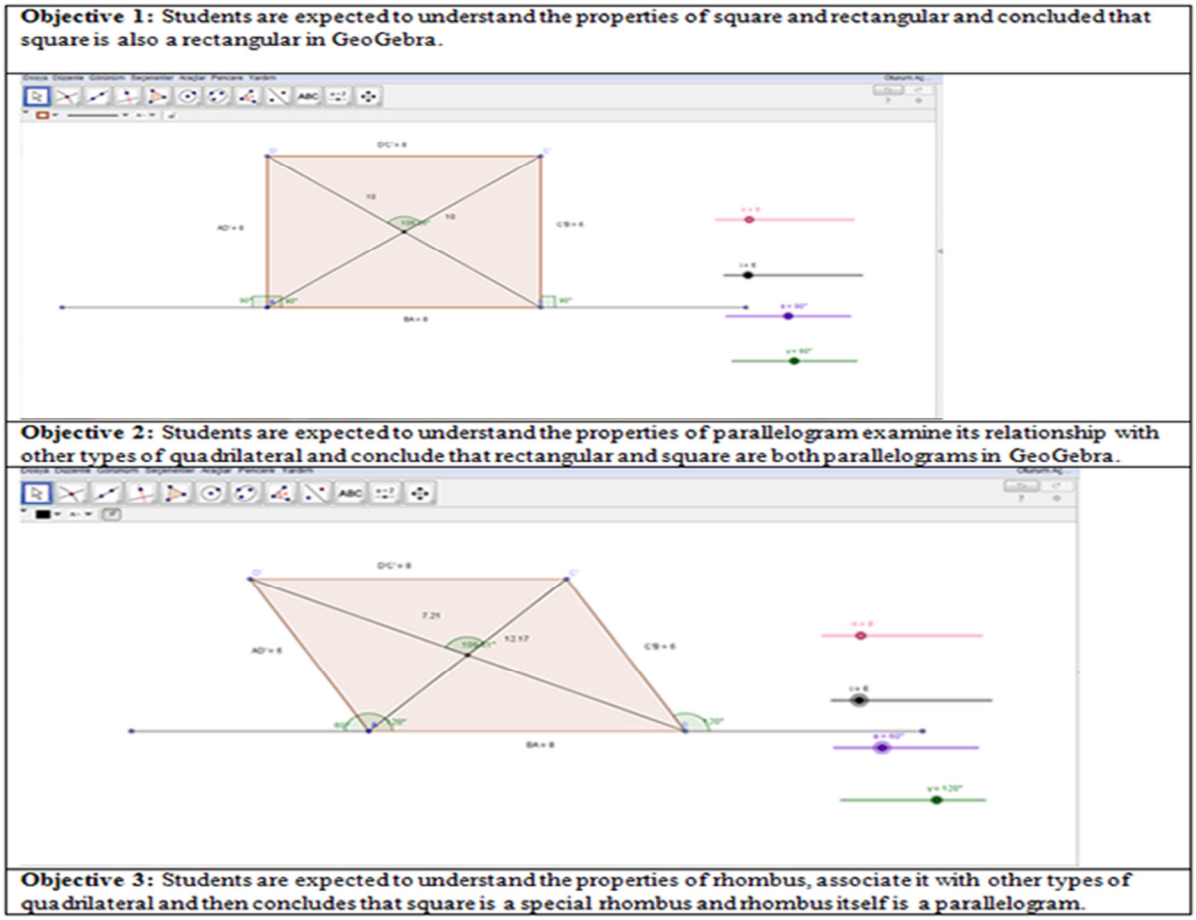


Figure 7. Example of Computer-Aided Homework Prepared by the Pre-Service Teacher (PT26) Along with its Objectives

According to the student difficulties regarding the use of technology which were presented by the pre-service teachers (84%, 27 participants), they argued that students would not face any difficulty because almost all of them were accustomed to using technology, and even if they did, they could overcome the problem by receiving support from their peers or the teacher. Yet, it was seen that the pre-service teachers also addressed the technological difficulties that emerged in instruction and when they were answering their peers' questions and made their self-evaluations accordingly. Along with the general difficulties and the difficulties specific to the software used by the pre-service teachers in their second instructional plans, the distribution of the pre-service teachers regarding the precautions that can be taken to overcome these difficulties are given in Table 3.

