Analysis of Teaching Materials Developed by Prospective Mathematics Teachers and Their Views on Material Development

[1] Mathematics Education Department, Ereğli Faculty of Education, Bülent Ecevit University, Zonguldak, Turkey.
email: timurkoparan@gmail.com

Timur Koparan [1]

ABSTRACT

This study aimed at exploring the quality of teaching materials developed by prospective mathematics teachers and their viewpoints on developing teaching materials. It was carried out with 170 prospective teachers from 4 classes in the Fall Semester of 2014-2015 Academic Year. During the first 8 weeks of the 14-week-long study, the theoretical parts and teaching technologies of the course were introduced. In the next 6 weeks, the prospective teachers were expected to present the materials they developed in a classroom environment. Data were collected through the materials prepared by the prospective teachers, classroom observations, and survey questions. The data underwent content and descriptive analysis. Findings indicate that prospective teachers can prepare materials and use the teaching technologies at a satisfactory level. They believed they gained the necessary knowledge, skills, and attitudes in this course to develop and use teaching materials, and they would like to take advantage of these knowledge and skills in their teaching profession. In accordance with the findings, it is concluded that prospective teachers have positive views and attitudes to general teaching technologies and material development.

Keywords: *Mathematics education, teaching materials, computer supported mathematics education, dynamic software, prospective teachers*

INTRODUCTION

We live in an age of rapid social change and improvements have gained speed, and information and communication are influential in every moment of human life. Many researchers, communities and institutions underline the importance of educating teachers to use proper technologies and materials in teaching mathematics (Association of Mathematics Teacher Educators, 2006; International Society for Technology in Education, 2008; National Council of Teachers of Mathematics, 2000; Niess, 2006). New information, opportunities and tools have re-shaped our viewpoints of mathematics, expectations from it, the way we use it and, most of all, our processes of learning and teaching it (Milli Eğitim Bakanlığı, 2013).

In the learning environments centered only on the course books, the students cannot fully acquire the skills of making predictions and judgements, intuitive thinking, getting motivated, doing experiments, discerning the experiment results and extracting formulas from these results. However, material based learning environments enable acquisition of these skills (Gündüz, Emlek, & Bozkurt, 2008).

Recent educational technology advances have been reflected in the teaching materials, which, in turn, have resulted in more improved teaching materials in terms of quality and quantity, and brought many benefits for teachers and students. Use of teaching equipment helped teachers and reduced their teaching time, use of the board and too many words to a great extent (Koşar, Yüksel, Özkilic, Avci, Alyas, & Çiğdem, 2003). Also, using materials have direct effects on realization of educative purposes in the teaching and learning process and these effects are among the major reasons for teachers to use materials.

Materials make students are more interested in the classes, become more active, do more exercise in accordance with their individual qualities, become more successful, experience real learning, get the chance to collaborate, think critically, and improve their problem solving and creative skills (Koparan, 2015). Besides contributing to the success of teaching programs, materials help the classes to become more enjoyable, enable better time management and increase productivity levels in classes. Since using classroom materials facilitate learning, teachers should take advantage of materials regardless of what methods and techniques they employ. Changes and developments in science and technology mean that students are expected to be educated to have better qualities, which makes it a sheer necessity for teachers to create more effective learning environments. It is inevitable to use materials to create effective learning environments. Instead of students getting knowledge from only one source and memorizing it, education now aims at training individuals in finding information and how to use that information for problem solving (Kazu & Yeşilyurt, 2008).

Which technologies are ideal for learning mathematics? What are the attitudes and beliefs of prospective teachers about teaching mathematics with technology? What are the difficulties experienced during material development? Do the teachers and prospective teachers have the opportunities to gain the knowledge and experience necessary to integrate technology into classroom teaching and learning? These questions must be answered for better mathematics teaching.

Changes in the mathematics curriculum all over the world, including the use of technology, have been advocated in recent years. New technologies support learners in exploring and identifying mathematical concepts and relationships. The advantages of these technologies include their dynamic nature, speed, communication and collaboration tools which are central to the process of taking ownership of knowledge. Findings from a number of research studies have shown that strategic use of technological tools can stand by both the learning of mathematical procedures and skills as well as the development of advanced mathematical competence, such as reasoning, problem solving, and justifying (Gadanidis & Geiger, 2010; Nelson, Christopher, & Mims, 2009; Pierce & Stacey, 2010; Roschelle, Shechtman, Tatar, Hegedus, Hopkins, Empson, Knudsen & Gallagher, 2010). Future mathematics teachers need to be ingenious in practices of technology (Powers & Blubaugh, 2005). Preparing tomorrow's mathematics teachers to use technology is one of the most important topics facing teacher education programs today (Kaput, 1992, p. 515; Waits & Demana, 2000).

New mathematics teaching programs have been applied in Turkey since 2013. The advised teaching technologies and materials for mathematics classes include books, concrete materials, compasses, rulers and so forth, dynamic geometry software, interactive applications on websites in Turkish and other languages, graphics software, spreadsheets, calculators, smart boards and tablets, simulations, games, teaching objects and micro worlds. Teachers need to gain experience before they begin the profession for a proper and effective use of these teaching technologies and materials. Studies have demonstrated that the views of prospective teachers about mathematics teaching influence their use of materials in classes. Finding out the views of prospective teachers about the topic is thought to contribute to the literature of the field.

Developing Teaching Materials

In conventional learning environments, students usually lack the opportunities to make predictions and judgements, think intuitively, get motivated, do experiments, and extract formulas from these experiments depending on the results. However, learning environments with teaching materials make almost all of these opportunities possible. The teaching materials used in this study are concrete teaching objects, worksheets and concept maps, dynamic software, and smart board materials.

Concrete materials include concrete instantiations of mathematical concepts and mathematical equipment such as pictures to serve this aim, and real life objects (Van de Walle, 2007). These touchable and movable concrete materials are accepted to help form a clear understanding of mathematical concepts (Moyer, 2001). They not only facilitate student learning of the subject but also help teachers with teaching. They also enrich education and deepen the subject. Moreover, using concrete materials is supported by many theories (Bruner, 2006; Dienes & Golding, 1971; Piaget, 1971; Skemp, 1987).

In recent years, the constructivist theory of learning and teaching has been widely accepted as a way of teaching concepts effectively and learning meaningfully. This theory promotes the idea that best learning is achieved when the individuals personally do and express what they have learned (Bodner, 1990). Proponents of this idea adopted this approach to their teaching with various strategies. Although there are many teaching materials based on constructivist theory, worksheets are more of importance in this approach, and worksheets developed for various purposes can be found in the literature.

Concept maps, which show concepts of a subject and the relationship between these concepts graphically, are two-dimensional diagrams used to figure out how the students perceive and synthesize the concepts; define the pre-concepts and misconceptions, and evaluate their conceptual understanding. A concept map is an educative strategy that helps with a better apprehension of newly learnt subjects, integration of old and new information, improvement of students' level of conceptual perception, and aid their success (Heinze-Fry & Novak, 1990). In concept maps, key words and information are circled and these circles are connected to each other with linking words or sentences.

