# Prospective mathematics teachers' views about using computer-based instructional materials in constructing mathematical concepts

Esra Bukova-Güzel
Department of Secondary
Matheamtics Ecducaiton
Dokuz Eylul Universtiy
Izmir, Turkey

Berna Cantürk-Günhan
Department of Primary
Mathematics Education
Doluz Eylul Universtiy
Izmir, Turkey

## Abstract

*The purpose of the study is to determine prospective mathematics teachers' views about using computer-based instructional materials in constructing mathematical concepts and to reveal how the sample computer-based instructional materials for different mathematical concepts altered their views. This is a qualitative study involving twelve prospective secondary mathematics teachers from a public university in Turkey. The data were gathered from two semi-structural interviews named pre-interview and post-interview. Between these interviews computer-based instructional materials were introduced to the participants. Findings revealed that the participants had positive perceptions toward these materials and believed that such tools help integrating mathematics and daily life.*
*Keywords: Computer-based instructional materials, prospective teachers, mathematical concepts.*

## Introduction

Clearly, the rapid development of technology influences education as well as other fields. Modern technologies such as computer-based software, the internet and sophisticated electronic modeling programs present new opportunities for teaching and learning at all educational levels (Boling, 2003; Poland, La Velle, & Nichol, 2003; Repenning, Rausch, Phillips, & Ioannidou, 1998; Resnick, 1995, 1998; Wilensky & Stroup, 1999). As a result, it has increased the necessity of the using "computer-based instructional materials (CBIM)" in learning environments to support students' learning and to help knowledge construction. The necessity of using CBIM can also be observed in different applications; i.e., many universities make a concerted effort to integrate appropriate technologies into teaching and learning practices (Fass, 1998; Gordon, 1993; McAlpine & Gandell, 2003).

Integrating CBIM into education has been of great importance because using computers as a tool for instruction provides many benefits. According to Lajoie (1993), some of these benefits are that CBIM helps support students' cognitive processes by reducing memorizing and encouraging awareness about problem-solving process, allows students to engage in mathematics, and supports hypothesis testing by allowing students to easily test conjectures (Kurz, Middleton, & Yanik, 2004). Naeslund (2001) also states that computer use in teaching leads to changes in pedagogy, contributes to pupil motivation and activity, and provides the possibility of both collaboration and individualization. Similarly, in another study, it has been determined that using CBIM in education facilitates students' learning, and increases students' motivation and interest in lessons (Yalın, 2000). In addition, when students use computers as cognitive tools, they can have access, analyze, interpret, organize their personal knowledge, think deeply, and perform their learning tasks effectively (Pea, 1985; Kozma, 1992; Mayes, 1992; Reeves, 1999; Jonassen, 2000 cited in Yıldırım, 2005). To be able to use technology as a cognitive tool, it is important to provide students with an appropriate learning context (Yıldırım, 2005). Jonassen and Reeves (1996) have stated that learning with technology requires a constructivist learning context which emphasizes that learning occurs when it is supported by different perspectives within meaningful contexts; social interactions are also critical in this learning process (cited in Oliver & Herrington, 2003). Duffy & Cunningham (1996) highlighted some pedagogical goals in the constructivist learning context such as the provision of experience in the knowledge construction process, provision of realistic and relevant contexts, encouragement of ownership, the use of multiple modes of representation, appreciation of multiple perspectives, and development of self-awareness in the knowledge construction process (cited in Oliver & Herrington, 2003).

The importance of using CBIM and developing a proper learning environment for this purpose is clear from the above-mentioned explanations. Furthermore, technology has tremendous potential for enhancing mathematics instruction and it can be used to strengthen student learning and to assist in developing mathematical concepts (Kurz, Middleton, & Yanik, 2004). As NCTM (2000) highlights in its standards, technology can facilitate mathematical problem solving, developing a deep understanding of mathematics, communication, reasoning, proof. Moreover, technology can provide students with opportunities to explore different representations of mathematical ideas, support them in making connections both within and outside of mathematics, and allow students to focus on decision making and reflection (cited in Niess, 2006). Due to such effects of technology upon learning, teachers should use CBIM in their classroom.

In a recent study conducted by Smith & Shotsberger (2001), most prospective teachers identified technology as important in mathematics education to assist in concept development but were uncomfortable with discussing the specific uses of technology for instruction due to lack of knowledge. Many prospective teachers feel that they are not prepared to teach using technology after they graduate (Carlson & Gooden, 1999). If teachers want to use and integrate technology in their learning environment, they will have a great role. In particular, new teachers are expected to enter the educational field with knowledge not only in their content areas, but of technology as well (Ayas, 2006).

