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A REVIEW STUDY ON THE USE OF MATERIALS IN MATHEMATICS COURSES IN TURKEY

Melike ÖZÜDOĞRU•

Abstract

This study is a review of the literature and aimed to examine material use in mathematics courses while teaching various topics in different grade levels. In other words, this study aimed to understand the current condition in terms of what kinds of materials were included by teachers in mathematics courses to teach different subjects and their effect on mathematics outputs. In this study, a meta-review procedure was employed. Meta-review is a systematic review of studies employed to analyze the data collected from multiple studies to reach a general judgment regarding the results of these studies. Having examined the studies conducted after 2004, 67 studies (42 thesis and 25 research articles) were included in this meta-review study. In this study, descriptive and content analysis methods were employed to generate themes and two themes were generated: 'the type of materials' and 'cognitive and affective contribution of materials'. As a result of this analysis, it was determined that researchers included materials using computer software and web sources, concrete materials related to mathematics; materials not directly related to mathematics; metacognitive materials and a mix of these materials. Also, it was revealed that materials contributed to different student outcomes such as achievement, attitude, retention levels, self-efficacy, motivation, anxiety, spatial visualization skills, geometric thinking skills, making inferences, hypothesizing skills and concretization abilities of students.

Keywords: Instructional Materials, Type of Material, Meta-Review, Mathematics.

1. Introduction

Mathematics is a course which has a linear content organization, sequential and continual learning (Murphy, 2016). Students need to learn previous concepts to get a firm and permanent understanding of mathematics; otherwise, they may struggle with mathematical computations and concepts throughout their mathematical courses. However, the results of many studies revealed that students struggle while learning mathematics (Murphy, 2016). It was reported by The National Assessment of Educational Progress report that less than 20% of high school seniors demonstrated a thorough understanding of the mathematical concepts in 2000 and in 2013 approximately 26% of high school seniors showed strong knowledge accuracy of the mathematical concepts which was expressed by the United States Department of Education (Murphy, 2016).

In Turkey, the report published by MONE (2010), the results of the Program for International Student Assessment (PISA) (2006) measuring the reading, mathematics and scientific knowledge and skills

• Dr. Res. Asst., Manisa Celal Bayar University, Faculty of Education, Department of Curriculum and Instruction. e-mail: ozudogru123@gmail.com.

of students under 15, revealed that Turkish students achieved at a fairly low level. However, this millennium age requires a good understanding of mathematics, performing mathematical operations skillfully and using mathematics in daily and business life. Therefore, there is a need for instruction in which students are mentally, affectively and physically active.

It can be seen that many countries continually evaluate their mathematics learning levels and look for methods working better in the learning of mathematics. Although lecturing is an old method, it is one of the most frequently used methods by teachers. However, for meaningful learning of students, lecturing is not sufficient enough to teach mathematics (Sidekli, Doğramacı, Yangın & Daşdemir, 2012). Also, it was revealed that the inclusion of different approaches, strategies, methods and different curricula in mathematics courses can make an important impact on the learning of students (Murphy, 2016). For these reasons, in Turkey, a fundamental change has been made in the curricula. With the regulation conducted in 2004, the curriculum that has been applied since 2004-2005 school year focused on student-centered and active instruction instead of teacher-centered lecture type of instruction (Kablan, Topan & Erkan, 2013). Also, as stated by Domino (2010) the best practices in mathematics are those that allow students to have many experiences in the learning of mathematics. In this sense, one of the effective ways to learn mathematics may be through the use of materials.

In the learning environment, the utilization of different materials for effective understanding and active involvement of students in mathematics courses is very important to overcome the abstractness of mathematics (Dede & Argün, 2003). Teaching materials can be defined as different ways through which information can be delivered to learners. In addition, traditional teaching methods focus only on the answers of problems; however, when materials are integrated into teaching-learning process for the solutions of problems, the way a problem is handled and the strategies developed for the solutions of problems are taken into account, which is more important than just answering the problems (Dede & Argün, 2003).

Additionally, the inclusion of materials in the teaching-learning process help students move away from the ordinary implementation of procedures and steps that are used to solve problems (Domino, 2010). Materials can be used in the learning of many areas of mathematics such as algebra, geometry and probability (MONE, 2012). The functions and importance of different teaching materials were based on the Dale's Cone of Experience (1969) and some of the properties of it was explained as: The more the number of sensory channels were involved in the learning process, the better we learn and the later we forget, what we learn best is what we learn by doing ourselves and as also stated by (MONE, 2017) the best instruction progresses from concrete concepts to abstract ones and from simple concepts to complex ones, which were aimed to be provided with the inclusion of different materials.

Hartshorn and Boren (1990) defined materials as the objects which have some important properties such as they appeal to several senses and can be touched, moved, transformed and rotated while teaching students mathematical concepts or reinforcing them. In the teaching-learning process visual, audio-visual, real objects and many others are implemented in order to increase the learning of students (Toptaş, Çelik & Karaca, 2012). Domino (2010) explained four types of materials. First, materials as exemplified by Kablan, Baran, Işık, Kal and Hazer (2013) are objects that students familiar with in their everyday life, such as beads, buttons, coins, dice, and Popsicle sticks. Second, materials can be objects that have educational applications such as children's building blocks, jigsaw puzzles, and Legos. Third, materials are specifically designed to be used in teaching mathematics, such as algebra tiles, pattern blocks, cubes, isometric paper, rods, colorful beads, game cards, scale, tangrams and as Şengül and Körükcü (2012) introduced (+, -) Labels and Board, Numerical Axis Model, Piston Thermometer materials, finally, there are virtual materials.