Dynamic geometry software (Cabri 2D, Geogebra, Cabri 3D) provide students with an environment for doing research on geometric relations, enabling them to build structures and test them (Güven & Kösa, 2008). Thanks to the drag and drop features of the dynamic geometry software, students can do research on mathematical concepts, structures and relationships; define the features of the concepts and associate these features to each other (Koparan & Kaleli Yılmaz, 2015). In this way, learning environments dominated by direct teaching are replaced by the ones centered on association and discovery (Kağızmanlı, Tatar, & Akkaya, 2011). GeoGebra is a dynamic mathematics software combining the diverse possibilities of computer algebra systems with the easy use of dynamic geometry software (Hohenwarter, Hohenwarter, & Lavicza, 2008). Given its usability, it can be applied in almost all subjects of mathematics from primary school to university. GeoGebra is an efficient software that provides students with an environment to observe, calculate, think and do mathematics (Oreilly, 2009).

Another improvement in information technology is the rise of smart boards. Smart boards are among the efficient means of distance education and remote access to information. By presenting visual materials supported with sound and animations, smart boards help to achieve permanency in learning. They play a significant role in supporting the memorability of mathematics, which is one of the most difficult attainments for students.

A lot of money is spent on technological products within various projects in Turkey. Within the F@TİH project started in 2010, smart boards account for the primary source of expense. They enable users to access web sources and, at the same time, present them to the whole class, play videos to help in teaching concepts, show homework to other students, handwrite, save files for later use, write and draw in different colors, choose software proper to content (Acrobat Reader, PowerPoint, Flash Player, Microsoft Journal, Media Player, Internet Explorer etc.), and organize texts and drawings quickly (Hall & Higgins, 2005).

The Aim and Problem of the Research

This study aimed at exploring the quality of teaching materials developed by prospective mathematics teachers and eliciting their viewpoints on developing teaching materials and course material (see Table 1). At the same time, this study offers examples to mathematics teachers and researchers on materials used in mathematics teaching. Within the scope of this study, following research questions were aimed to be answered:

(1) What is the distribution of the materials developed by the prospective mathematics teachers according to the subjects? In which subjects is more material being developed?

(2) What types of materials are developed by the prospective mathematics teachers?

(3) What are the prospective mathematics teachers' views on the material development course and tools?

METHODOLOGY

Case study method was employed in this study. This method is especially suitable for individual studies since it makes it possible to study a problem in depth in minimum time. The most important advantage of this method is that it provides the chance to focus on a special case (Çepni, 2008). This method focuses on an aspect of a case and makes it possible to juxtapose different data collection techniques (Çepni, 2008). The case method is employed in this study carried out on 170 prospective mathematics teachers; it inquires their views about the teaching technologies and material development course, and on developing materials. This work consists of activities related to mathematics education in the scope of a pedagogical training program. These activities are as follows: concrete materials, videos, websites, worksheets, concept maps, dynamic software (Cabri II, Cabri 3D, GeoGebra, TinkerPlots) and other mathematics software (Derive 6, Fractal Grower etc.), and smart board program (Starboard). Participants are mathematicians who have received a bachelor degree in pure mathematics education. The participants get the chance to become mathematics teachers if they successfully complete the course. The constructivist approach has been adopted in course activities and the materials development process. Emphasis was put on how the prospective teachers prepare different learning environments.

Participants

This study was carried out in a state university in the Western Black Sea Region with 170 prospective mathematics teachers from four (4) different classes who took the teaching technologies and material development course. The teaching technologies and material development course was taught in the same way in four classes for 14 weeks. At the end of the term, the survey in Table 6 was completed by 154 prospective teachers.

Data Collection Tools

The data in this study consisted of concrete materials, concept maps, worksheets, dynamic software and smart board materials developed by the prospective teachers. While the materials were being presented in the classroom environment, observatory notes were taken by the researcher. These notes included information, for example, about the subject, usage, and purpose of the materials. At the end of the 14-week-long process, a survey was applied to ascertain prospective teachers' reflections on the course of teaching technologies and material development, and developing teaching materials. The survey had 22 Likert-type items (Table 6) and four open-ended items. Two experts who taught material course in the creation of data collection tools offered their opinions on the open ended items that aimed at getting deeper information about the prospective teachers' reflections. These survey questions now follow; the first two questions allow for more than one answer:

1. What is the level of importance of using the teaching materials in mathematics education? Write three of them which you think are the most useful.
2. What are the technologies and applications that you are thinking of using in your professional life?
3. What do you think about the contribution of the course of teaching technologies and material development to your teaching education?
4. What do you think about the way the course of teaching technologies and material development is taught, which included classroom activities after theoretical parts were studied? What are your views and suggestions for a more efficient teaching of this course?

Procedure

During the first 8 weeks of the 14-week-long study which was comprised of 4 hours (2 theoretical + 2 practical) of classes every week, the researcher taught the theoretical framework of the study. In this theoretical part, prospective teachers were introduced to processes of material development, points to consider while developing materials, concrete materials, videos, websites, worksheets, concept maps, dynamic software (Cabri II, Cabri 3D, GeoGebra, TinkerPlots) and other mathematics software (Derive 6, Fractal Grower etc.), and smart board program (Starboard). They used the computer laboratory for practical sessions. The course content is displayed in Table 1 in detail.

Table 1. The schedule of the course activities

Week	Content
1	Basic concepts of instructional technology and material development
2	Worksheets, concept maps, videos, concrete materials, learning objects puzzles, games, presentations
3	Cabri 2D activities: Basic geometric objects (line, segment, ray, vector, triangle, circle, etc.) measuring angles, perimeters, areas of geometric figures, perpendicular line, parallel line, midpoint of segment, angle bisector, perpendicular bisector, reflection, symmetry, translation, rotation, dilation, measurement transfer, geometric locus problems, exploring geometric and algebraic theorems
4	Geogebra activities: Basic geometric objects (line, segment, ray, vector, triangle, circle, etc.) measuring angles, perimeters, areas of geometric figures, perpendicular line, parallel line, midpoint of segment, angle bisector, perpendicular bisector, reflection, symmetry, translation, rotation, dilation, measurement transfer, geometric locus problems,
5	Cabri 3D activities: Some basic constructions (Points, lines, circles and some objects in space), forming basic geometric objects (prisms, sphere, cylinder, cone etc.), open polyhedron tool, cut polyhedron tool and intersection surfaces.
6	TinkerPlots activities: Adding data, making common graphs, comparing groups, exploring relationships, describing centers of distributions,
7	Derive activities: Calculating derivative, limit, and integral of functions, factoring algebraic expression, solving equation, and drawing graphics, matrix, vector, sum and product
8	Smartboard activities: Screen items, toolbar, add links to objects, gallery, smart board lesson examples with Starboard software.
9-14	Material presentations of the prospective teachers.

In the following 6 weeks, prospective teachers presented the materials they prepared. They were asked to develop 6 materials, namely a concrete material, a concept map, a worksheet, two dynamic materials, and a smart board material. Concrete materials were brought to the classroom while the others were emailed to the researcher. All the materials developed were presented in the classroom environment by the prospective teachers. Thus, the other prospective teachers were informed about for which acquisition and why a material was developed and how to use it. While the prospective teachers prepared all the materials except smart board materials on their own, they were allowed to prepare smart board materials individually or with a partner. During their presentations, the researcher made observations, took notes and also asked questions to get more detailed information about the materials. When all the prospective teachers finished their presentations, the survey in Table 5 was applied to find out their viewpoints on this course and using materials in mathematics classes.