Most mathematics curricula necessitate that mathematics teachers should integrate technology into mathematics learning. For example, the curriculum development studies in Turkey led to increased importance of using technology in teaching mathematics (Ministry of National Education [MNE], 2006). Some examples about technology integration are presented in these curricula and benefits are expected from technology-supported activities through education. The curriculum revision was based on the philosophy of constructivism which proposes that learners need to build their own understandings of new ideas. Students learn more effectively if they have experience about applying ideas to new situations. From this perspective, using technology is of great importance. Some researchers express that using technology in mathematics learning environments supports constructivism by providing different representations of mathematical concepts, discovery and problem solving, relating real life to mathematical concepts, presenting concrete representations of abstract mathematical concepts, motivating students, making lessons more interesting, providing an active learning environment, having positive attitudes, and supplying visualization (Durmuş, 2001; Mcdonald, 2005; Bukova, 2006; Kersaint, 2007). In the light of all these, it is essential for mathematics teachers to use technology and to integrate technology in mathematics teaching. If mathematics teachers are to use CBIM in their lessons, they should be supported and encouraged toward using CBIM during their education years. Prospective mathematics teachers should receive training about using different technologies and be informed about computer software concerning mathematics and applying their knowledge in practice. It should be determined whether samples of CBIM aiming at constructing mathematical concepts will positively affect prospective mathematics teachers' views toward CBIM. Besides, prospective mathematics teachers may be asked to prepare learning materials.

Hereby, prospective mathematics teachers should develop and use CBIM in their future lessons. The purpose of this study is to determine prospective secondary mathematics teachers' views toward using CBIM to construct mathematical concepts and to reveal how CBIM samples about different mathematical concepts altered their views.

## Method

The qualitative case study design was used in this study involving twelve prospective secondary mathematics teachers at Dokuz Eylul University in Izmir, Turkey. The study lasted for eight weeks during academic year 2006-2007. The data were gathered from two semi-structural interviews containing pre-interview and post-interview. In the first week, pre-interviews were made with twelve prospective secondary mathematics teachers at the beginning of the study. The purpose of pre-interviews was to identify the participants' views about the effects of using instructional learning tools in constructing mathematical concepts and the approaches they use when preparing CBIM. The representations prepared by the researcher were introduced to the participants. This application continued for six weeks and each instructional learning tool was presented to the participants in different weeks. These representations about mathematical concepts as instructional learning tools contain flash animations, dynamic graphs, Geometer's Sketchpad activities, video-clips, spreadsheets, and power-point presentations. For example, the flash animations were presented during the second week of the study and so on. After all the representations were presented, discussions were held with the participants about these tools. After the representations, post-interviews were carried out with the participants. The purpose of post-interviews was to determine how the participants' views about the effects of using the instructional learning tools in constructing mathematical concepts changed after the representations were presented and whether their approaches about CBIM preparation changed or not.

## Participants

The purposeful sampling method was used in selecting the participants. There were twelve participants in this study (6 females and 6 males) from the Faculty of Education. Their ages ranged from 20 to 22 years old. All the participants were trained to become secondary school mathematics teachers. Six of them were in their fifth year and had completed the courses about subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, integration of technology into mathematics education, and school experience. The remaining six students were in the fourth year and had received the courses about subject matter knowledge, software programs such as Geometer's Sketchpad, Derive, Power-point, and Microsoft-Word. The specialties of the participants are given in Table 1. In this table, the letters represent the first letters of the participants' names. The participants were classified according to three different levels in Table 1. The first level was named as the low level (L) in which the participants had limited knowledge and experience about computer programs and software. E, M, N, and Y were at this level. The second level was named as the medium level (M) in which the participants had greater knowledge and experience of computer programs and software than the low level. A, İ, H, and Z were at this level. The third level was named as the high level (H) in which the participants had the greatest knowledge and experience about computer programs and software. This level included B, G, R, and S.

**Table 1:** The characteristics of the participants

| Computer Software and Computer Programs | | | | | |
|---|---|---|---|---|---|
| Classes | Microsoft Office | Geometer's Sketchpad | Derive | Flash | MathCad |
| The Fourth Class (4) | A, G, İ, M, N, R | İ, G, M, R | G, A, R | G, R | G, R |
| The Fifth Class (5) | B, E, H, S, Y, Z | E, Z, H, B, S | Z, H, B, S | B | B, S |

## Instruments

The qualitative method was used to collect the data in this study. The data were gathered from two semi-structural interviews containing the pre-interview and the post-interview. In these interviews, three open-ended questions were asked to the participants and the interview guide was used at this stage. The open-ended questions concerned the following areas: "How did CBIM affect the construction of mathematical concepts", "Were you able to prepare the CBIM? If you want to prepare CBIM, what will you take into account?", and "Which representation did you like the most? Or which representations did you like? Why did you like them?" The first and second questions were asked to the participants both during the pre-interview and the post-interview. And the third question was only asked during the post-interview, which attempted to determine the participants' views about the computer-based instructional materials (CBIM) prepared and presented to them by the researchers. All the interviews were recorded by an audio-recorder and analyzed later.