Table 3. The General Difficulties and The Difficulties Specific to the Software used by The Pre-Service Teachers in Their Second Instructional Plans, The Distribution of the Pre-Service Teachers Regarding the Precautions that can be Taken to Overcome These Difficulties

Difficulty due to technological use	**General or software-specific difficulty**	**Precautions taken to overcome the difficulty presented or recommendations on possible precautions**	**Number of Pre-Service Teachers**	
			f	**%***
Students do not know or understand the commands and functions of basic buttons in software	General	Explaining the directions of technology and practice for the activity to be performed, improving students' knowledge and skills in the software through exemplary practices	19	59
Student prejudice against use of technology	General	Eliminating the prejudice by proving the effectiveness through exemplary practices, explaining the directions of technology and practice, making an explanation from what is simple to complex.	11	34
Students have different preparedness levels of technological use	General	Describing the main functions and buttons, having students work in groups, enriching the course integrated with technology by showing and getting it done.	18	56
Software does not allow an exponent such as -3^2 to be entered without parentheses	Excel	Informing students of the limitations of the software	6	19
Evaluation of correctness or incorrectness of the given statement in English (true-false)	Microsoft Mathematics	Informing students of the limitations of the software	9	28
Assigning the 0^0 ambiguity with the value of 1	GeoGebra	Informing students of the limitations of the software	5	16
Software being in a foreign language	Cabri 3D	Explaining the basic functions and buttons in a clear way if software in a foreign language is to be used	13	41

*: *Percentage values may exceed 100% because the intervention types of some of the pre-service teachers were placed under multiple codes.*

According to the table, it is seen that the pre-service teachers took the student difficulties regarding the use of technology into consideration and presented suitable precautions to overcome those difficulties.

3.2 Role and Effect of Technology in Instruction

Pre-service teachers' opinions on the role and effect of technology in their instructions and learning were examined under the themes of hardships when benefiting from information and communication technologies to overcome the student difficulties and how these hardships affected their instructions, whether there was a change in their perspective of benefiting from information and communication technologies to overcome the student difficulties, whether they would benefit from technological tools to overcome the student difficulties when they would start teaching professionally and the means and restrictions for students that may come along with benefiting from technological tools to overcome the student difficulties in mathematics education.

When the pre-service teachers were asked about the difficulties they had when using the technological tools to overcome the student difficulties and how those difficulties affected their micro-instructions, 24 of the participants reported that they did not find it that difficult to use the software in general, consulted their friends in the group when they stumbled and did not face any difficulty when using ICT tools in their micro-instructions. In addition, they reported that they would benefit from the technological tools to overcome the student difficulties when they start teaching professionally. On the case, 11 of the 24 pre-service teachers emphasized that the field and frequency of practice need to be organized in a very well manner by emphasizing that it might lose its effectiveness on students to benefit from ICT tools in all difficulties in time. Yet, 8 of the pre-service teachers reported that they had difficulty when using the software to prepare their activities and felt nervous in their micro-instructions even though they had received the help of their peers to overcome the difficulties they had. Moreover, these pre-service teachers also stated that it would be difficult to practice it in the classroom and

students might also have difficulty if they had any difficulties. 3 of the 8 pre-service teachers stated that they would not like to benefit from technological tools to overcome the student difficulties when they start teaching professionally whereas 5 of them reported that they could perform the activities which are easy to construct in the company of software. Thoughts of the pre-service teachers on this subject are presented below along with some examples cited from the interviews on their self-evaluations.

" [I] didn't have much difficulty when using the software. There were things I had trouble with when preparing the activity, but I found my way by trying or asked a friend in the group and got it done together ... instructions have been very effective. It really impressed me how it is very easy to understand the things I find difficult to understand at this age with the help of technology. I wish teachers taught us that way when we were learning. I'll totally benefit from technology where my students have difficulty in understanding when I start teaching. I won't be using it all the time because some software isn't worth dealing with in some cases, there may something to teach better by explaining on the board, so you have to arrange it well." (PT16)

" [I] found it difficult to use Excel. It was quite difficult to write the formulas. I felt even nervous during my instruction, but I'll use them [the ICT tools] when I start teaching because I think students will have more permanent learning that way. My students may have difficulty as I did but I'll prepare activities easier for them [students] to do. Maybe it won't be difficult activities to prepare but I can prepare them to be sufficient to achieve my objective at least. Some of the friends prepared really good activities. I mean you get it done when you put forth effort. Maybe I'll prepare more professional things [activities] by trying and trying in the future." (PT12)