Data Analysis

In this study, content analysis of the materials prepared by the prospective teachers, descriptive analysis of the explanations about the materials, and both content and descriptive analysis of their responses to the survey in Table 7 were made. The data gained through open-ended questions were subjected to content analysis and a code list was made. To do this, firstly, the data were read and codes were created. Then, the responses by each prospective teacher to the questions were examined and codes were prepared for each question. This operation was repeated a few times, and lastly, similar codes were combined and presented with frequencies. The concrete materials were photographed. Concept maps and worksheets were scanned. Materials produced with dynamic software were presented on screen.

RESULT

The findings in this study are presented under three headings which are findings gained through analysis of the materials produced by the prospective teachers, findings from researcher's observations, and findings gained through views of prospective teachers on teaching technologies and material development course and developing materials. Findings gained through materials were also presented under 5 sub-headings which are findings from concrete materials, concept maps, worksheets, dynamic software, and smart board materials.

Findings from Materials

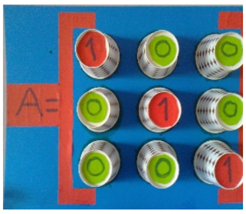
Concrete materials were grouped depending on mathematics and geometry subjects. Table 2 shows the distribution of the materials by subjects.

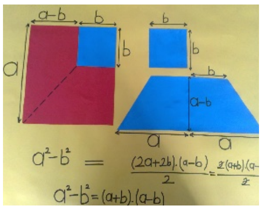
Table 2. Distribution of the concrete materials by subjects

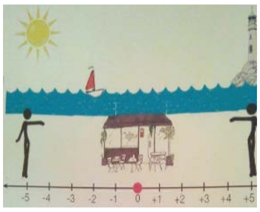
Topic	f (%)	Topic	f (%)
Numbers	25 (15%)	Famous mathematicians	2 (1%)
Triangle	20 (12%)	Factorial	2 (1%)
Trigonometry	18 (11%)	Ellipse	2 (1%)
Identities	16 (9%)	Coordinate plane	2 (1%)
Solid geometry	13 (8%)	Series	1 (0.6%)
Cluster	9 (5%)	Integral	1 (0,6%)
Circle	8 (5%)	Matrix	1 (0,6%)
Function	8 (5%)	Relation	1 (0,6%)
Angles	7 (4%)	Fractal	1 (0,6%)
Symmetry, reflection, rotation	7 (4%)	Similarity	1 (0,6%)
Polygon	6 (4%)	The analytical point	1 (0,6%)
Propositions	5 (3%)	Logarithm	1 (0,6%)
Absolute value	4 (2%)	Equations	1 (0,6%)
Probability	3 (2%)	Binomial expansion	1 (0,6%)
Plane geometry	3 (2%)		

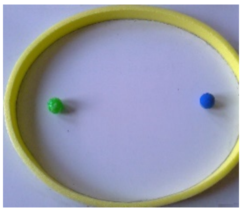
Examination of the data in Table 2 indicates that prospective teachers prepared concrete materials mostly on mathematics subjects, and most of these materials were about numbers (analysis, sieve of Eratosthenes, n(n+1)/2 etc., modelling, monopoly-type games, approximate values of square roots, Hanoi towers, GCD and LCM, fractions). The concrete materials related to trigonometry were generally on unit circles, signs of trigonometric functions by quadrants, defining the trigonometric values of certain angles, pi etc., and the concrete materials on identity were usually materials that modelled expansions like perfect squares, difference of two squares. Concrete materials on geometry were mostly on triangles. These materials were mostly the ones that visualized Pythagorean Theorem and the ones on sum of angles of a triangle and its area, angle-side relations, and triangle inequality. Solid materials were associated to surface areas of three dimensional objects, their volumes, relationship between their volumes, expansion of these objects, and their appearance from different viewpoints. The materials on angles were generally prepared on corresponding, alternate, exterior alternate and interior alternate angles. The ones on circles were usually on the association of central angle to inscribed angle, and the ones on polygons were mostly about angles, sides, diagonals, and finding areas by using Pick's Theorem. Besides, prospective teachers for the function subject, made use of function machines and puppets to represent function graphs, Box-Behnken design; Galton board for probability; equal arm scales for equations; washing machines for absolute value; sea shells for logarithms; lower triangular matrix, upper triangular matrix, zero matrix for the subject of matrix and, glasses to form unit matrices. When all the materials examined, some of them were seen to address to more than one acquisition. Figure 1 illustrates some of the concrete materials prepared by the prospective teachers.

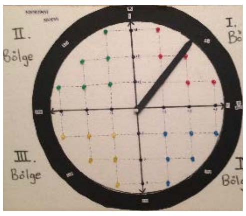

Equation

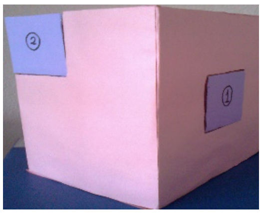

Matrix

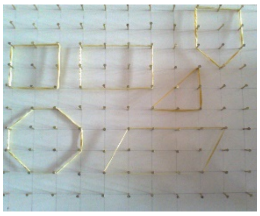

Identities


Absolute Value


Ellipse

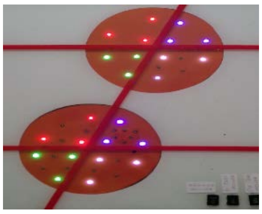

Trigonometry


3D Surface Area


Polygon Areas


Pythagorean Theorem


Symmetry Reflection Rotational


Angles

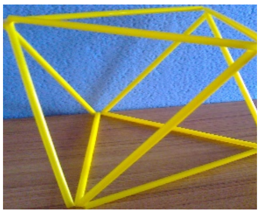
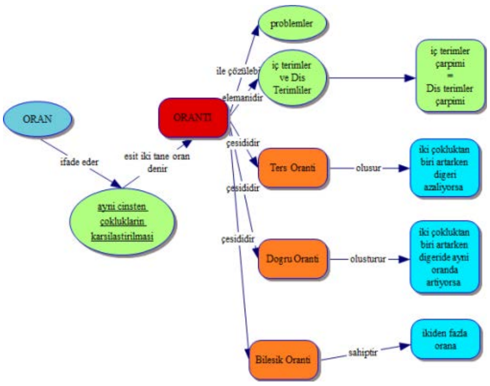

Regular Octahedron

Figure 1. Examples of concrete materials developed by prospective teachers.

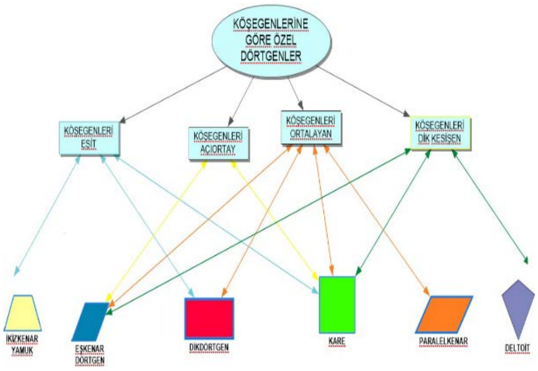
Concept maps were also grouped depending on the mathematics and geometry subjects. Table 3 displays the distribution of concept maps developed by prospective teachers by subjects.