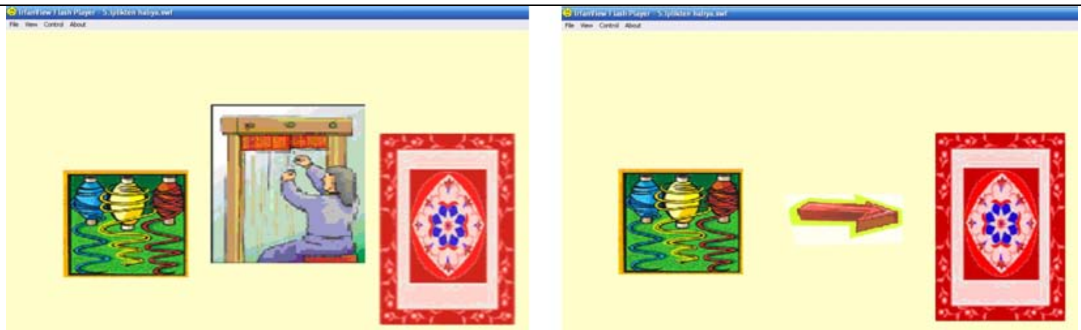
## Materials

In this study, the representations were used as materials to examine the prospective mathematics teachers' views and whether their views changed when they were confronted with different examples and discussed these materials. When the materials were prepared, it was noticed that the CBIM would help constructing mathematical concepts. The CBIM developed to construct mathematical concepts included animations, spreadsheets activities, dynamic graphical representations, Geometer's Sketchpad representations, power-point representations, and video clips. These materials were introduced in the following part.

*Flash Animations*

The Flash animations were mainly used to sample the real world applications of mathematical concepts in this study. These representations were important in that they integrate the real world with mathematical concepts. They also helped construct mathematical knowledge, procedures, and concepts by using mathematical models. It was intended that these materials would be interesting, emphasize the critical points of the concepts, and allow meaningful learning. Nine representations were presented using flash animations concerning the limit concept, function concept, induction, and factorization. Figure 1 shows an example. In this animation, the aim was to construct the function concept in the form of a machine; more specifically, the loom as a machine, the fiber as input, and the carpet as output. When such animations are constructed, the importance of tripartite principle of input, output and rule in constructing the concept of function should be revealed by emphasizing that reaching from an input to an output is only possible by selecting the appropriate rule.

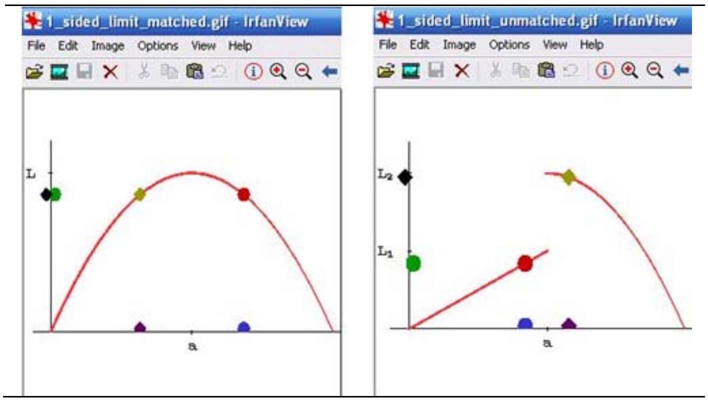
**Figure 1**: An example of flash animations about the function concept.



*Dynamic Graphs*

In this study, the dynamic graphs were mainly used to reveal the change in the function's value when x approaches a different point. These representations were important to estimate the behavior and limit of a function and to think critically and mathematically through active manipulation of the graphs. One example is given in Figure 2. This dynamic graph aimed to provoke discussions about how the functions will behave when x approaches a point both on the left and right sides. In other words, it attempted to examine whether functions have a limit value or not. When such material was used to highlight the importance of neighborhood and approximation in limit, it demonstrated that when you approach a point from right and left, limit can be said to exist at that point only when the approach value is the same.

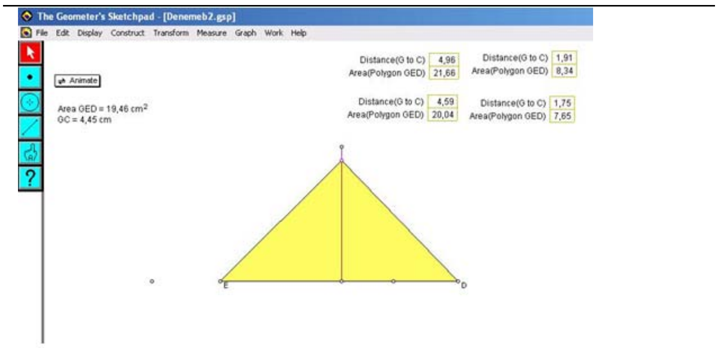
Figure 2: An example of dynamic graphics about the limit concept.