Moreover, computers provide extensive opportunities in supporting the learning process of mathematics by including a variety of software and web sources such as computer games, vitamin portal, WebQuest, 3D glasses, interactive boards, virtual manipulatives, Microsoft excel, videos, websites, Geometers' Sketchpad, GeoGebra, Cabri, Microsoft PowerPoint slides, Macromedia Flash, etc. For example, according to Dede & Argün (2003) spreadsheets provide many opportunities to better understand mathematical concepts and issues. Students can establish links between numerical, algebraic and graphical forms of abstract concepts of mathematics with the help of electronic materials. In addition to these materials, there are computer algebra systems and dynamic geometry systems (Doktoroğlu, 2013). Computer algebra system (e.g. Derive, Mathematica, Livemath) is beneficial in the teaching-learning process of abstract mathematical concepts such as numbers, sets, logic, divisibility, fractions, word problems, derivative, functions, trigonometry, exponential and logarithmic functions, complex numbers, polynomials, equations, etc. In this way, students can improve their computational skills and discover associations, visualize them and practice mathematical concepts. In addition, dynamic geometry software such as Geometers' Sketchpad,

Cabri stress the relations among points, lines, angles, polygons, circles, and other geometric concepts. Moreover, another mathematical software GeoGebra is a combination of both a computer algebra system and dynamic geometry systems. It supports teaching and learning of mathematics and enables the examination of multiple representations of the subject. They appeal to students with different types of skills, abilities, preliminary knowledge and characteristics. Computer software and web materials enable integrating pictorial, verbal, and symbolic representations of mathematical problems easily. The main difference between physical and digital materials was stated by Olkun (2003) that while physical materials can be touched and develop psychomotor learning, computer software and web materials provide more flexibility for manipulation. The implementation of computer software in the teaching-learning process also has a positive effect on the achievement of students because they let students see 3-dimensional relationships (Önal & Göloğlu-Demir, 2012). Furthermore, students have the opportunity to observe how a change in the value of a variable may affect other values of patterns as stated by İnan (2006).

Moreover, Domino (2010) stated that the use of materials in teaching mathematics assists students in several specific ways: Firstly, they help in relating real-world situations to mathematical symbols and verbalizing mathematical thinking. Also, materials give chance to learners to work together cooperatively in solving problems, discuss mathematical ideas and concepts, learn that there are many different ways to symbolize and solve problems and finally, discover that they can solve mathematics problems not just following teachers' directions. In this sense, the use of materials makes mathematics more understandable and assists students in their comprehension of abstract mathematical concepts (Domino, 2010). Similarly, Kul, Çelik and Aksu (2018) stated that materials are important to construct learners' mathematical concepts and to be able to associate these concepts with their previous knowledge and experience. Also, Murphy (2016) revealed that materials provide higher accuracy in computational tasks, a deeper understanding of the mathematical topics and create a less-anxious mathematics environment. Therefore, they contribute to students' achievement in mathematics. In addition, when the materials were included in the teaching-learning process, the learning, motivation, modeling abilities of students improved positively (Dede & Argün, 2003). Also, students may develop a positive attitude towards mathematics, self-confidence and mathematical self-efficacy (Güzeller & Akın, 2012; Tataroğlu, 2009; Yorganci & Terzioğlu, 2013).

Achievement of students is one of the most important variables that determines the effectiveness of instruction. There is no convincing evidence showing that the use of materials helps students attain higher achievement in mathematics when compared with the traditional method. The results of many studies revealed that the use of materials allowed students learn actively and resulted in higher mathematics achievement (Aksoy, Çalık & Çinar, 2012; Andiç, 2012; Bayturan, 2011; Çelik & Çevik, 2011; Gürbüz, 2007; Olkun, 2003; Önal & Göloğlu-Demir, 2012; Özdemir & Tabuk, 2004; Reimer & Moyer (2005); Sowell, 1989; Tezer & Kahraman-Deniz, 2009; Tural-Sönmez, 2012; Yücesan, 2011). On the other hand, Öztürk (2012) highlighted the result that students' mathematics achievement increased in the group using dynamics mathematics software GeoGebra although the difference between groups was not statistically significant. Similarly, Tataroğlu (2009) found that the use of software and web sources in learning second-degree functions did not make a significant difference in terms of academic achievement. In addition, Enki (2014) found that the experimental and control group did not differ significantly when unit cubes, symmetry mirrors, and acetate papers were included in the teaching-learning process. Kul et al. (2018) in their meta-review study did not find a significant difference in terms of the effectiveness of instruction between teaching by including materials and without including them, but they found meaningful differences in terms of mathematics topic, type of material, and application time. For this reason, there is a need for systematic investigation of studies about the effects of material usage while teaching different subjects of mathematics in different grade levels on the cognitive and affective outcomes of students.

Kablan et al. (2013) included 57 experimental research in their meta-analysis studies which included different materials such as computer presentations, hands-on materials, cartoons, concept maps, and a combination of different materials. However, seven of these studies were conducted in mathematics courses. Also, Kul et al. (2018) included 54 studies conducted in mathematics courses at different grade levels using a variety of materials in their meta-analysis study. However, they included only the studies which included computer software and internet sources to investigate the effect of them on mathematics achievement. In this regard, the examination material used in teaching different subjects of mathematics in different grade levels on the cognitive and affective outcomes of students is thought to contribute both to literature and studies related to mathematics education. To this end, this review of the literature study by bringing the findings of many studies conducted at different grade levels, years, in teaching different topics including a variety of participants and materials may reveal the effect of material use in mathematics courses.

2. Method

A comprehensive search was conducted to find studies which included different materials in the teaching-learning process of mathematics. Databases used in this review were Academic Search Complete, Education Research Complete, ERIC, Middle East Technical University's Catalog, Psychology and Behavioral Sciences Collection, and ULAKBIM Turkish National Databases. 'Mathematical materials', 'mathematics achievement', 'material development' and 'computer-assisted mathematics instruction' were used as descriptors or search terms. This search yielded 25 studies. In addition, a search was also conducted for master's theses and dissertations studies which included different materials in the teaching-learning process of mathematics. For this reason, theses and dissertations provided at the National Theses Center of the Council of Higher Education were reviewed. This search yielded 42 studies, all of them were accessible online and included required information.

This review included studies conducted after 2004 to date, which was accepted as a predetermined criterion. The new curriculum development efforts accepting constructivist approach started in Turkey in 2004 and implemented in the 2004-2005 academic year in pilot schools and implemented nationwide in all elementary schools in the 2005-2006 academic year. In this study, articles, conference proceedings, thesis and dissertations open to access published after 2004 were included. Moreover, studies conducted in Turkey and sampling Turkish students; articles which were written in Turkish or English and studies including the implementation of materials in one group or experimental studies with one group or with control groups were included in this meta-review study. However, besides review articles, studies including mathematical materials together with biological, chemical, physical, etc. materials were not included in this meta-review study.