Table 3. Distribution of concept maps by subjects

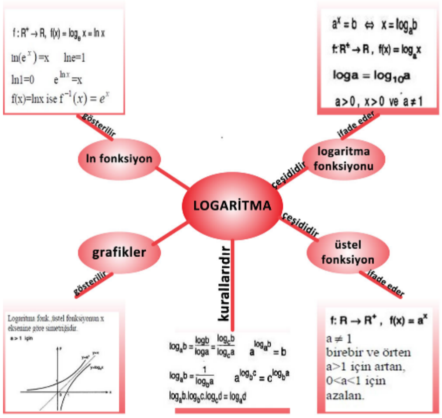
Topic	f (%)	Topic	f (%)	Topic	f (%)
Numbers	20 (12%)	Sequences, series	5 (3%)	Angles	3 (2%)
Analytic of the line	12 (7%)	Factorization	5 (3%)	Plane geometry	3 (2%)
Polygon	12 (7%)	Probability	4 (2%)	Analytic of the circle	2 (1%)
Solid geometry	12 (7%)	Polynomial	4 (2%)	Circle	2 (1%)
Triangle	11 (6%)	Integral	4 (2%)	Transformations	1 (0,6%)
Cluster	9 (5%)	Limit	4 (2%)	Statistics	1 (0,6%)
Logarithm	8 (5%)	Permutations	4 (2%)	Word problems	1 (0,6%)
Ratio and proportion	8 (5%)	Matrix	4 (2%)	Logic	1 (0,6%)
Function	7 (4%)	Operation	3 (2%)	Relation	1 (0,6%)
Quadratic equations	7 (4%)	Trigonometry	3 (2%)		
Complex numbers	5 (3%)	Linear equations	3 (2%)		



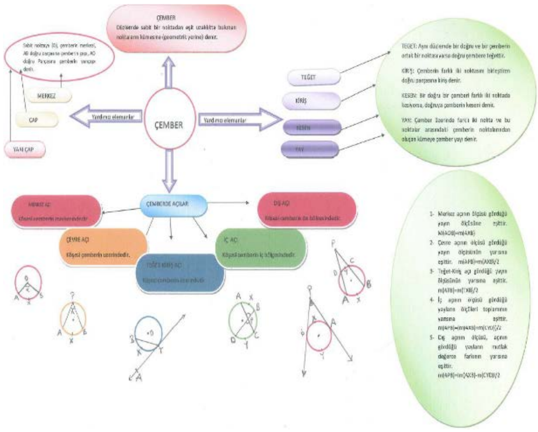
Ratio and Proportion



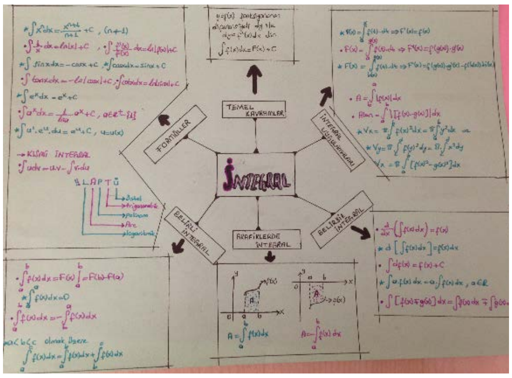
Quadrangles



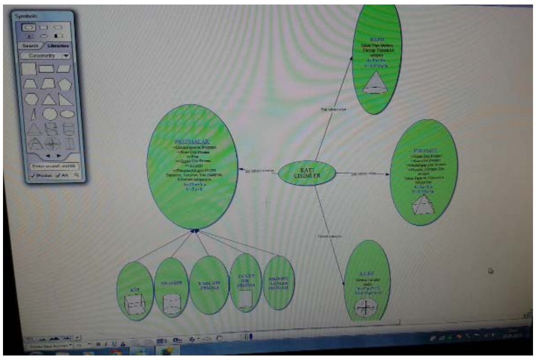
Logarithm



Circle



Integral



Solids (with inspiration software)

Figure 2. Examples of concept maps developed by prospective teachers.

Figure 2 illustrates some of the concept maps prepared by the prospective teachers. Some of the concepts maps were prepared manually while others were made in Word or some other special software (inspiration, etc.). Although most of these maps were relevant, the most frequent problems with them were the use of too much writing and too many formulas, unwritten or miswritten inter-concept associations and exclusion of some prominent concepts.

Table 4 displays the distribution of worksheets developed by prospective teachers by subjects.

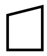
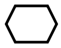
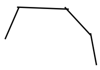
Table 4. Distribution of worksheets by subjects

Topic	f (%)	Topic	f (%)	Topic	f (%)
Numbers	36 (21%)	Limit	3 (2%)	Polygon	12 (7%)
Function	11 (6%)	Relation	3 (2%)	Triangle	8 (5%)
Trigonometry	9 (5%)	Logarithm	3 (2%)	Solid geometry	6 (4%)
Fractal	8 (5%)	Absolute value	3 (2%)	Analytic of the line	4 (2%)
Factorization using identities	6 (4%)	Probability	2 (1%)	Angles	3 (2%)
Cluster	6 (4%)	Complex numbers	2 (1%)	Circle	3 (2%)
Equations and parabola	5 (3%)	Pascal's triangle and the binomial theorem	2 (1%)	Vector	3 (2%)
Ratio and proportion	5 (3%)	Sequences	2 (1%)	Symmetry, reflection, rotation	2 (1%)
Word problems	5 (3%)	Logic	1 (0.6%)	Coordinate plane	2 (1%)
Permutations combinations	4 (2%)	Operation	1 (0.6%)	Conic	1 (0.6%)
Derivative	4 (2%)	Statistics	1 (0.6%)		
Polynomial	3 (2%)	Cubic equation	1 (0.6%)		

As can be seen in Table 4, the most popular subject with the prospective teachers for concept maps was number. These concept maps were mostly on exponential numbers, divisibility rules, root numbers, whole numbers, natural numbers, and prime numbers. Worksheets had the suitable format for both self-study and group study, and they were engaging. By employing an appealing approach, the features, associations and concepts that were intended to be taught were enclosed in the activities in a systematic and planned way, and open-ended questions were used to encourage students to discover. However, there were also worksheets which were comprised of only questions. They had no or few directives, and were aimed at just conveying the basic knowledge to students.

Table 5 displays one of the worksheets prepared. In this worksheet, prospective teachers stated that they intended to get the students to find how many triangles are created within polygons by diagonals drawn from vertices, and depending on it, find the sum of the interior angles of a polygon by making use of the sum of interior angles of a triangle.

Table 5. An example of worksheets developed by prospective teachers

Polygon	Figure	Number of edges	The number of triangles formed by diagonals drawn from one corner	The total measures of the polygon interior angle
Quadrilateral		4	2	2. 180
Pentagon				
Hexagon				
…				
…				
n-sided polygon				

Have you ever wondered how you can find the sum of the interior angles of a polygon? Take the first line of the table below as an example and fill in the required information in a similar way.

1. What sort of relationship is there between the side numbers of polygons you made and the number of triangles created in these polygons?
2. In what ways does the sum of the interior angles of polygons vary depending on the number of sides?
3. Find the number of triangles formed in a polygon with n-sides (n-gen), and the relation that gives the sum of the interior angles of the polygon. Write these relations in the correct place in the table above.

Each prospective teacher was assigned to prepare 2 materials using any of dynamic software of Cabri II, Geogebra, Cabri 3D and TinkerPlots. Distribution of used software is shown in Figure 3.