*Geometer's Sketchpad Activities*

The Geometer's Sketchpad activities mainly aimed to show dynamic representations of the properties of the triangles' area in this research. These representations were important to estimate the changes in area when the conditions were altered, to provide mathematical exploration and sense-making. It was intended that these materials should provide making mathematical conjectures and using dynamic capabilities to visualize an idea under a wide variety of situations. Figure 3 shows an example. This Geometer's Sketchpad activity aimed to discuss how the area of the triangle changed depending on the change in height.

Figure 3: An example of the Geometry Sketchpad activities about the area of the triangle.




*Video-clips*

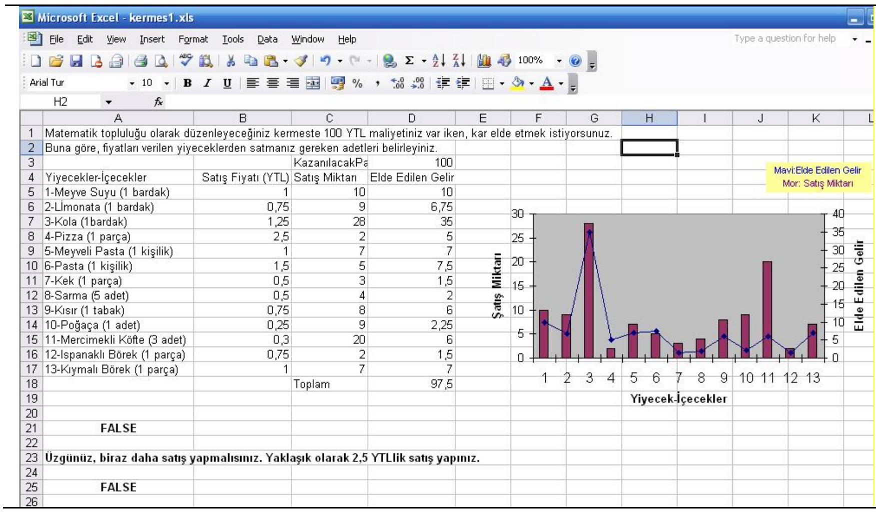
The main purpose of using video-clips in this research was to show the constitution of three-dimensional figures such as cylinder and rectangular parallelepiped. These representations were important as they promote mathematical thinking and higher-order thinking, enrich students' understanding, generate mathematical concepts by providing visualization, assist students like a scaffolding, and reveal the quality of 3-D figures to students. Figure 4 provides one example of these video-clips, which aimed to identify the cylinders with circular shape and same areas by using the CDs. It was intended that students would recognize the characteristics of the cylinders generated in the video-clip.

*Spreadsheets*

The spreadsheet activities were mainly performed to construct mathematical models about the given situations in this study. These representations were important to explore mathematical formulas, to develop problem solving skills, to gain different points of view, to discover the properties of mathematical concepts, to provide different data for given examples, and to interpret the relationships between the data and their graphs. Figure 5 introduces an example of a spreadsheet activity aiming to provide an understanding for a given situation, to compose mathematical models, to examine the correctness of these models, and to interpret the data graphs. This material will also contribute to the development of mathematical modeling skills.

Figure 4: An example of the video-clips activities about cylinder.