2.1. Data Analysis

In this meta-review study, data were analyzed according to descriptive and content analysis methods to obtain themes (Yıldırım & Şimşek, 2008). First of all, great attention was paid to the abstracts of each study to come up with some common themes. Having a brief overlook of the abstracts, the emphasis was then put on respectively to the methods and the findings of each study. The findings of each study was conceptualized, listed and pulled together under certain sub-themes to draw a general picture of what different research say about material use. In this way, first group sub-themes were generated and they were gathered under 'The type of materials' theme. This group of sub-themes was entitled as (1) materials using computer software and web sources; (2) concrete materials related to mathematics; (3) materials not directly related to mathematics; (4) metacognitive materials; (5) a mix of materials. Moreover, the generated second group sub-themes (1) achievement, (2) attitude, (3) retention, (4) self-efficacy, (5) motivation, (6) anxiety, (7) mathematical skills and abilities were gathered under 'Cognitive and affective contribution of materials' theme. Also, the research design, sample of studies, mathematical subjects, type of materials explained in the reviewed studies were shown in Appendix A.

3. Results

For the current meta-review study, a total of 67 studies were reviewed based on the predetermined criteria to understand the current condition in terms of what kinds of materials were included by teachers in mathematics courses to teach different subjects in Turkish educational settings. Considering the grades of the participants, studies mostly included materials at the secondary level (6th, 7th and 8th grades). On the other hand, just one study was conducted at each of the 2nd, 3rd, a mix of 6th, 7th, 8th grades, besides vocational school, which were shown in Table 1.

Table 1. *Reviewed studies according to Grade Levels*

Grade Levels	Reviewed studies and theses
2nd grade	Malaş (2011)
3rd grade	Çekirdekci, Toptaş & Çekirdekci (2016)
4th grade	Tutak & Birgin (2008)
5th grade	Dışbudak (2017), Genç & Öksüz (2016), Hot (2019), Şahin (2013)
6th grade	Budak (2010), Erşen (2014), Helvacı (2010), Kablan, Baran, Işık, Kal & Hazer (2013), Kılıç, Tunç-Pekkan & Karatoprak (2013), Konak (2019), Özdemir & Küpcü (2010), Öztürk M. (2011), Şen (2010), Şengül & Körükcü (2012), Taş (2016), Tural-Sönmez (2012), Yeniçeri (2013), Yücesan (2011), Zengin A. (2019)
7th grade	Birgin, Kutluca & Gürbüz (2008), Çelik & Çevik (2011), Dereli (2008), Doktoroğlu (2013), Egelioğlu (2007), Enki (2014), Kontaş (2016), Oğras & Bozkurt (2011), Önal & Göloğlu-Demir (2012), Özdemir & Tabuk, (2004), Özerbaş (2012), Selçik & Bilgici (2011), Ubuz, Üstün & Erbaş (2009), Üner (2009)
8th grade	Akgül (2014), Andiç (2012), Barçın (2019), Filiz (2009), Gürbüz, (2007), Öztürk B.

	(2012), Tezer & Kahraman-Deniz (2009), Tuncer (2008), Uysal Koğ & Başer (2011), Uzun (2008)
6th, 7th, 8th grades	Bedir, Ersözlü & Duygu (2013)
9th grade	Bayturan (2011), Gelibolu (2009), Karaaslan (2013), Şimşek (2013)
10th grade	Arıcı (2012), Bedeloğlu (2016), Bilen (2016), Kutluca (2009), Tataroğlu (2009), Zengin Y. (2011)
11th grade	Acar (2015), Akbay (2015), Bayındır-Kocaman (2015), Yılmaz, Ertem, & Güven (2010)
Education faculty	Akçayır (2011), Aksoy, Çalık & Çınar (2012), Kan (2014), Tatar, Kağızmanlı Akkaya (2014), Şimşek & Arıkan (2012)
Vocational school	Yorganci &Terzioğlu (2013)

Materials can be included to teach different learning areas of mathematics such as numbers & algebra, measurement & probability, and geometry. This meta-review study revealed that almost an equal number of studies were conducted at geometry and numbers & algebra sub-domains but only four studies were conducted at measurement & probability sub-domain as shown in Table 2.

Table 2. *Reviewed Studies in terms of researchers and Mathematical Sub-Domains*

Mathematics topics	**Studies related to Geometry Sub-Domain**	**Studies related to Measurement & Probability Sub-Domain**	**Studies related to Numbers & Algebra Sub-Domain**
geometrical objects and structures	Bedir, Ersözlü & Duygu (2013); Kılıç, Tunç-Pekkan &Karatoprak (2013); Çekirdekci, Toptaş & Çekirdekci (2016); Şahin (2013)-Thesis; Taş (2016)-Thesis		
measurement (length, perimeter, areas, volume)	Özdemir & Küpcü (2010); Zengin A. (2019)-Thesis		
triangle, quadrilaterals (square and rectangle etc.)	Tutak & Birgin (2008); Akbay (2015)-Thesis; Arıcı (2012)-Thesis Dışbudak (2017)-Thesis; Egelioğlu (2008)-Thesis; Filiz (2009)-Thesis; Genç & Öksüz (2016); Hot (2019)-Thesis; Karaaslan (2013)- Thesis		
polygons	Budak (2010)-Thesis; Selçik & Bilgici (2011); Genç & Öksüz (2016); Helvacı (2010)-Thesis; Hot (2019)-Thesis; Ubuz, Üstün & Erbaş (2009)		
circle	Oğras & Bozkurt (2011); Bedeloğlu (2016)-Thesis		
transformation geometry (fractals, rotation, reflection, translation)	Önal & Göloğlu-Demir (2012); Akgül (2014)-Thesis; Barçın (2019)-Thesis; Egelioğlu (2008)-Thesis; Enki (2014)-Thesis		
circle, cylinder, sphere	Özdemir & Tabuk, (2004); Özerbaş (2012); Kontaş (2016)		
trigonometry	Öztürk (2012); Yılmaz, Ertem, & Güven (2010)		
analytical geometry	Akçayır (2011)-Thesis; Tatar, Kağizmanli & Akkaya (2014)		
permutation and combination		Andiç (2012)	
probability and statistics		Çelik & Çevik (2011) Gürbüz (2007) Şen (2010)	
relation, functions, and operations			Bayturan (2011)-Thesis Şimşek (2013)-Thesis
mathematics-II course			Aksoy, Çalık & Çınar (2012)
coordinate plane and graphs of linear equations with one and			Birgin, Kutluca & Gürbüz (2008); Doktoroğlu (2013); Kablan, Baran, Işık, M. Kal & Hazer (2013); Tezer &