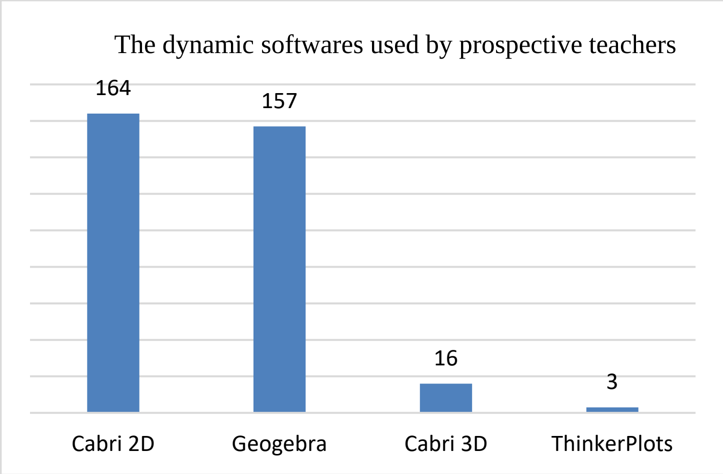
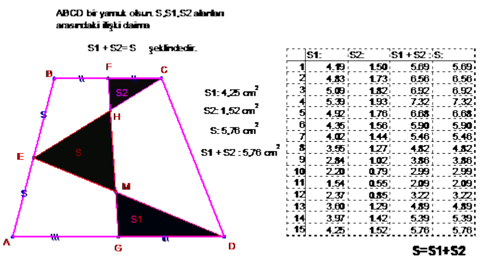
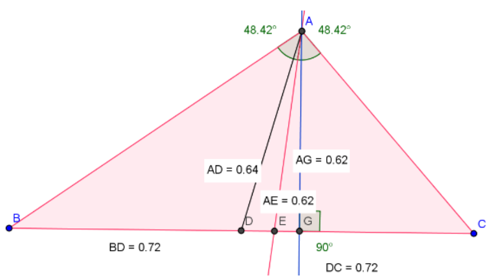


Figure 3. Distribution of software preferred by prospective teachers to develop dynamic material.

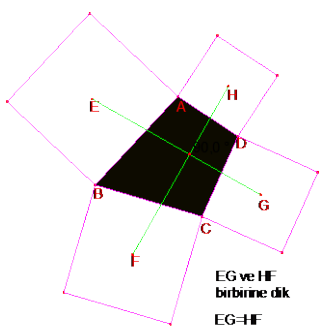
The data in Figure 3 shows that prospective teachers used mostly Cabri II and Geogebra to develop their materials. In the ones prepared with Cabri II, the most used tools were ones for angles, length measuring, area, tables, hide/show object whereas the most used ones in Geogebra materials were for angles, length, hide/show object, area, translate and rotate. The least used tools were for geometric solid, measurement transfer, homothetic. Among the geometry subjects, the most popular materials were on triangles.



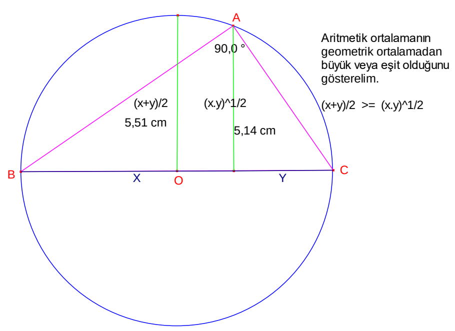
Area in trapezoid



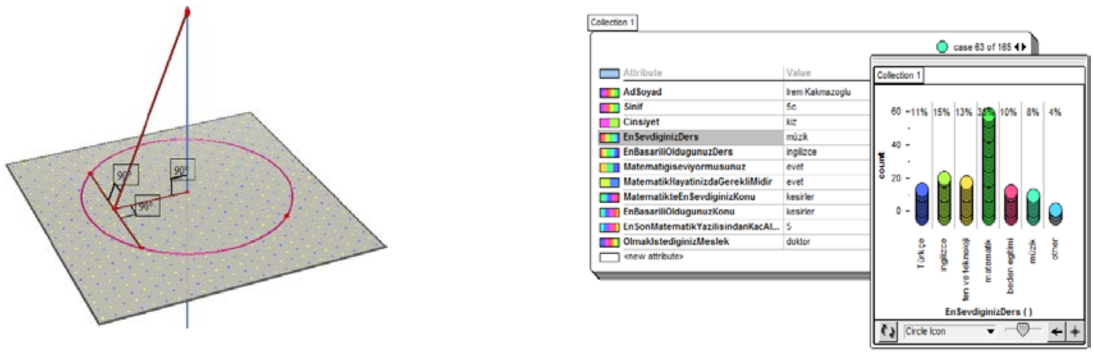
The relationship between median, altitude and angle bisectors



Van Aubel's theorem



The relationship between arithmetic and geometric mean



Theorem of three perpendiculars

Data anaysis with TinkerPlots

Figure 4. Examples of dynamic materials developed by prospective teachers.

As can also be seen in Figure 4, they utilized dynamic software sometimes to illustrate a theorem, in some others, to examine the relationship between two or more objects in a geometric figure, or to analyze data. It was clear that the materials prepared with dynamic software, as well as being proper for illustrating some relationships, enabled the students to make observations and inferences. The most common problems with the materials developed in dynamic mediums are; ignoring the difference between the drawing and the structure; the figures are distorted when moved, that is, they are not dynamic, trying to put points on the objects without using the point tool, marking the junction points without using the junction tool, inability to separate the dependent and independent points, measuring in the reverse direction while measuring angles (Geogebra), getting geometric position for different points, lacking knowledge about some concepts (Parabola, ellipse, hyperbola, etc.), while finding the length of a side clicking on the polygon and finding side perimeter of it, failure to save, failure to write mathematical equations in the medium of Geogebra, and data in different categories due to software error within TinkerPlots.

Prospective teachers were able to add various attachments (pictures, videos, Word docs, PDF docs, animations, sound, etc.) to the smart board software and connect them to some pictures and buttons, which enabled them to make their presentation without any interruption. Figure 5 shows a section from the sample of a class with a smartboard.

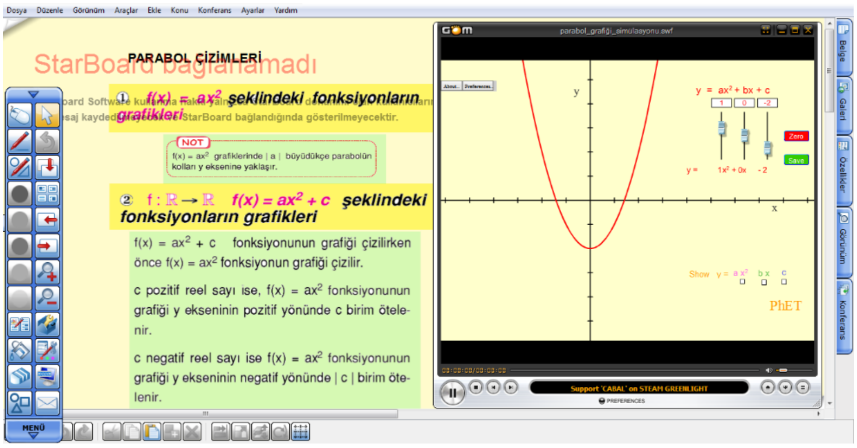


Figure 5. A section from the sample of a class with a smartboard.