**Figure 5:** An example of the spreadsheets activities about equations, inequality, interpreting graphic.



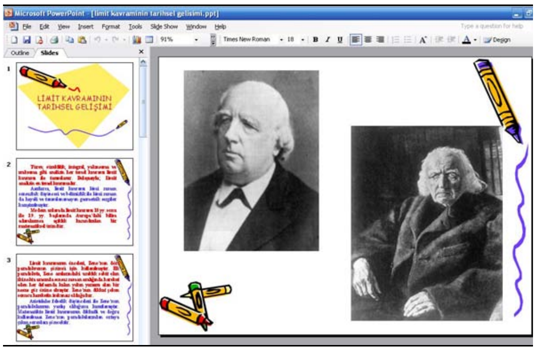
| | A | B | C | D |
|---|---|---|---|---|
| 1 | Matematik topluluğu olarak düzenleyeceğiniz kermeste 100 YTL maliyetiniz var iken, kar elde etmek istiyorsunuz. | | | |
| 2 | Buna göre, fiyatları verilen yiyeceklerden satmanız gereken adetleri belirleyiniz. | | | |
| 3 | | | KazanılacakPa | 100 |
| 4 | Yiyecekler-İçecekler | Satış Fiyatı (YTL) | Satış Miktarı | Elde Edilen Gelir |
| 5 | 1-Meyve Suyu (1 bardak) | 1 | 10 | 10 |
| 6 | 2-Limonata (1 bardak) | 0,75 | 9 | 6,75 |
| 7 | 3-Kola (1bardak) | 1,25 | 28 | 35 |
| 8 | 4-Pizza (1 parça) | 2,5 | 2 | 5 |
| 9 | 5-Meyveli Pasta (1 kişilik) | 1 | 7 | 7 |
| 10 | 6-Pasta (1 kişilik) | 1,5 | 5 | 7,5 |
| 11 | 7-Kek (1 parça) | 0,5 | 3 | 1,5 |
| 12 | 8-Sarma (5 adet) | 0,5 | 4 | 2 |
| 13 | 9-Kısır (1 tabak) | 0,75 | 8 | 6 |
| 14 | 10-Poğaça (1 adet) | 0,25 | 9 | 2,25 |
| 15 | 11-Mercimekli Köfte (3 adet) | 0,3 | 20 | 6 |
| 16 | 12-Ispanaklı Börek (1 parça) | 0,75 | 2 | 1,5 |
| 17 | 13-Kıymalı Börek (1 parça) | 1 | 7 | 7 |
| 18 | | | Toplam | 97,5 |
| 19 | | | | |
| 20 | | | | |
| 21 | FALSE | | | |
| 22 | | | | |
| 23 | Üzgünüz, biraz daha satış yapmalısınız. Yaklaşık olarak 2,5 YTLlik satış yapınız. | | | |
| 24 | | | | |
| 25 | FALSE | | | |
| 26 | | | | |



*Power-point presentations*

In this research, the PPT presentations were mainly used to provide knowledge, to assess students' understanding, to present a history of mathematical concepts, and to offer mathematical games. These representations were important as they introduce mathematical and general knowledge and render lessons interesting. One example is given in Figure 6. In this PPT presentation, the aim was to present a history of the limit concept and its development.

**Figure 6:** An example of the power-point representations about the history of the limit concept.



## Procedure

The researchers investigated the learning tools in the literature. They also organized the representations to integrate technology into mathematical concepts. These representations included flash animations, dynamic graphs, Geometer's Sketchpad activities, video-clips, spreadsheets, and power-point representations. The application lasted for seven weeks. All students who took part in the study were interviewed at the beginning of the study. The interviews, which form the bulk of the material, are characterized by reflective conversations. The duration of the interviews varied between 20 and 25 minutes. Before each interview took place, the students were informed about the purpose of the interview. All interviews were tape-recorded after the permission of the participants was obtained. The pre-interviews were carried out during the first week. The flash animations were introduced to the students during the second week. Dynamic graphs, Geometer's Sketchpad activities, video-clips, spreadsheets, and power-point representations were presented respectively during five weeks. Each representation lasted for about 90 minutes. After each representation was introduced, the students were asked to hold discussions about the representations. At the end of these representations, all students were interviewed during the seventh week. All the data were verbatim transcribed.

## Data Analysis

The interviews were audio-taped. The data were transcribed verbatim and then coded. Evaluation was guided by the ideas of qualitative content analysis (Mayring, 2006). The coded data were presented and described under these main themes, and then the results were interpreted and discussed. The main themes included "The participants' views about the effects of technology on constructing mathematical concepts", "The participants' approaches for preparing CBIM used to construct mathematical concepts", and "The participants' views about the presented CBIM". The participants' responses were grouped under these main themes. Efforts were also exerted to evaluate whether there were any differences between the prospective teachers' views in the pre- and post-interviews.

## Results

This chapter discusses the findings obtained from the pre-interviews and post-interviews. During the interviews, the participants responded to questions such as "How did CBIM affect the construction of mathematical concepts", "Were you able to prepare the CBIM? If you want to prepare CBIM, what will you take into account?", and "Which representation did you like the most? Or which representations did you like? Why did you like them?".

The analysis of the pre- and post-interviews revealed certain themes in relation to the use of the CBIM. The results of this study are presented under these themes, along with the necessity of using technology in mathematics education, using technology in constructing mathematical concepts, preparing this kind of materials, and views about the presented tools. In the pre-interviews, most of the students (n=11) stated that the CBIM should be used in constructing mathematical concepts but only one student in the fourth grade was not sure about the need to use technology for this purpose. On the other hand, all the prospective mathematics teachers mentioned positive views regarding the use of CBIM to construct mathematical concepts in the post-interview. As demonstrated by the following quotation, the student's undecided attitude in the pre-interview about the contribution of technology use changed in the post-interview.