two unknowns	Kahraman-Deniz (2009); Uysal Koğ & Başer (2011) Karaaslan (2013)-Thesis; Konak (2009)-Thesis; Uzun (2018)-Thesis; Üner (2009)-Thesis
numbers sets, divisibility, gcd-lcm and fractions	Kılıç, Tunç-Pekkan & Karatoprak (2013); Tural-Sönmez (2012)-Thesis; Yeniçeri (2013)-Thesis
word problems	Malaş (2011) Thesis
integers	Şengül & Körükcü (2012); Dereli (2008)-Thesis
derivative	Şimşek & Arıkan (2012)
second-degree equations and functions, trigonometric functions	Tataroğlu, (2009)-Thesis; Bilen (2016)-Thesis; Kutluca (2009)-Thesis Zengin Y. (2011)-Thesis
Mathematics-I course	Yorganci &Terzioğlu (2013)
sets	Yücesan (2011)- Thesis; Erşen (2014)-Thesis
exponential and logarithmic functions	Acar (2015)-Thesis
summation symbol, summation rules, series	Bayındır-Kocaman (2015)-Thesis
logic	Gelibolu (2008)-Thesis
lineer algebra-vector, matrix, systems of linear equations	Kan (2014)-Thesis
ratio and proportion	Öztürk, M. (2011)-Thesis
Pascal triangle and Binomial expansion	Tuncer (2008)-Thesis

According to Table 3, two themes were generated as a result of the review study which was conducted on the effects of using materials in mathematics courses were as follows: (1) The type of materials and (2) Cognitive and affective contribution of materials. Also, the generated sub-themes were presented under each theme and were shown in Table 3.

Table 3. *Themes and sub-themes obtained from the included studies*

Themes	Sub-themes	
1. The Types of Materials	(1) Materials related to computer software and web sources	GeoGebra; Minecraft game; interactive whiteboard; dynamic geometry software; Microsoft excel; videos web-site; interactive worksheet, spreadsheets; coypu software; Geometers' Sketchpad; Okulistik and Morpa Kampüs software 'fun Math' website; audio lectures, animated visuals; Microsoft PowerPoint slides and vitamin portal; Macromedia Flash 8; Allaire Homesite 4.5; ActionScript 2.0; macromedia Dreamweaver, flash mx 2004 software and html; flash mx 2004 software; html; GSP software; vitamin program; Microsoft picture manager program; WebQuest; 3D glasses; interactive boards; virtual manipulatives (NLVM NCTM-illuminations, WisWeb, E-Lab and SAMAP)
	(2) Concrete materials related to mathematics	wooden manipulatives made of cubes; unit cubes, symmetry mirror; acetate paper; geometry board, dotted papers, drawing sets (protractor, compass, ruler; visual materials [(+, -) labels and board, numerical axis model, piston thermometer model)]
	(3) Materials not directly related to mathematics	origami; photo camera; removable and re-glued objects; colored cardboard
	(4) Metacognitive materials	cartoons; concept mapping and vee diagrams; imtm
	(5) A mix of materials	plotting paper, presentation material supported by animations and coloring; PowerPoint materials and concrete materials (number scales and equation models and sugar cube, purse, crackers or screws); bingo cards and worksheets; concrete (unit cupes) and virtual manipulatives; video camera and computer screen capture software; visual materials (animations, metaphors, algebra tiles, concept cartoons, macromedia flash cs 5, swish max, ispring
2. Cognitive and Affective Contribution of Materials	Achievement	Acar (2015)-Thesis; Akbay (2015)-Thesis; Akçayır (2011)-Thesis; Akgül (2014)-Thesis; Aksoy, Çalık & Çınar (2012); Andiç (2012)-Thesis; Arıcı (2012)-Thesis; Barçın (2019)-Thesis; Bayındır-Kocaman (2015)-Thesis; Bayturan (2011)-Thesis; Bedeloğlu (2016)-Thesis; Bedir, Ersözlü & Duygu (2013); Bilen (2016)-Thesis;

	Birgin, Kutluca & Gürbüz (2008); Budak (2010)-Thesis; Çekirdekci, Toptaş & Çekirdekci (2016); Çelik & Çevik (2011); Dereli (2008)-Thesis; Dışbudak (2017)-Thesis; Doktoroğlu (2013)-Thesis; Egelioğlu (2008)-Thesis; Erşen (2014)-Thesis; Filiz (2009)-Thesis; Gelibolu (2008)-Thesis; Genç & Öksüz (2016); Gürbüz (2007); Helvacı (2010)-Thesis; Hot (2019)-Thesis; Kablan, Baran, Işık, Kal & Hazer (2013); Kan (2014)-Thesis; Karaaslan (2013)-Thesis; Kılıç, Tunç-Pekkan & Karatoprak (2013); Konak (2009)- Thesis; Kontaş (2016); Kutluca (2009)-Thesis; Malaş (2011)-Thesis; Oğras & Bozkurt (2011); Önal & Göloğlu-Demir (2012); Özdemir & Küpcü (2010); Özdemir & Tabuk (2004); Öztürk, M. (2011)-Thesis; Özerbaş (2012); Selçik & Bilgici (2011); Şahin (2013)-Thesis; Şen (2010)-Thesis; Şengül & Körükcü (2012); Şimşek & Arıkan (2012); Taş (2016)- Thesis; Tatar, Kağizmanli & Akkaya (2014); Tezer & Kahraman-Deniz (2009); Tural-Sönmez (2012)-Thesis; Tuncer (2008)-Thesis; Tutak & Birgin (2008); Ubuz, Üstün & Erbaş (2009); Uysal-Koğ & Başer (2011); Uzun (2018)- Thesis; Üner (2009)-Thesis; Yeniçeri (2013)-Thesis; Yılmaz, Ertem, & Güven, (2010); Yorganci & Terzioğlu (2013); Yücesan (2011)-Thesis; Zengin A. (2019)-Thesis; Zengin Y. (2011)-Thesis
Attitude	Dereli (2008)-Thesis; Enki (2014)-Thesis; Helvacı (2010)-Thesis; Hot (2019)-Thesis; Kontaş (2016); Kutluca (2009)-Thesis; Özdemir & Tabuk (2004); Özerbaş (2012); Tataroğlu, (2009)-Thesis; Yorganci & Terzioğlu (2013)
Retention	Acar (2015)-Thesis; Çekirdekci, Toptaş & Çekirdekci (2016); Dereli (2008)-Thesis; Erşen (2014)-Thesis; Genç & Öksüz (2016); Konak (2009)-Thesis; Tatar, Kağizmanli & Akkaya (2014); Tuncer (2008)-Thesis
Self-Efficacy	Akbay (2015)-Thesis; Bedeloğlu (2016)-Thesis; Bilen (2016)-Thesis
Motivation	Akçayır (2011)-Thesis; Dereli (2008)-Thesis; Helvacı (2010)-Thesis
Anxiety	Barçın (2019)-Thesis; Dereli (2008)-Thesis
Mathematical Skills and Abilities	Akbay (2015)-Thesis; Akgül (2014)-Thesis; Arıcı (2012)-Thesis; Bilen (2016)-Thesis; Egelioğlu (2008)-Thesis; Filiz (2009)-Thesis; Kan (2014)-Thesis; Karaaslan (2013)-Thesis; Şahin (2013)-Thesis; Tatar, Kağizmanli & Akkaya (2014); Uzun (2018)-Thesis