"[I]'ve never been good with computers. I found it really difficult when preparing for my instruction. I couldn't do what I wanted to do ... if I have difficulty, students will do, too. That's why I'll prefer preparing concrete materials when I start teaching because students will have questions if I use software. I don't think I'll be able to assist them [my students] with the software much. I don't see myself that competent." (PT29)

The pre-service teachers were asked whether their perspective of benefiting from information and communication technologies to overcome student difficulties changed and, if any, why it changed in the positive or negative way. 8 of 32 pre-service teachers stated that their positive perspectives did not change and found it effective after the practice for which they had already had good opinions before the practice. 21 pre-service teachers reported that they had had no positive or negative perspective before the practice but it changed in the positive way because they thought it would be very effective on students. 13 of these 21 pre-service teachers additionally stated that their perspective changed positively because the instruction contributed to their content knowledge and allowed for mathematical exploration for their own learning. 3 of the pre-service teachers stated that their opinion did not changed after the practice because they had not believed it would have been effective, giving the reason that students would certainly have difficulties in an activity which they prepared also having troubles and it would be more advantageous to use concrete materials rather than ICT tools. The differences among pre-service teachers' perspectives are shown below along with some exemplary opinions cited from self-evaluations and the interviews on their self-evaluations.

"Instructing by using technology caused me to form different perspectives. Because mathematical software doesn't just make you look at a given subject from a single perspective. When appropriate, I said 'I didn't know that' and I found out that many things were actually different in my mind and how true and false my associations had been. As a pre-service mathematics teacher, I realized which software to use on which subject and which is to be the best. Therefore, it stroke me positively." (PT32)

"I realized I also have misconceptions and lack of learning. It affected my current learning in a positive way. At least, it made me realize lack of learning in me and decrease the possibility of learning the future subjects incorrectly." (PT8)

"I used to think that you use formulas only in the probability subject. But I saw that it became more understandable when using technology and I think I can overcome possible difficulties now through technology very easily." (PT25)

"I managed to get over with the troubles with some subjects (e.g. histogram) in the past by benefiting from technological tools. (PT22)

"The instruction I designed was on rational and irrational numbers. The software helped students get closer to irrational numbers so much as they wanted that this procedure attracted my attention, too. Since I taught these concepts, they become much clearer to me and I can say that I will always remember these visuals." (PT13)

"I think I can notice the niceties that seems small but are actually important in my instruction now. I could have caused didactical obstacles accidentally in future. For example, shaping concepts involving the niceties such as parameter - unknowns, equation - equivalence in my mind affected my current instruction for sure." (PT3)

"It made me explore my misconceptions. I think it prevented me from instructing the concepts I would learn incorrectly." (PT20)

" [I]'m actually embarrassed to say but there are many friends who thinks like me, so I'm more comfortable. While we were trying to overcome student difficulties with the help of technology, we also noticed our

misconceptions. I think it's been very effective on our learning, too. For example, I've always been bad at answering the question 'How does the shape look like when we rotate it by a certain angle?' or 'What is the degree of the shape after rotating it?' But when our friend showed in GeoGebra how a concave polygon is rotated by drawing circles through all of its vertexes, where it comes when rotated at a certain angle and how to find the rotating angle of a rotated shape, I got lightened" (PT21)

" [I] can say we actually overcame our own difficulties. For example, when our friend was instructing the volume, it was a conceptual learning for me, too. I mean when the volume base area is given in x height, it actually seems like the repetition of the base area. When our friend showed it didn't form volume, gave the volume of a field's layer in x height and repeated that field's layer volume as much as the height to achieve that volume in GeoGebra, it was also a discovery for me, let alone the students" (PT30)

The pre-service teachers were asked before the instructions what the means and restrictions might come along for students by benefiting from information and communication technologies to overcome student difficulties in mathematics education. The participants, in general, emphasized the importance of overcoming difficulties for their future learning and only 7 pre-service teachers argued regarding the means and restrictions of ICT tools that they could save time while others did not declare any opinion. After the micro-instructions, 3 of the pre-service teachers pointed out as a restriction that not every difficulty can be overcome with ICT tools and exemplified the case. This is exemplified by the opinions of the participants cited from the interviews on their self-evaluations.