> "I don't consider it as a requirement to use CBIM in learning. I remember that during my years as a student, we were never given a technology-based instruction but we were successful in mathematics lessons. That's why, CBIM can be used but I do not see why it is necessary. Maybe it can be used to perform applications; otherwise, I don't think that it needs to be used to construct concepts." (M- 4th grade, pre-interview)
>
> "Such materials certainly contribute to the formation of mathematical concepts. Before the presentations, I obviously could not decide whether CBIM is really necessary. However, now… I think that these materials must certainly be used in mathematics lessons. I'm sure now that these materials will benefit by emphasizing the critical points of concepts, presenting visual examples of concepts, and integrating mathematical concept with real world…." (M- 4th grade, post-interview)

Table 2 introduces the views of the prospective mathematics teachers in the fourth grade concerning the effects of using CBIM on construction of mathematical concepts. The participants' views changed from the pre- to post-interviews. Especially, the views of the participants at low (L) and medium levels (M) changed during the process and they believed that the CBIM positively affected the construction of mathematical concepts, discussing and sharing mathematical knowledge and understanding. The participants also mentioned that using CBIM in constructing mathematical concepts improved students' learning outcomes such as motivation, higher-order thinking, researching skills, and communication among the peers. As clear from Table 2, most of the participants stated that the CBIM could represent mathematical concepts more concretely, helped a better understanding of the mathematical concepts, provided visualization and real world examples for the mathematical concepts, and created an opportunity for exploring and discovering results. These are very important results in terms of the need for the use of such materials. Table 2 also shows that the opinions of the participants at all levels changed positively after the representations. Although the low-level participants stated four different views in the pre-interviews, they indicated eight different views in the post-interviews. It was observed that while the most significant change of view occurred in low-level participants, medium- and high-level participants' views also changed positively.

The views of the prospective mathematics teachers in the fifth grade in relation to the same questions are shown in Table 3. Table 3 demonstrates that these participants' views also changed from the pre- to post-interviews. These participants' views were consistent with those of the fourth-grade participants. They also expressed different views than those of the fourth-grade students; for instance, many students said that it improved higher-order thinking and creative thinking, prevented the formation of misconceptions about mathematical concepts, and enabled acquisition of procedural knowledge.

**Table 2**: Prospective mathematics teachers' views about the Effects of Technology in Constructing Mathematical Concepts in The Fourth Grade.

| Prospective mathematics teachers' Views | 4L1 | 4L2 | 4M1 | 4M2 | 4H1 | 4H2 |
|---|---|---|---|---|---|---|
| Technology can help understand mathematical concepts. | M, N | M, N | - | A | R | R, G |
| It can facilitate retention of learning. | M | M | A | A | - | - |
| It can represent mathematical concepts more concretely and provide visualization. | M | M, N | A, İ | A, İ | R, G | R,G |
| It can lead students to higher-order thinking. | - | - | - | - | G | G |
| It can provide students' motivation. | - | - | A | A, İ | - | R |
| It can improve research abilities. | | | | | G | G |
| It can promote students' mathematical thinking. | - | - | - | İ | R | G, R |
| It can sophisticate students' intuitive thinking. | - | M | - | - | - | - |
| It can help students think creatively. | - | N | - | - | - | - |
| It can enhance students' psychomotor skills. | - | N | - | - | - | R |
| It can create opportunities to explore and discover results. | - | N | - | İ | G, R | G, R |
| It can relate the real world to the mathematical concepts. | M | M, N | A | A, İ | G, R | G, R |
| It can promote active learning. | - | - | - | A | G, R | G, R |
| It can create associations among mathematical concepts. | | | | A | | G |
| It can promote sharing of knowledge. | | | | | | G |
| It can advance the mathematical modeling approach. | - | - | - | - | R | R |

* 4L1 indicates fourth-grade students with low level pre-views, while 4L2 indicates fourth-grade students with low level post-views. (L: low level, M: medium level, H: high level)

**Table 3**: The Fifth-Grade Prospective mathematics teachers' Views about the Effects of Technology in Constructing Mathematical Concepts.

| Prospective mathematics teachers' Views | 5L1 | 5L2 | 5M1 | 5M2 | 5H1 | 5H2 |
|---|---|---|---|---|---|---|
| Technology can help understand mathematical concepts. | - | E, Y | Z | H, Z | B, S | B, S |
| It can facilitate retention of learning. | - | E | H | H, Z | - | - |
| It can represent mathematical concepts more concretely and provide visualization. | - | E | H, Z | H, Z | B, S | B, S |
| It can lead students to higher-order thinking. | - | E, Y | - | Z | B, S | B, S |
| It can enhance students' motivation. | - | - | H | H, Z | - | S |
| It can improve students' problem solving ability. | - | - | Z | Z | - | - |
| It can enhance students' reasoning skills. | - | - | - | Z | S | S |
| It can advance students' mathematical thinking. | - | - | - | Z | - | B |
| It can sophisticate students' intuitive thinking. | - | - | - | Z | - | - |
| It can help students think creatively. | E | E, Y | - | Z | S | - |
| It can enhance students' psychomotor skills. | E | E | - | Z | - | - |
| It can create opportunities to explore and discover results. | - | E, Y | H | H, Z | S | S |
| It can relate the real world to the mathematical concepts. | - | E, Y | H, Z | H, Z | B | B, S |
| It can promote active learning. | - | E | H | H, Z | - | B |
| It can create associations among mathematical concepts. | - | E | H | H, Z | S | B, S |
| It can advance the mathematical modeling approach. | - | Y | - | - | - | - |
| It can enable acquisition of procedural knowledge. | - | Y | - | - | S | S |
| It can prevent the formation of misconceptions about mathematical concepts. | - | Y | - | Z | - | S |