3.1. Materials related to computer software and web sources and their effect on student outcomes

The use of computer software and web sources allowed students to learn actively and resulted in higher mathematics achievement in learning different subjects including geometry, measurement & probability topics and subjects included in numbers & algebra sub-domain as shown in Table 2 and Table 3. In addition, the inclusion of computer software (Capri, Coypu or GeoGebra Geometers' Sketchpad), besides improving learning of students, increased their motivation in learning of basic geometry concepts (Selçik & Bilgici, 2011); triangle, square and rectangle (Tutak & Birgin, 2008); polygons (Budak, 2010) and coordinate plane and graphs of linear equations (Birgin, Kutluca & Gürbüz, 2008). Doktoroğlu (2013) revealed that while seventh grade students who learned Cartesian coordinate system and linear relation by using GeoGebra did not differ significantly from traditional instruction group in terms of student achievement but the use of same material with the same students in teaching graphing of linear equations had a significant effect on achievement of students in favor of the group using GeoGebra.

Şen (2010) found that intuitive thinking controlled probability computer-aided instruction software was more effective in preventing misconceptions, increasing the level of mathematics achievement and retention level of students compared to Vitamin program and traditional instruction methods in which only teaching way was the inclusion of mathematics textbook approved by Ministry of Education. Moreover, the inclusion of computer software and web sources in teaching mathematics besides achievement affected the attitude of students in the mathematics-I course while learning integers, rational, reel, irrational, exponential numbers, square roots, linear equations, inequalities, functions) in a vocational school (Yorgancı & Terzioğlu, 2013).

Furthermore, the inclusion of video streaming helped students to remember visual symbols and formulas and retain them in mind besides helping students study the subject many times that they could not learn during the lesson by assisting students to learn at their own pace and supported meaningful learning (Şimşek & Arıkan, 2012). Also, Malaş (2011) indicated that the use of computer-assisted mathematics activities besides increasing the achievement of students, attracted their attention and students enjoyed the learning process and were eager to participate in-class activities.

As it can be seen in Table 3, there are many studies which have significant effect on the attitudes of students towards mathematics (Dereli (2008)-Thesis; Enki (2014)-Thesis; Helvacı (2010)-Thesis; Hot (2019)-Thesis; Kontaş (2016); Kutluca (2009)-Thesis; Özdemir & Tabuk (2004); Özerbaş (2012); Tataroğlu, (2009)-Thesis; Yorganci & Terzioğlu (2013), the inclusion of different type of materials did not have a significant

effect on the attitudes of students. Some studies revealed that the use of dynamic geometry software (Akgül, 2014); computer-assisted instruction (Andiç, 2012) and GeoGebra (Barçın, 2019) did not have significant effect on the attitude of 8th grade students towards mathematics. Bayturan (2011) found that the use of computer-assisted instruction did not have significant effect on the attitude of 9th grade students towards mathematics. Also, Bilen (2016) and Şimşek (2013) revealed that the use of interactive worksheets and GeoGebra did not have significant effect on the attitude of 10th grade students towards mathematics respectively. Özdemir and Küpcü (2010) revealed that the use of individualized mathematics teaching materials did not have significant effect on the attitude of 6th grade students towards mathematics. In addition to these, Bilen (2016) stated that 10th grade students who used interactive worksheets significantly differed from the control group in terms of achievement and self-efficacy, but they did not differ in terms of engagement levels and attitude toward mathematics.

On the other hand, Öztürk B. (2012) highlighted the result that students' mathematics achievement increased in the group using dynamics mathematics software GeoGebra although the difference between groups was not statistically significant. Similarly, Özerbaş (2012) revealed that the use of WebQuest while teaching cylinder to 7th grade students resulted in an insignificant difference between pre- and post-test scores of the experimental group in terms of achievement but the attitude level in the experimental group were higher than the control group. Also, Tataroğlu (2009) found that the use of software and web sources in learning second-degree functions did not make a significant difference in terms of academic achievement but a significant difference was obtained in favor of the experimental group in terms of the attitude of students towards mathematics. Şimşek (2013) expressed that although GeoGebra group attained higher achievement and attitude scores than the control group, 9th grade students who were in the GeoGebra and traditional instruction groups did not differ significantly while learning functions in terms of achievement scores and attitude towards mathematics.

Besides positive effect of materials on achievement, attitude, retention, self-efficacy, motivation, anxiety levels of students as shown in Table 3, the use of materials had important effect on mathematical skills and abilities such as spatial visualization skills of 11th grade students using Minecraft game (Akbay, 2015); geometric thinking skills of 8th grade students using dynamic geometry software (Akgül, 2014); inference and hypothesizing skills of 8th grade students using GeoGebra and Cabri dynamic geometry software (Filiz, 2009); associating linear algebra concepts and discovering the relations between geometric and algebraic properties of pre-service teachers using GeoGebra (Kan, 2014); spatial visualization skills of 9th grade students using Geogebra and GSP software (Karaaslan, 2013) developing thinking and visualization skills of pre-service teachers besides their retention levels, learning in a short time, concretization abilities while learning the analytical analysis of the circle using dynamic software (Tatar, Kağizmanli & Akkaya, 2014) and finally, conceptual understanding and retention levels of 8th grade students while learning linear equations and slope using GeoGebra (Uzun, 2018).