Prospective teachers paid close attention to the introduction of smart boards and the activities prepared with them. This is thought to derive from the Fatih Project which supplied smart boards to all high schools in Turkey. Since prospective teachers have to use all these technologies, they showed more interest.

Findings from Prospective Teachers' Views

In order to find out their views about the course of teaching technologies and material development, and developing materials, the data collecting tool was applied on 154 prospective teachers. The data gained were displayed in Table 6 in frequencies and percentages.

Table 6. Prospective teachers' views about the course of teaching technologies and material development, and developing materials

Items	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I liked preparing materials for maths class.	2(1.3%)	8(5.2%)	34(22,1%)	**73(47.4%)**	37(24%)
Every prospective maths teacher should take the teaching technologies and material development classes.		3(1.9%)	21(13.6%)	62(40.3%)	**68(44.2%)**
There is no need to develop materials to teach maths	53(34.4%)	**56(36.4%)**	34(22.1%)	10(6.5%)	
Use of materials in maths classes helps with permanent learning.		1(0.6%)	11(7.1%)	69(44.8%)	**72(46.8%)**
Making use various materials in maths classes increases the productivity.			10(6.5%)	67(43.5%)	**77(0.50%)**
The process of material development might help to improve students' mathematical thinking.			9(5.9%)	**80(51.9%)**	65(42.2%)
I am not interested in the materials related to maths	56(36.4%)	**69(44.8%)**	22(14.3%)	5(3.2%)	1(0.6%)
I have gained knowledge which I didn't have before I took the teaching technologies and material development classes.			14(0.9%)	**78(50.5%)**	61(39.6%)
Teaching technologies and material development course is an unnecessary one.	**88(57.1%)**	54(35.1%)	12(7.8%)		
Mathematics subjects are abstract; you can't develop materials for all of them.	11(7.1%)	13(8.4%)	32(20.8%)	**64(41.5%)**	34(22%)
I have enough knowledge about teaching technologies and material development.	3(1.9%)	17(11%)	39(25.3%)	**72(46.8%)**	21(13.6%)
Developing materials is time-consuming and difficult.	2(1.3%)	17(11%)	44(28.5%)	**62(40.3%)**	29(18.8%)
Materials could be inspiring to discover new information.	2(1.3%)		26(16.9%)	**77(0.50%)**	48(31.2%)
Thanks to this course, I have now more enthusiasm for mathematics itself and to teach it.		9(5.9%)	50(32.5%)	**66(42.9%)**	28(18%)
Using materials in classes saves time in classes.	2(1.3%)	17(11%)	33(21.4%)	**60(39%)**	37(24%)
I think this course is helpful for my teaching life.	1(0.6%)	3(1.9%)	12(7.8%)	**82(53.2%)**	54(35.1%)

Since I have no efficiency in using computers, I have difficulty in preparing materials.	34(22.1%)	**42(27.3%)**	27(17.5%)	36(23.3%)	14(0.9%)
Preparing no materials is not a loss for a maths teacher.	28(18%)	**44(28.6%)**	41(27%)	34(22.1%)	5(3.2%)
I might try to use different materials to teach maths		6(4%)	22(14.3%)	**83(53.9%)**	41(27%)
Using materials in maths classes will make them more enjoyable.		3(1.9%)	8(5.2%)	**72(46.8%)**	69(44.8%)
Thanks to this course, I won't have difficulty in preparing materials for maths classes.		7(4.5%)	29(18.8%)	**75(48.7%)**	42(27.3%)
In my teaching career, I can help my colleagues to prepare materials.	1(0.6%)	6(4%)	31(20.1%)	**86(55.8%)**	29(18.8%)

As can be seen from Table 6, teacher candidates mostly agree or strongly agree with the positive items and do not agree or strongly disagree with the negative items.

The first open-ended question asks them about the three sorts of materials they like best and their responses are shown in Figure 6.

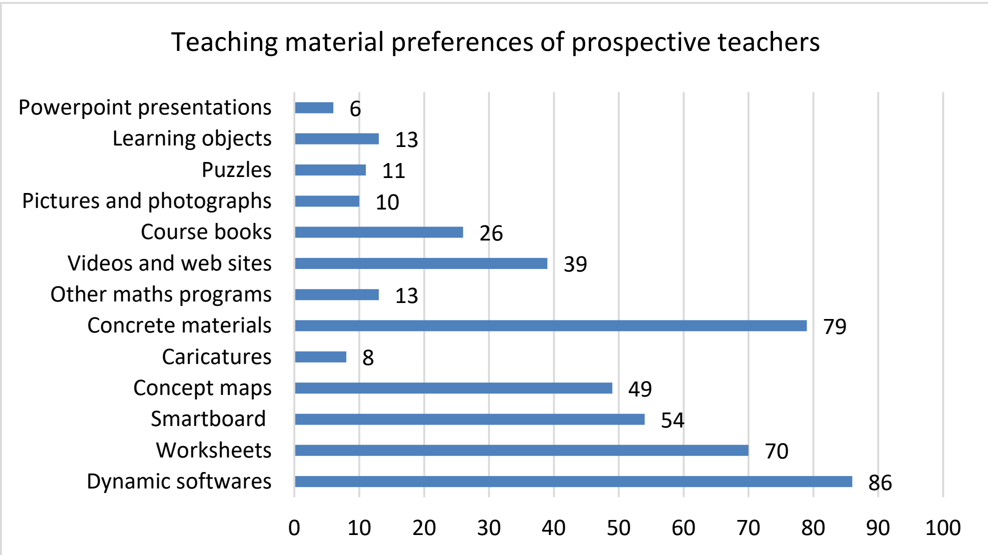


Figure 6. Teaching material preferences of prospective teachers.

As it can be seen in Figure 6, the most preferred materials are dynamic software, concrete materials, and worksheets respectively.

The second open-ended question asks them about the materials they are thinking of using in their professional lives. The responses are shown in Figure 7.

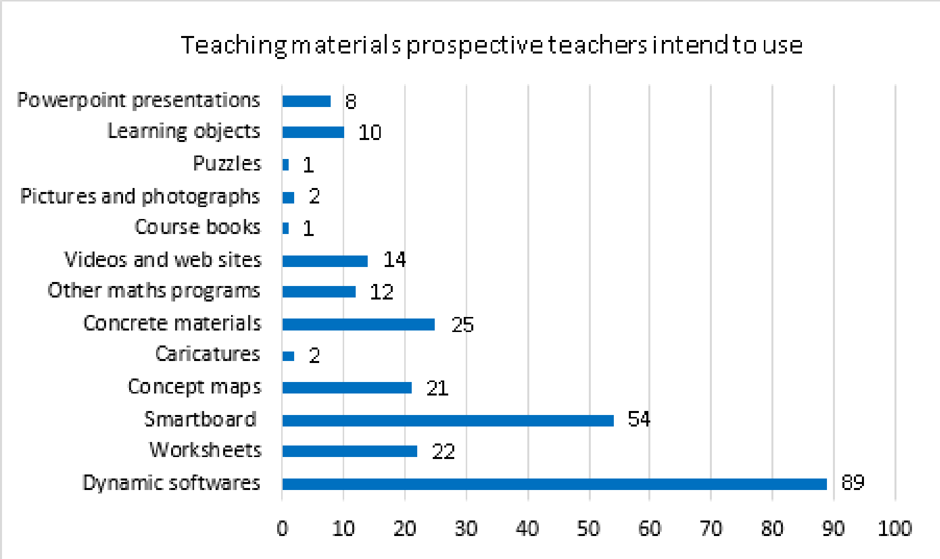


Figure 7. Teaching materials prospective teachers intend to use.