* 5L1 indicates fifth-grade students with low level pre-views, while 5L2 indicates fifth-grade students with low level post-views. (L: low level, M: medium level, H: high level)

In addition to the fourth-grade participants' views, most of the fifth-grade participants stated that the CBIM could create associations among mathematical concepts, promote creative thinking and advance problem solving skills. The views of the fifth-grade participants with low-level technology use changed positively after the presentations. The views of the fifth-grade participants with medium-level technology use also changed but not as much as the change in the views of low-level students.

Half of the participants (İ, R, G) in the fourth grade stated that they could prepare the CBIM and the rest mentioned opposite views in the pre-interview. However, in the post-interview, all of the participants in the fourth grade expressed that they could prepare some CBIM to construct mathematical concepts. They expressed these views after watching different presentations about CBIM. Table 4 presents the students' responses to the question "What will you take into account when preparing the instructional tools?".

**Table 4:** The Fourth-Grade Prospective mathematics teachers' Approaches for preparing CBIM used in constructing mathematical concepts

| **Prospective mathematics teachers' Views** | **4L1** | **4L2** | **4M1** | **4M2** | **4H1** | **4H2** |
|---|---|---|---|---|---|---|
| It should be appropriate for lesson's objectives. | - | M, N | - | İ | G, R | G, R |
| It should be suitable for students' pre-knowledge and experiences. | - | N | - | A, İ | G, R | G, R |
| It should be interesting. | - | M, N | İ | A, İ | G | G, R |
| It should stimulate higher-order thinking. | - | M | - | - | - | - |
| It should create bonds among mathematical concepts. | - | - | - | - | - | R |
| It should emphasize the critical points of the concept. | - | - | - | A | - | G, R |
| It should connect the real world with mathematical concepts. | - | - | - | A | - | R |
| It should allow students to interpret and generalize about mathematical concepts. | - | - | - | İ | - | - |

As seen in Table 4, the fourth-grade participants stated that the CBIM should be suitable for students' pre-knowledge and experiences, be appropriate for lesson's objectives, be interesting, emphasize the critical points of the concept, and promote higher-order thinking. Most of the fourth-grade participants did not perceive themselves as self-sufficient to prepare CBIM. However, after the presentations, they came to the conclusion that they can prepare some materials. Because all prospective teachers watched examples of such materials and they had knowledge of Microsoft-Word, they imagined what they could do, or what kind of materials they could construct.. That's why their views changed in the post-interviews. A prospective teacher's opinion is as follows:

> "Obviously I don't know how I can prepare this learning material using the Excel. Spreadsheets and Power-point presentations are tools from which I can benefit. Besides, I can prepare video-clips but I can better prepare their contents. These tools which I can prepare will help to increase interest in lessons, to understand mathematics and to use applications" (N, 4th grade, post-interview).

Table 4 also reveals that the high-level participants planned to pay attention more to the criteria about the preparation phase. It was determined that most of the prospective teachers thought they would benefit from instructional materials in order to integrate mathematics and daily life.

All of the participants in the fifth grade mentioned that they could prepare the CBIM to construct mathematical concepts both in the pre- and post-interviews. Table 5 shows their approaches and views about preparing some CBIM used in constructing mathematical concepts. In addition to the fourth-grade prospective mathematics teachers' views, it was made clear by most of them that CBIM should be prepared to prevent misconceptions about concepts, be original and provide visualization.

In the post-interview, the students were asked the question "Which representations did you like the most?". 92% of the students said that they liked flash activities, 67% of the students liked Geometer's Sketchpad activities, 50% of the students liked excel activities, 33% of the students liked dynamic graphic activities, 25% of the students liked video, and 25% of the students liked PPT activities. Below are some of prospective teachers' views after the presentations.