" [I] can't say that I had leaned towards overcoming student difficulties with the help of technology before the instructions. Despite the technological era which we go through now, I think I've somehow had my learning without technology before, I can continue to do so. It's not so easy to use software ... for example, in the multiplication subject in which students had hard times with association in my instruction, I showed that multiplication is performed by multiplying the digit values and showed the example of 13x10= 10x10+10x3 by proving that the area of a rectangular field which is expressed as 13x10 can also be shown as the total area of a square and a rectangular area by breaking the rectangular field and colorizing it in GeoGebra. I wanted the students to show different multiplications in this way. It's alright, it may be visually nice but I can do it on the board with concrete materials." (PT29)

" [A]ctually, I can't prepare nice activities in software. I don't know, maybe I get discouraged too soon because technology scares me. It was not that necessary in some of the instructions given by our friends. For example, multiplication of fractions was shown with sliders in GeoGebra but we can show it with fraction cards, too. It may be difficult to distinguish the colors in fraction cards; it was clear in GeoGebra but I think it wasn't that necessary." (PT7)

According to participants' opinions within the framework of the restrictions abovementioned, 3 of the pre-service teachers rather emphasized the restrictions although the instructions seemed to include means. The fact that these participants believed that ICT tools would not be effective in overcoming the difficulty before the instructions had an influence on their post-instructional opinions. As for the means offered, the pre-service teachers addressed the means that may be offered by ICT tools within different frameworks after the instructions. Means offered in general and the exemplification of the contributions which those means can make by the pre-service teachers and the distribution of the pre-service teachers are shown in Table 4.

Table 4. Means that can be Offered by ICT Tools and the Exemplification of the Contributions Which Those Means Can Make by The Pre-Service Teachers

Means that can be offered by ICT tools	The exemplification of the contributions which means offered can make by the pre-service teachers	f	%*
Visualization	"*[I]t* provides ease of use."	22	69
	"The pi example embodies the abstract concepts."		
	"It gives the opportunity to see 3-D fields and students learn permanently and meaningfully with association."		
Time saving	"It provides the opportunity to reinforce with more examples and practices that take too much time to support with concrete materials can be done."	8	25
Providing opportunity to explore	"Since it has properties such as dragging, dynamism ... students explore the concepts on their own."	27	84
	"Students learn permanently by seeing, trying."		
	"They generalize things by trying and denying."		
	"Interpreting the solution step by step."		
	"[S]ince it gives the opportunity to solve problems by association, students learn permanently and meaningfully."		
Attractiveness	"It ensures active participation in the class."	14	44
Funny	"Students develop positive attitude towards mathematics."		
Offering opportunity of multiple representation	"Students see all the visuals together, a more conceptual structure is formed, and permanent learning is achieved."	18	56
Economy	"It may be necessary to buy too many materials for concrete materials at hand but there are smart whiteboards or computer laboratories in all classrooms today."	11	34
Dynamic homework	"It supports off-school learning."	13	41
	"Student learning is enriched with the opportunity to check the correctness and student can acquire the habit of studying"		

*: *Percentage values may exceed 100% because the opinions of some of the pre-service teachers were placed under multiple codes.*

According to the table, means that can be offered to students in mathematics education by benefiting from ICT tools to overcome student difficulties and the importance of their possible contributions are emphasized over different themes by 91% (29) of the pre-service teachers participated in the instructions.

5. Discussion and Conclusion

It is emphasized that computer-aided mathematical instruction should not be an option but assume a complementary role for the system and its contributions to the mathematical instruction include overcoming the difficulties that students have (MNE, 2005). In addition, according to NRCS (1997: 30- 31), computer-aided instruction is recommended among the methods to be followed in the instructional process upon the identification of misconceptions. Teacher's duties include identifying and eliminating student difficulties (National Council of Teachers of Mathematics [NCTM], 2000). Efficiency of this process is related to the efficiency of instructions given by teachers with the help of technological tools. Hence, it is important and necessary to bring teachers and pre-service teachers in basic knowledge and skills to ensure the use of technology in the classroom settings. In this study, the effectiveness of the instruction in which pre-service teachers benefit from information and communication technologies to overcome the difficulties regarding a selected concept was investigated. The effectiveness of pre-service teachers' micro-instructions was examined under the themes of identification of the student difficulty, explanation of reason or reasons of this difficulty, methods used in the practice, activities developed for the student difficulty, assessment-evaluation, and difficulties regarding the use of technology.