3.2. Concrete Materials and their effect on student outcomes

The availability of materials created a rich learning environment and at the same time, enabled students to interact with each other and the teacher. For instance, because negative numbers cannot be observed in the physical world, this makes the learning of integers difficult. Şengül & Körükcü (2012) used '(+, -) Labels and Board, Numerical Axis Model, Piston Thermometer' materials in their research. It was found that the use of visual materials in teaching is more effective in terms of learning mathematics and the retention level of students compared to traditional methods. Moreover, the study conducted by Kılıç et al. (2013) showed that the use of geometry board, point papers, drawing sets (protractor, compass and ruler) revealed the changes in students' mathematical thinking skills. On the other hand, Enki (2014) found that the use of unit cubes, symmetry mirrors, and acetate paper in learning two and three-dimensional objects, reflection and rotation did not make a significant difference in terms of academic achievement.

3.3. Materials not directly related to mathematics and their effect on student outcomes

Arıcı (2012) found that the use of origami while learning triangles resulted in a statistically significant change in spatial visualization, geometry achievement and geometric reasoning abilities of 10th grade students. Moreover, Bedir et al. (2013) informed that students who completed their assignments taking photos about geometrical objects were more successful than students completing their assignments from textbooks. When students were asked to take the photos of geometrical objects (prism, pyramid, cone, sphere, and cylinder) in their surroundings and nature they learned more by storing, grouping and studying the properties of geometrical objects by these pictures. These researchers concluded that the camera is an effective material while learning geometry and mathematics. Erşen (2014) revealed that using removable and re-glued objects, colored cardboard while learning sets resulted in learning and retaining more besides the

positive attitude of 6th grade students towards mathematics than the control group. Furthermore, the use of materials had important effect on mathematical skills and abilities such spatial visualization, geometry achievement and geometric reasoning abilities of 10th grade students using origami (Arıcı, 2012).

3.4. Metacognitive materials and their effect on student outcomes

Metacognitive materials like cartoons, concept maps and Vee diagrams have a significant effect on student learning since they enhance the integration and association of conceptual and procedural knowledge and accurate construction of information. Dereli (2008) found that the use of cartoons while learning integers improved learning, attitude, retention levels of 7th grade students and reduced mathematical anxiety. Oğraş and Bozkurt (2011) stated that teaching circle subject through concept mapping and Vee diagrams have positive effects on the students' performance in geometry. Similarly, Özdemir and Küpcü (2010) stated that Individualized Mathematics Teaching Material (IMTM) increased students' mathematics achievement while teaching measurement subjects (length, perimeter and area of triangle, square and rectangle, the relationships between them, and the volumes of rectangular prism and cube).

3.5. A mix of materials and their effect on student outcomes

Kablan et al. (2013) stated that PowerPoint enriched with pictures and animations, concrete materials such as number scales and equation model and materials which are used in daily life such as sugar cube, purse, crackers or screws together had statistical significance in increasing the learning of students. Similarly, Egelioğlu (2008) revealed that the use of presentation materials supported by animations, coloring and plotting paper together while learning transformation geometry and areas of quadrilaterals improved learning and the epistemological believes of 7th grade students. Konak (2009) revealed that the use of bingo cards and worksheets while assessing the learning algebraic statements, equalities and equations subjects resulted in statistically significant achievement of 6th grade students but there was not any significant difference in terms of retention. Uysal Ko and Başer (2011) found that teaching algebraic expressions and equations using a mix of materials (animations metaphors, algebra tiles, concept cartoons, Macromedia Flash CS 5, Swish Max, iSpring) affected abstract thinking skills of students' and learned helplessness in mathematics positively. In addition, the use of materials had important effect on epistemological believes of 8th grade students (Egelioğlu, 2008) and building and drawing geometric structures of 5th grade students when a mix of materials were used (Şahin, 2013).

Discussion, Conclusion and Suggestions

In this study, the aim was to examine material use in mathematics courses while teaching various topics in different grade levels and to understand the current condition in terms of what kinds of materials were included by teachers in mathematics courses to teach different subjects and their effect on mathematics outputs. According to the results, students who were thought by including any kinds of materials at any grade had higher mathematics achievement than students who were taught by traditional teaching methods. In other words, this can also be interpreted as that students who were thought using any kinds of materials performed better than the students who did not use materials. It can be stated that teaching with computer software (PowerPoint materials, GeoGebra, Cabri, spreadsheets etc.), concrete materials (number scales and equation models) and also with materials that are used in daily life (sugar cube, purse, crackers, photo camera or screws) enabled students to acquire and retain more knowledge, which is in line with the findings of many studies stated in Table 3 that the inclusion of materials had a positive effect on mathematics achievement and retention. The reason for this finding might be immediate feedback. Students received immediate feedback while using the computer software and concrete materials. In this way, students become aware of their misconceptions as also stated by, Şen (2010), who found that the use of computer software was more effective in preventing misconceptions, increasing the level of mathematics achievement and retention level of students while learning probability. In this way, the attitudes of students towards mathematics was also improved positively. Also, while using materials students had the opportunity to be able to work at their own pace, which might be the reason for the positive effect of materials on the learning of students. On the other hand, the results of some studies revealed an insignificant difference in terms of student achievement (Enki, 2014; Kul, Çelik, & Aksu, 2018; Öztürk, 2012; Tataroğlu, 2009). The reason for this result might be the duration of material uasage. As stated by Sowell (1989) that the positive effect of materials may be observed on the achievement of students after their steadily and a long time use.

The findings of the study revealed that there were more thesis studies than published research articles. The reason for this finding may be that the development and implementation process of materials is more demanding than teaching according to traditional methods. Therefore, researchers prefer to put up with the severe process of designing and implementing materials in mathematics courses to prepare their

theses or dissertations. In this sense, teachers and instructors may be rewarded by the administrators in order to encourage all teachers and instructors in terms of the inclusion of materials in mathematics. Also, the implementation process of materials requires the skills and experience of teachers or instructors, besides classroom management abilities of them. Also, the type of materials and the topic that the materials will be included may also affect the decision to include material or not. For this reason, teachers and instructors may be provided with in-service training in terms of the use of different materials.

Another result is that among 67 studies, most of them included computer software and web sources; very few of them included concrete materials, materials not directly relating to mathematics, metacognitive materials and a mix of materials. The reason for including computer software and web sources more than other type of materials might be that in Turkey, the Ministry of National Education has started a project aiming at enhancing the use of computers and computer-based materials in instruction process (Fatih Project, 2012). For this reason, the number of computers in schools has been increased and the internet is accessible in almost all schools. Students obtained the opportunity to be able to study at computer labs to engage in mathematical software. Similarly, Reimer and Moyer (2005) stated the advantage of using digital materials as that computer software and web-based materials can be easily accessed and they are clearer in associating abstract concepts and symbols with visual images. On the other hand, Olkun (2003) found that although both computer and concrete groups improved, fourth-graders gained more when concrete materials were used, while fifth graders benefited more from the computer-based materials. Moreover, Kul, Çelik, & Aksu, (2018) found in their meta-analysis study that the use of both physical and digital materials had significantly higher effect sizes. For this reason, future studies should include these types of materials in the teaching-learning process of mathematics, which helps students make connections between real-life events and mathematical facts.