As Figure 7 shows, the materials that prospective teachers are thinking of using most are dynamic software, smartboard applications and concrete materials respectively.

The third open-ended question asks about their views on the contribution of the course of teaching technologies and material development to their teaching education. The responses are analyzed and presented under various themes. The number of explanations for each theme is shown in the following Table 7.

Table 7. Distribution of explanations by theme

Themes	Citation example	Frequency
Attention and motivation	*"We can increase students' attention and motivation to maths classes with what we have learnt in this course"*	123
Permanent learning	*"This course gave us ideas about what to do in a classroom environment for a permanent learning."*	112
Facilitating learning	*"I think the materials materialize the math lesson and make it easier for the learners to learn"*	107
Visualization	*"Difficult-to-teach three dimensional objects and geometrical place problems are taught easily through visualization"*	106
An entertaining learning environment	*"We came to see that maths classes could be more enjoyable and fruitful. It is more enjoyable to teach mathematics by using material"*	98
Benefit	*"Dynamic software allows us to do things that are not possible in other environments. For example; constructions can be moved to observe unchanging features and changing variables can be transferred easily to the table. This allows observation of the relationship between variables and making generalizations easier"*	97
Conceptual understanding	*"By using materials in classes, we can achieve the conceptual understanding"*	95
Necessity	*"I realized that I had taught my classes in a very abstract way during my teaching applications. I think this course is really necessary for the profession"*	90

Professional development	*"It has absolutely made a great contribution and enabled me to think in multiple ways. We didn't have a course like this. I think we improved ourselves by using the programs we didn't know about before." "It is for sure that boards and chalks aren't enough today. I can say that the classical methods in my head have turned into teaching methods supported by new technologies." "I think this course has provided us with the knowledge necessary to offer a better education and teach mathematics easily. Its effect on our viewpoints and horizon is undisputable. We understood that mathematics is not just about formulas." "I didn't know about dynamic software. I'll actively use them"*	88
Encouraging use of technology	*"I got used to using computers while working with the introduced software. I think it will be more interesting to prepare materials with this software in the medium of a classroom". "I'm not good with technology. Thanks to this course, my curiosity about it increased. This course was very helpful for me"*	85
Concretization	*"It was a very helpful course in that we learned how to concretize concepts while teaching maths. Thanks to this course, we have been introduced to many different materials"*	77
Practicality	*"I won't have difficulty, especially, in teaching geometry. It is difficult to prepare concrete materials for each subject but dynamic software is really practical to form materials. When a structure is formed with dynamic software, movable and fixed, that is, unchanging features are focused. I'll absolutely use these programs"*	64
Time saving	*"Materials visualize the theoretical information and help the students grasp more quickly"*	62
Awareness	*"It gave me ideas about the activities I want to do in my classes. It was very good and productive for me. We can present the concepts in a more efficient way with the programs we were introduced to"*	59
Common effect	*"I admire the EBA(www.eba.gov.tr/)-like web sites that were introduced during the classes and host lots of materials. Some teachers I know didn't know about these sites. I told them about these sites. They also admired them"*	38

As shown in Table 7, the most prominent themes for prospective teacher are attention and motivation, permanent learning, facilitating learning and visualization.

The responses of prospective teachers to the fourth open-ended question were analyzed and displayed in percentages in Table 8.

Table 8. Views about the teaching of the course of teaching technologies and material development

Views	Percentages f (%)
Application after theory was right and proper. Otherwise it would have just remained at a theoretical level.	49 (32)
Teaching the class with classroom activities was really a good choice. Developing our own materials made us more active during the classes. We had the chance to examine the materials prepared by classmates.	37 (24)
The content and application of the course were quite relevant and it really helped. The teaching was efficient. We were introduced to lots of materials. Evaluation and discussion of the materials were quite useful.	20 (13)
Sharing different materials was useful for our professional development.	13 (8)
I think more time should be spared for this course.	9 (6)
That the material and subject selection were left to us was great.	8(5)
It was a tiring course but we'll, for sure, use it in our professional lives.	7(5)
We had too much homework.	6(4)
I find it unnecessary to present our homework in [the] classroom	3(2)
The first 2 or 3 weeks could have been studied through distance education.	2(1)

As shown in Table 8, prospective teachers stated that it is quite useful to share their learning to face the implementation of the activities and products. Several teacher candidates complained about giving presentations to the class and having a lot of assignments.

DISCUSSION AND CONCLUSION

Prospective mathematics teachers believe that a board and a pen are enough to teach mathematics before the application. They have the idea that mathematics knowledge is already available and people discover this information. Because they did not take training courses and they were unaware of the learning theory before this course. All participants learned about learning approaches (such as discovery learning, constructivism) for the first time in the course process.

The results of this study, in which prospective mathematics teachers' views -- about the quality of the materials developed in the teaching technologies and material development course, the course itself, and material use -- are explored, show that the concrete materials and concept maps prepared by the prospective teachers clustered around the subject of numbers. Since the subject includes many sub-titles such as natural numbers, whole numbers, prime numbers, rational numbers, exponents, root numbers, more materials on it were developed than on any other subject.

As for materials prepared with dynamic software, prospective teachers mostly preferred Cabri II and Geogebra, and most of the materials developed were on geometry. This is thought to be because visualization is more common to geometry than to mathematics, that the prospective teachers chose to feature visualization in dynamic software, and that the classes are mostly made up of Euclidean geometry. In fact, Tatar, Akkaya and Kağızmanlı (2011) in their study on Geogebra found that prospective teachers prepared materials mostly (62%) on geometry subjects. Few of the other materials, however, were prepared by using software Cabri 3D and TinkerPlots, which shows that all dynamic software could be used properly in all classes. More than one tool is seen to be utilized in the materials produced in dynamic environments. In this way, both the features and various examples of the concept dealt with were intended to be reflected through dynamicity. Only very few of the materials lacked dynamicity. It is concluded that prospective teachers use the dynamic software not only to draw shapes but also to create a dynamic learning environment.

Most of the prospective teachers think that the learning environments created in the teaching technologies course will make positive contributions in teaching mathematics. They also emphasized the themes such as “encouraging use of technology”, practicality, saving time, visualization, permanent learning, professional development, concretization, necessity, common effect, awareness, an entertaining learning environment, conceptual understanding, attention, and motivation. Similar results had also been gained in various studies about the views of prospective teachers on computer use in learning and teaching mathematics (Corbalan, Paas, & Cuypers, 2010; Tatar, Akkaya, & Kağızmanlı, 2011; Usluel & Umay, 2005). Besides, some teachers were found to be hesitant about material development and use. Their main concerns were the university entrance examination system in Turkey, less time, a lot of issues in the teaching program and abstract issues in mathematics.

Prospective teachers paid close attention to the homework and activities associated with teaching technologies and material development. This is thought to be due to the introduction of smart boards to all high schools in Turkey within the Fatih Project, and the emphasis on using information technologies and dynamic software in new curriculums. Prospective teachers stated that they found these technologies necessary and important for the classes since they had to use them. Another conclusion of the study is that prospective teachers would like to use dynamic software in their professional lives. When their views about the way teaching technologies and the material development course is taught are examined, they are glad to be free in choosing subjects and materials, and pleased, especially, with the chance they got to discuss and evaluate the materials prepared by other prospective teachers. This shows that applications for material development were on target.