It is considered necessary for teachers to be equipped and expertized on what difficulties students may have in certain concepts or subjects and how they can overcome that difficulty (Bingölbali & Özmantar, 2009). According to the findings, preliminary knowledge of the pre-service teachers on the concepts of error, misconception, and difficulty, their relationships and reasons seems to be sufficient. It is important for pre-service teachers to know these concepts because their competency in these concepts will be able to help them with planning and performing their instructions. Most of the pre-service teachers stated that the interviews with the teachers had been more effective than the literature review in identifying the student difficulties. They indicated the reason was that teachers could explain these difficulties and the perceptions underlying them in a clear way and by giving examples because they had had the chance to examine and analyze the perceptions that cause these difficulties for years. They also told how they discussed the reason or reasons for these difficulties with the groups before the micro-instruction allowed them to analyze those reasons in-depth and incubate possible activities for their instruction in the discussions on how the difficulties were to be overcome with

technology. These components specified by the pre-service teachers, face-to-face interviews with teachers and group discussion settings are among the methods that can be used in the process of identifying student difficulties (NRCS, 1997: 29). Moreover, the fact that the pre-service teachers referred students to group studies with cooperation is one of the most basic practical outputs of social learning theories (Blythe, Allen and Powell, 1999; Hawley and Valli, 1999; NCTM, 1991). The result of this study also comply with the results regarding the positive contributions of cooperation and group study emphasized in abovementioned studies to pre-service teachers' instructions. The fact that the pre-service teachers were constantly in exchange of ideas with their peers before and after the micro-instructions had a positive impact both cognitively and affectively on them and this aspect of the interviews was also emphasized by the pre-service teachers.

It was observed in pre-service teachers' instructional plans and micro-instructions that they made a significant progress in different intervention types they used when benefiting from information and communication technologies to overcome the student difficulty regarding the given concept. The preferred types of intervention are among the general intervention types that can be utilized during the process of overcoming student difficulties in the literature (Bingölbali & Özmantar, 2009; Bingölbali, 2010; NRCS, 1997). The fact that the pre-service teachers embraced the idea that students are less likely to have the same difficulty when they are confronted with the inconsistencies and misunderstanding in their solutions and thoughts and when they are made explore why they are not true and the fact that the pre-service teachers listened to their peers in their micro-instructions, made evaluations and, if necessary, support the process of contradiction with other questions assisted their effective use of strategy in the process of overcoming the student difficulties.

As for the activities developed by the pre-service teachers for the given student difficulty, they involve visual and dynamic properties that allow for exploring concepts, making observations and assumptions, and analyzing in general. The pre-service teachers used the activities to create learning environments that would allow for conceptual and deep understanding for overcoming the given conceptual difficulty. This purpose of use, according to Hughes (2005), is that technology is used as in level 3, and it is emphasized that teachers should perform activities on level 3 so that technological transformation in education and quality learning can be achieved. In addition, the attainments which the activities prepared by the pre-service teachers covered seems not to be too much below or above the level targeted by the instructional program. Although the means offered by the tools in the instruction of concepts when technology, which is presented as a disadvantage in the literature, is in play, may cause to specify attainments and activities too much above the level targeted by the program in some cases (Harris, Mishra and Koehler, 2009), organization of the activities in accordance with attainments shows that this was not the case in the study. When considering that this is an indicator of how students can perform learning on their levels, this coincides with the fact that the activities were created in accordance with the purpose.

Keeping in mind that technological content knowledge is the relationship between technology and content and, for example, certain software is addressed as the content it possesses regarding a given mathematical concept (Mishra & Koehler, 2006), how the pre-service teachers preferred appropriate software for specific student difficulties can be considered a progress for the technological integration. Consequently, the pre-service teachers designed activities that would enable them to identify the appropriate software and use the intervention types in a way that they could overcome the difficulty in the elimination of the difficulties regarding the concept they had specified.