In addition, in the studies included in the current meta-review different materials were used to teach different learning areas as numbers & algebra, measurement & probability and geometry. In this meta-review study, while only four studies integrated materials in teaching subjects at measurement & probability sub-domain, almost equal number of studies were conducted at geometry and numbers & algebra sub-domains including fractions and decimals, relation, functions and operations, second degree functions, equations with one unknown, sets, Cartesian coordinate system and linear relation, graphs of linear equations, divisibility, word problems, integers and finally just one research at derivative. Besides these subjects, because students experience hardship while learning, complex numbers, logarithm, limit, continuity, integration, analytical geometry etc. they should also be taught by integrating materials. Moreover, most of the studies which were conducted by integrating materials in teaching subjects at geometry sub-domain included triangle, square, rectangle, their properties, circle subject. Moreover, subjects such as prism, cube, sphere, cone, pyramids should be taught using a mix of both computer software and concrete teaching materials because these subjects are quite abstract for students to visualize in their mind. For this reason, integrating different type of materials in the teaching-learning process may help them to see three-dimensional relationships.

The results of the study showed that most of the studies which included materials were conducted at the secondary level and especially at 6^{th}, 7^{th} and 8^{th} grades. However, there are fewer studies which included materials conducted at high school levels and higher education level in order to see the effects of them in learning different mathematics topics. However, the National Council of Teachers of Mathematics (NCTM) recommended the inclusion of materials into the teaching-learning process of mathematics at all grade levels (NCTM, 2000) because they provided opportunities for students to touch, visualize the topics that they learned to understand new mathematical concepts. Students who merely memorize mathematical facts or procedures without understanding them are often not sure when or how to use what they have known and such learning is often quite fragile (Bransford, Brown, & Cocking, 1999 cited in Domino, 2010). For this reason, teachers should get in-service training programs in order to be able to use some computer software, web sources, concreate and daily life manipulatives and to be able to write mathematical formulas, graphs, etc. Also, for better teaching, appropriate educational software materials should be prepared and the access to them should be facilitated by the school or university administrators.

Furthermore, this meta-review study revealed that the use of materials affected the self-efficacy skills of students (Akbay, 2015; Bedeloğlu, 2016; Bilen, 2016). The reason for this result might be that self-efficacy believes of students enhance as they experience learning material individually. Also, students who lack knowledge had the opportunity to learn the answers of questions by working on the materials individually or in groups instead of just learning the correct answer from the answer key.

In addition, this meta-review study revealed that the inclusion of any type of materials including computer software and web sources, concrete and meta-cognitive materials had positive effects on a variety of student outcomes such as achievement, attitude, retention, self-efficacy, motivation, anxiety, spatial visualization skills, geometric thinking skills, inference and hypothesizing skills and concretization abilities. However, the effect sizes of these materials on different outcomes of students should be examined through comprehensive meta-analysis studies to be able to confirm the findings of this study statistically.

Implications for practice may be that curriculum designers can design curricula by including different materials in the teaching-learning process of mathematics and teacher educators may guide future teachers to prepare, encourage the use different materials in their teaching practices. Future studies may also investigate the effect of material use on other student outcomes such as engagement, problem-solving abilities, participation and decrease in mathematical errors.

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Appendix A. Reviewed Studies

Researchers	*Level of Education*	*Content*	*Material*	*Results*	*Themes*
Acar (2015)-Thesis	11th grade (n=35)	exponential and logarithmic functions	GeoGebra	computer-based instruction with GeoGebra had a more significant effect on the achievement of students than traditional instruction	materials using computer software and web sources
Akbay (2015)-Thesis	11th grade (n=91)	triangle	Minecraft game	there was a significant difference between pre-test and post-test scores of the experimental group in terms of achievement, spatial visualization and self-efficacy levels of students while learning triangle but there was no difference in terms of rotation skills.	materials using computer software and web sources
Akçayır (2011)-Thesis	pre-service teachers (n=180)	analytical geometry subject	interactive whiteboard	interactive whiteboard increases the achievement of pre-service-teachers. The motivation of the experimental group was higher than the control group	materials using computer software and web sources
Akgül (2014)-Thesis	8th grade (n=34)	transformation geometry (fractals, rotation, reflection, translation), geometric	dynamic geometry software	dynamic geometry software-assisted instruction had a significant effect on students' mathematics achievement in transformation geometry and geometric thinking compared to the control group but it did not have a significant effect on students' attitude towards mathematics.	materials using computer software and web sources
Aksoy, Çalık & Çınar (2012)	junior pre-service teachers (n=136)	mathematics-II	microsoft excel	excel graph plotting increases the achievement of pre-service-teachers.	materials using computer software and web sources
Andiç (2012) Thesis	8th grade (n=34)	permutation and combination	computer-assisted instruction	computer-assisted instruction had a positive effect on academic achievement but it didn't change the attitude of students towards mathematics.	materials using computer software and web sources
Arıcı (2012)-Thesis	10th grade students (n=184)	triangles	origami	there was a statistically significant change in spatial visualization, geometry achievement and geometric reasoning abilities of students who used origami.	materials not directly related to mathematics
Barçın (2019)-Thesis	8th grade (n=50)	transformation geometry	GeoGebra	the experimental group statistically differed from the control group in terms of achievement. Although the anxiety levels of students decreased, their attitude towards mathematics did not change.	materials using computer software and web sources
Bayındır-Kocaman (2015)-Thesis	11th grade (n=49)	summation symbol, summation rules, series	wooden manipulatives made of cubes	computer-assisted instruction has a positive effect on the academic achievement of students.	concrete materials related to mathematics
Bayturan (2011)-Thesis	9th grade (n=60)	relation, functions and operations	computer-assisted instruction	teaching mathematics with computer-assisted instruction increased the achievement of students significantly but there were no significant differences in the attitude of students towards mathematics in both the experimental and the control groups.	materials using computer software and web sources
Bedeloğlu				achievement test scores of the	