Using materials in mathematics teaching is an important determinant of understanding mathematics topics. As emphasized in literature, teachers who can produce different materials in teaching should be able to use them effectively. Future teachers who are today’s candidate teachers must be aware of the material development process.

Better and permanent learning is more likely to be achieved with the inclusion of more sense organs in the learning process. Material supported mathematics teaching will attain the objectives if the teachers have a clear idea of what materials are to be used, how, and for what purposes. In parallel with the shift in the understanding of teaching, prospective teachers need to be well-equipped for preparing and developing teaching materials that could help improve student learning. It is important to reflect the modern teaching approaches in the process of prospective teachers’ education. In this sense, this study is thought to help the teachers and researchers with training of prospective teachers and the subject of teaching technologies and material development.

REFERENCES

Association of Mathematics Teacher Educators. (2006). Preparing teachers to use technology to enhance the learning of mathematics: A position of the association of mathematics teacher educators. Retrieved from

http://amte.net/Approved%20AMTE%20Technology%20Position%20Paper.pdf

Bodner, G. M. (1990). Why good teaching fails and hard-working students do not always succeed? Spectrum, 28(1), 27-32.

Bruner, J. S. (2006). In search of pedagogy: Volume I. New York, NY: Taylor and Francis Group.

Cepni, S. (2008). Araştırma ve proje çalışmalarına giriş [Introduction to research and project work]. Trabzon, Turkey: Celepler Matbaacılık.

Corbalan, G., Paas, F., & Cuypers, H. (2010). Computer-based feedback in linear algebra: Effects on transfer performance and motivation. Computers & Education, 55(2), 692-703.

Dienes, Z. P., & Golding, E.W. (1971). Approach to modern mathematics. New York, NY: Herder and Herder.

Gadanidis, G., & Geiger, V. (2010). A social perspective on technology enhanced mathematical learning from collaboration to performance. ZDM, 42(1), 91–104.

Gündüz, S., Emlek, B., & Bozkurt, A. (2008). Computer aided teaching trigonometry using dynamic modeling in high school. 8th International Educational Technology Conference (pp. 1039-1042). Eskişehir, Turkey: International Educational Technology Conference.

Güven, B., & Kösa, T. (2008). The effect of dynamic geometry software on student mathematics teachers' spatial visualization skills. Turkish Online Journal of Educational Technology, 7(4), 100-107.

Hall, I., & Higgins, S. (2005). Primary school students perception of interactive whiteboards. Journal of Computer Assisted Learning, 21(2), 91-101.

Heinze-Fry, J., & Novak, J. (1990). Cocept mapping brings long-term movement towards meaningful learning. Science Education, 74, 461-472.

Hohenwarter, J., Hohenwarter, M., & Lavicza, Z. (2008). Introducing dynamic mathematics software to secondary school teachers: The case of GeoGebra. Journal of Computers in Mathematics and Science Teaching, 28(2), 135-146.

International Society for Technology in Education. (2008). National educational technology standards for teachers. Retrieved from

www.iste.org/Content/NavigationMenu/NETS/ForTeachers/NETS_for_Teacher.htm

Kağızmanlı, T. B., Tatar, E., & Akkaya, A. (2011). Analytic analysis of lines with dynamic mathematical software. Procedia - Social and Behavioral Sciences, 3, 2505-2509.

Kaput, J. J. (1992). Technology and mathematics education. In D. A. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp.). New York, NY: Macmillan.

Kazu, H., & Yesilyurt, E. (2008). Ögretmenlerin ögretim araç Gereçlerini Kullanım Amaçları [Intentions to use the teachers' teaching tools]. Fırat Üniversitesi Sosyal Bilimler Dergisi, 18(2), 175–188.

Koparan, T. (2015). The effect of dynamic geometry software on prospective teachers' achievement about locus problems. The Turkish Online Journal of Educational Technology, special issue 2, 589-693.

Koparan, T., & Kaleli Yılmaz, G. (2015). Using dynamic geometry software for the intersection surfaces. Journal of Education and Training Studies, 3(5), 195-205.

Koşar, E., Yüksel, S., Özkılıç, R., Avcı, U., Alyas, Y., & Çigdem, H. (2003). Ögretim teknolojileri ve materyal geliştirme [Instructional technology and material development]. Ankara, Turkey: PegemA Yayınları.

Milli Eğitim Bakanlığı. (2013). Ortaögretim matematik ögretim programı [Secondary school mathematics teaching program]. Ankara, Turkey: MEB Talim Terbiye Başkanlıgı Yayınları.

Moyer, P. S. (2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. Educational Studies in Mathematics, 47, 175-197.

National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics. Reston, VA: National Council of Teachers of Mathematics.

Nelson, J., Christopher, A., & Mims, C. (2009). TPACK and web 2.0: Transformation of teaching and learning. Tech Trends, 53(5), 80–85.

Niess, M. L. (2006). Guest editorial: Preparing teachers to teach mathematics with technology. Contemporary Issues in Technology and Teacher Education, 6(2), 195-203.

Oreilly, M. (2009). A complex thing made simple with GeoGebra. Mathematics, Statistics, Operation Research Connections, 9(2), 11-12.

Piaget, J. (1971). Biology and knowledge. Chicago, IL: The University of Chicago Press.

Pierce, R., & Stacey, K. (2010). Mapping pedagogical opportunities provided by mathematics analysis software. International Journal of Computers for Mathematical Learning, 15(1), 1–20.

Powers, R., & Blubaugh, W. (2005). Technology in mathematics education: Preparing teachers for the future. Contemporary Issues in Technology and Teacher Education, 5(3/4). Retrieved from http://www.citejournal.org/vol5/iss3/mathematics/article1.cfm

Roschelle, J., Shechtman, N., Tatar, D., Hegedus, S., Hopkins, B., Empson, S., . . . Gallagher, L. (2010). Integration of technology, curriculum, and professional development for advancing middle school mathematics: Three large-scale studies. American Educational Research Journal, 47(4), 833–878.

Skemp, R. R. (1987). The psychology of learning mathematics. Hillsdale, NJ: Erlbaum.

Tatar, E., Akkaya, A., & Kagızmanlı, T. B. (2011). İlkögretim matematik ögretmeni adaylarının GeoGebra ile oluşturdukları materyallerin ve dinamik matematik yazılımı hakkındaki görüşlerinin analizi [An analysis of the materials constructed with Geogebra by primary prospective mathematics teachers and their wievs about dynamic mathematics software]. Turkish Journal of Computer and Mathematics Education, 2(3), 181-197.

Usluel, Y. K., & Umay, A. (2005). İlkögretim matematik ögretmen adaylarının ögretimde BİT kullanımına bakışı: Boylamsal bir çalışma [Primary mathematics teacher views about information and communication technologies in teaching]. Eurasian Journal of Educational Research, 19, 102-111.

Waits, B. K., & Demana F. (2000). Calculators in mathematics teaching and learning: Past, present, and future. In M. J. Burke & F. R. Curcio (Eds.), Learning mathematics for a new century (pp. 51–66). Reston, VA: National Council of Teachers of Mathematics.

Van de Walle, J. A. (2007). Elementary and middle school mathematics: Teaching developmentally (6th ed.). Boston, MA: Pearson.