In the study, it was addressed by the pre-service teachers whether the students overcame difficulties regarding the concept specified with different assessment-evaluation techniques in their micro-instructions. The pre-service teachers mostly used different technological assessment-evaluation tools in accordance with both summative and formative purposes of assessment-evaluation. The finding of this study show that the pre-service teachers took the approach of technologically-integrated assessment-evaluation tools, for which it is emphasized in the literature that these are not taken into consideration by teachers and teacher candidates (Kissane, Bradley and Kemp, 1994; Kissane, Kemp and Bradley, 1996). Furthermore, majority of the pre-service teachers emphasized that they thought their instructions were effective in overcoming the given student difficulties, maybe the students could make correct explanations in the discussions and investigations in their instructions, in other words, they might think the difficulty was overcome but this should be reviewed in the classroom environment from time to time. The reason reported by the participants was that even though it is thought that the conceptual difficulty has been overcome, students may interpret another related concept incorrectly. These opinions of the participants, according to NRCS (1997: 30- 31), are included among the methods to be followed in the instructional process upon the identification of misconceptions. Eventually, the same methods are not utilized in the process all the time because when considering that some difficulties can be overcome quickly while others require too much effort and the validity of the concept in individual's mind absolutely needs to be tested, this finding reflects the cognitive and positive effect of the process on the pre-service teachers.

According to the findings, it is seen that the pre-service teachers took the student difficulties regarding the use of technology into consideration as being general or software-specific and presented suitable precautions

to overcome those difficulties. This reveals that teachers are aware of how they take or have to take students' preliminary knowledge on the technologies to be used into consideration.

As for the findings related to the effectiveness of the micro-instructions, it is seen that the pre-service teachers benefited from information and communication technologies and gave effective instructions to overcome student difficulties regarding the given concept in this pre-service training program. On the other hand, evaluations were also made within the scope of principles, thoughts, and judgments which are important as well in instructions. Pre-service teachers' opinions on the role and effect of technology in their instructions and learning were examined under the themes of hardships when benefiting from information and communication technologies to overcome the student difficulties and how these hardships affected their instructions, whether there was a change in their perspective of benefiting from information and communication technologies to overcome the student difficulties, whether they would benefit from information and communication technologies to overcome the student difficulties when they would start teaching professionally and the means and restrictions for students that may come along with benefiting from information and communication technologies to overcome the student difficulties in mathematics education.

When the pre-service teachers were asked about the difficulties they had when using the technological tools to overcome the student difficulties and how those difficulties affected their micro-instructions, 24 of the participants reported that they did not find it that difficult to use the software in general, consulted their friends in the group when they stumbled and did not face any difficulty when using ICT tools in their micro-instructions.. In addition, they reported that they would benefit from the technological tools to overcome the student difficulties when they start teaching professionally. Yet, 8 of the pre-service teachers reported that they had difficulty when using the software to prepare their activities and felt nervous in their micro-instructions even though they had received the help of their peers to overcome the difficulties they had. In addition, these pre-service teachers stated that they would have difficulty in applying it in the classroom and students would find it hard, too, if they already found it difficult and 3 of them reported that they would not like to benefit from technological tools to overcome student problems when they start teaching professionally whereas 5 of them reported that they might apply activities easy to construct in the company of software. 3 of the pre-service teachers, who reported that they would not like to benefit from them when they start teaching professionally, stated that their opinion did not changed after the practice because they had not believed it would have been effective, giving the reason that students would certainly have difficulties in an activity which they prepared also having troubles and it would be more advantageous to use concrete materials rather than ICT tools. When considering the case within the scope of principles thoughts, and judgment, how teachers form their own principles, thoughts, and judgments about the use of information and communication technologies in the classroom and these affects their instructions is supported by other researchers (Jedeskog & Nissen, 2004). Teachers are among important components of the educational process. If it is a requirement to change the shape of mathematical instruction in the classroom, one of the steps to take to this end is changing thoughts and beliefs regarding the mathematical learning and instruction (Pajares, 1992; Thompson, 1992). Yet, it cannot be expected from teachers to change their thoughts and beliefs immediately. It is known that especially teachers resisted changing of their radical and central beliefs in their belief system (Green, 1971; Rokeach, 1968). Guskey (2002) states that teachers' thoughts and beliefs about mathematical learning and instruction when they see how effective the instructional method applied is on students. Within this framework, it is obvious that instructions given in the real classroom settings and observation of their effects on students can be considered components of such a pre-service training.