> "… we must be trained during our mathematics education program to use computers and such software programs in educational purposes."
> "… I have always had trouble with the limit concept. Whoever watches the animations about the limit concept can comprehend that the limit concept is an approach, an approximate value and a concept related to the real world and that the limit of a function can even exist at a point which is not an element of the domain. I should use flash animations in my professional life. So I will improve my knowledge. When different CBIMs are used, students can learn by doing, making, thinking and relating. Because they motivate students, they should be particularly used for difficult mathematical concepts and concepts which students never relate to real world. It is very essential for students to understand the importance of mathematics. For example, constructing the correlation between the limit concept and the real world can assist in learning the limit concept meaningfully. In general, technology can be used as a computational tool but these representations exactly support opposite view. In other words, they demonstrated that technology can be used to visualize, explore, relate, generalize and analyze mathematical concepts and ideas."
> "They were interesting because they were very new applications for me. I think, they could open up different viewpoints to students. These materials could draw students' attention. When students realize that they can understand mathematical concepts, their participation in lessons will increase. Teachers could make an effort for students to think intuitively about mathematical concepts. However, it was very hard to perform these kinds of materials given the lack in Turkey's basic facilities such as the lack of technical structure in classrooms, the teachers' lack of knowledge about computers -even some teachers did not know how to start the computer-, and teachers' beliefs about computers and CBIM. Teachers' subject matter knowledge and pedagogical content knowledge are also important. I mean if a teacher's knowledge about mathematical is not adequate, he or she cannot design animations very well. He or she should imagine very carefully, reflecting the critical points of the concepts. I want to use these materials but I could not prepare all of them. I think cooperation is needed between mathematics teachers and computer programmers. Mathematics teachers will use their subject matter knowledge, learners' knowledge, pedagogical content knowledge and programmers will use their software knowledge".

**Table 5:** The Fifth-Grade Prospective mathematics teachers' Approaches for preparing CBIM used in constructing mathematical concepts.

| Prospective mathematics teachers' Views | 5L1 | 5L2 | 5M1 | 5M2 | 5H1 | 5H2 |
|---|---|---|---|---|---|---|
| It should be appropriate for the lesson's objectives. | - | E | H, Z | H, Z | B | - |
| It should be suitable for students' pre-knowledge and experiences. | E, Y | E, Y | H, Z | H, Z | S | B, S |
| It should be interesting. | - | Y, E | H | H, Z | - | B, S |
| It should be prepared to prevent misconceptions about the concept. | - | E | - | H | - | - |
| It should relate mathematical concepts to each other. | - | - | - | - | - | S |
| It should emphasize the critical points of the concept. | - | Y | Z | H, Z | - | B, S |
| It should connect the real world with mathematical concepts. | - | E | H | H | B | B |
| It should be original | - | E | - | - | S | S |
| It should provide visualization. | - | - | - | - | - | S |
| It should allow students to interpret and generalize about mathematical concepts. | - | - | - | - | - | B |

## Discussion and Conclusion

This study reports the views of pre-service mathematics teachers about using CBIM in constructing mathematical knowledge. It is believed that this study will make an important contribution to previous research. This study demonstrated that the views of the prospective mathematics teachers changed in the process and they came to believe that CBIM should have many properties. In this research, by drawing upon prospective mathematics teachers' views, it was determined that CBIM contributes to constructing mathematical concepts in many ways. Almost all the participants stated that the CBIM assisted to construct, visualize and concrete the mathematical concepts and related mathematical concepts to the real world. The post-interviews revealed that all the participants' views positively changed after the presentations. This result points to the requirement of extending the courses in mathematics teacher education programs to introduce computer-based instructional materials and to allow prospective mathematics teachers to be able to develop such materials. This is important because all the participants indicated that they want to integrate technology in their future professional life after seeing the presented samples. However, they expressed the necessity that they have to be more trained about technology. Carter & Burger (1994) argue that novice teachers need to be educated before graduating from teacher education programs in order to construct relationships among curriculum, learning and teaching by using technology.

Additionally, in some research (Carlson & Gooden, 1999; Gunter, 2001; Smith & Shotsberger, 2001) it was indicated that education of pre-service teachers aiming at using technology in mathematics courses is insufficient and they were not ready to use technology in their professional life besides they were unaware of possibilities which mathematical software supplies. This argument is in parallel to the result about the need for more education stated by the participants. Yet, such education should not be limited to introducing computer programs, special mathematical software and computer-based materials; in other words, it should not be simply given in a theoretical way but it should also present different applications of theoretical knowledge. Moreover, it is also desirable for pre-service teachers to develop their own examples by using interactively their learning about technology.

In general, it was observed that the views of all participants in the post-interviews changed positively in comparison to the pre-interviews. However, the views of the participants with little technology knowledge changed the most. Especially, it was shown that almost all the participants thought that abstraction in mathematical concepts should be eliminated by using the advantages of technology to some extent.

The following suggestions could be presented considering this study's results:

- In the process of teacher education, content knowledge and pedagogical content knowledge should be improved synchronously with the improvement in technological pedagogical knowledge.
- Both in-service and pre-service teachers' awareness should be raised about the advantages of technology-based mathematics learning.
- It has been confirmed that pre-service mathematics teachers' should be given sufficient knowledge about technology, computer software and especially mathematical software so as to able to use them in their future lessons. They should be provided with such knowledge in action.

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