Most of the pre-service teachers reported that they had had no positive or negative perspective before the practice but it changed in the positive way because they thought it would be very effective on students. They addressed these positive effects as means that can be offered in the mathematical instruction by benefiting from information and communication technologies to overcome student difficulties in the general sense. One of these means, of which contributions have been found by the literature, is visualization; whereas this theme is presented through embodying of concrete concepts and providing ease of understanding (Botzer and Yerushalmy, 2008; Karal and Abdüsselam, 2009; Metaxas and Karagiannidou, 2010; Sacristran and Noss, 2008; Selçik and Bilgici, 2011), the theme of exploring has been explained as generalizing by seeing and trying, denying or accepting, learning permanently and meaningfully by associating step by step (Baki, 2000; Corbalan, Paas & Cuypers, 2010; Kutluca and Birgin, 2007; Olivero and Robutti, 2007). The opportunity of multiple representation has been described in the literature as creating a better conceptual structure and support permanent learning through ensuring that students see all the visuals together (Brenner et al., 1997; Confrey, 1994; Kaput, 1989; Kieran, 1994; O'Callaghan, 1998; Yerushalmy, 1991). The importance of dynamic homework was emphasized by the pre-service teachers because it can support off-school learning and provide habit of studying. Means such as time saving, attractiveness, being funny, and economy were presented among the contributions that it can provide students.

Especially 13 pre-service teachers additionally stated that their perspective changed positively because

the instruction contributed to their content knowledge and allowed for mathematical exploration for their own learning. In the literature, teachers' and pre-service teachers' opinions on the student difficulties regarding the concepts and their thoughts about how they would handle them have been studied and their pedagogical content knowledge has been investigated (Chick & Baker, 2005; Fuller,1996; Stacey et al., 2001). When considering the mathematical exploration opportunities offered by technology to teachers and its contributions to their content knowledge in this study, these opportunities presented by technology can be addressed as its positive effects. These positive effects can be interpreted in the way that the pre-service teachers would overcome the points in which they have difficulty and could utilize the instructions that support conceptual learning in their future instructions in this study when considering that teachers do not dwell on the concepts with which they have trouble or which they cannot make sense of (Even, 1990) and they teach them without going beyond operational procedures (Even, 1990; Tirosh, 2000). Moreover, 11 pre-service teachers emphasized that the field and frequency of practice need to be organized in a very well manner by emphasizing that it might lose its effectiveness on students to benefit from ICT tools in all difficulties in time. These criticisms are among important indicators of the progress exhibited by the participants. The fact that the pre-service teachers found the chance to observe and present the effective factors in overcoming the student difficulties by benefiting from ICT tools during the instructions show that they acquired high-level awareness of potential problem sources and the solutions. It is obvious that the necessity of discussing in groups how benefiting from ICT tools to overcome certain difficulties may cause more challenging situations and how the scope and frequency of application should be so that its effect on students would not diminish can be considered one of the components of such a pre-service training program in the development of this awareness.

The findings obtained in the study consequently show that the pre-service teachers benefited from information and communication technologies and gave effective instructions to overcome student difficulties regarding the given concept in this pre-service training program. Moreover, the evaluations on principles, thoughts, and judgments reflect the positive change in pre-service teachers' opinions on benefiting from information and communication technologies to overcome student difficulties, possible opportunities which they may offer to students in mathematical instruction and the positive contributions to pre-service teachers' own learning. As for the process of pre-service training program, the fact that student difficulties were handled not as a small component of micro-instruction but a separate component within the frame work of TPCK and investigated along with pre-service activities such as literature reviews, interviews with teachers, group discussions, and self-evaluations supported the effectiveness of the process. On the other hand, this also revealed important components in taking the efficiency to the next level. For example, the necessity of discussing in groups how benefiting from ICT tools to overcome certain difficulties may cause more challenging situations and how the scope and frequency of application should be so that its effect on students would not diminish is one of the components of such a pre-service training program can also be regarded as a component of such a pre-service training program to provide pre-service teachers with a top-level awareness of potential problem sources and the solutions. Furthermore, the fact that instructions were given in real classroom settings in consideration that the pre-service teachers might change their previous negative thoughts and beliefs about using ICT tools in their instructions when they would see the effectiveness of these tools on students and the effects could be observed in the students can be certainly considered a component of such a pre-service training program. It is recommended that instructions developed to ensure this component can be applied in real classroom settings should also be applied in undergraduate lessons including school experience and teaching practices. It is also thought that this study will be effective in planning the instructional process of future studies due to examining the effectiveness of micro-instructions and taking the opinions of pre-service teachers.

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