(2016)-Thesis	10th grade (n=61)	angles of circles	GeoGebra and videos web-site prepared by the researcher	experimental group were significantly higher than those of the control group and self-efficacy levels of the experimental group increased significantly.	materials using computer software and web sources
Bedir, Ersözlü & Duygu (2013)	6th grade (n=16), 7th (n=14) and 8th (n=16)	geometrical objects	photo camera	students in the experimental group who completed their assignments taking photos about geometrical objects was more successful than students in the control group who completed their assignments from textbooks.	materials not directly related to mathematics
Bilen (2016)-Thesis	10th grade (n=68)	second degree equations and functions	interactive worksheets	students who used interactive worksheets significantly differed from the control group in terms of achievement and self-efficacy, but there was not any difference between these groups in terms of engagement and attitude.	materials using computer software and web sources
Birgin, Kutluca & Gürbüz (2008)	7th grade (n=43)	coordinate plane and graphs of linear equations	computer-assisted instruction the "spreadsheets" and "coypu" software	the results of this study showed that computer-assisted instruction was more effective than the traditional instruction on increasing the achievement of students.	materials using computer software and web sources
Budak (2010)-Thesis	6th grade (n=60)	geometry (polygons)	Geometers' Sketchpad	the use of dynamic mathematics software (GeoGebra) had a significant effect on teaching polygons.	materials using computer software and web sources
Çekirdekci, Toptaş & Çekirdekci (2016)	3rd grade (n=73)	geometry	Okulistik and Morpa Kampüs software 'fun Math' website audio lectures, animated visuals	computer-assisted instruction according to Bruner's cognitive development principles had a statistically significant effect on the students' academic achievement and retention levels.	materials using computer software and web sources
Çelik & Çevik (2011)	7th grade (n=56)	statistics and probability	Microsoft PowerPoint slides and vitamin portal	the computer-assisted instruction is more effective in increasing student achievement compared to traditional instruction.	materials using computer software and web sources
Dereli (2008)-Thesis	7th grade (n=61)	Integers	cartoons	teaching integers using cartoons improved learning, attitude, the permanence of the knowledge and reduced mathematical anxiety.	metacognitive materials
Dışbudak (2017)-Thesis	5th grade (n=60)	quadrilaterals	GeoGebra	GeoGebra had a positive effect on the students' achievement and enhanced students' perception while learning quadrilaterals	materials using computer software and web sources
Doktoroğlu (2013)-Thesis	7th grade (n=60)	cartesian coordinate system and linear equations	dynamic mathematics software (geogebra)	while teaching the Cartesian coordinate system and linear relation using Dynamic Mathematics Software had no significant effect on seventh grade students' achievement compared to the regular instruction but the use of the same software had a significant effect on teaching linear equations.	materials using computer software and web sources
Egelioğlu (2008)- Thesis	7th grade (n=31)	transformation geometry and areas of quadrilaterals	plotting paper, presentation material supported by animations and coloring	computer based instruction influenced the mathematics achievement and epıstemological belief positively.	a mix of materials
Enki (2014)-Thesis	7th grade (n=73)	2 and 3 dimensional objects reflection and rotation	unit cubes, symmetry mirror, and acetate paper	there was no statistically significant mean difference between the experimental and the control groups. The experimental group showed a positive attitude in terms of using manipulatives.	concrete materials related to mathematics

Erşen (2014)-Thesis	6th grade (n=60)	sets	removable and re-glued objects8 colored cardboard	Students learned and remembered more in the experimental group than the control group. Also, the attitude of students towards mathematics developed were more positive in the experimental group than the control group.	concrete materials not directly related to mathematics
Filiz (2009)-Thesis	8th grade (n=25)	geometry II	GeoGebra and Cabri geometry II dynamic geometry software in a web-based setting	students taught with web-based materials were more successful and improved their inference and hypothesizing skills compared to students taught with traditional instruction.	materials using computer software and web sources
Gelibolu (2008)-Thesis	9th grade (n=59)	logic	Macromedia Flash 8, Allaire Homesite 4.5 and ActionScript 2.0	computer-assisted instruction is more affective than traditional education in terms of student learning.	materials using computer software and web sources
Genç & Öksüz (2016)	5th grade (n=70)	Polygons and quadrilaterals	GeoGebra	GeoGebra was more effective in learning and retaining polygons and quadrilaterals compared to the instruction in which GeoGebra was not used.	materials using computer software and web sources
Gürbüz (2007)	8th grade (n=21)	probability	macromedia dreamweaver, flash mx 2004 software and html.	the instructional materials employed in this study was effective in teaching probability subject.	materials using computer software and web sources
Helvacı (2010)-Thesis	6th grade (n= 66)	polygons	computer based materials prepared using Adobe Flash CS4	computer-based materials significantly improved student learning, motivation and attitude towards mathematics.	materials using computer software and web sources
Hot (2019)-Thesis	5th grade (n=87)	triangles and quadrilaterals	Geogebra and Geometer's Sketchpad	dynamic geometry software improved students' academic performance and attitude towards mathematics.	materials using computer software and web sources
Kablan, Baran, Işık, Kal & Hazer (2013)	6th grade (n=92)	algebraic expressions and equations	PowerPoint materials and concrete materials (number scales and equation models and sugar cube, purse, crackers or screws)	there is statistically a significant increase in the learning of students in three groups using different materials; however, there was not a significant difference among these groups in terms of achievement scores.	a mix of materials using computer software, concrete teaching materials (materials both directly related to mathematics and not) and metacognitive materials
Kan (2014)-Thesis	68 second grade preservice teachers	lineer algebra-vector, matrix, systems of linear equations and linear dependence/ independence	GeoGebra	there is a statistically significant difference in students' learning, associating linear algebra concepts and discovering the relationships between geometric and algebraic properties between the experimental and the control groups in favor of the experimental group.	materials using computer software and web sources
Karaaslan (2013)-Thesis	9th grade (n=36)	vectors, linear equations, angles of polygon, length and area, similar and equal triangles,	GeoGebra and GSP software	activities prepared with the help of the GeoGebra and GSP software developed the performances and spatial visualization skills of students.	materials using computer software and web sources
Kılıç, Tunç-Pekkan & Karatoprak	6th grade (n=20)	geometry, numbers sets, divisibility,	geometry board, dotted papers, drawing sets	the analysis of videotapes and students' worksheets revealed the changes in students' mathematical	concrete materials related to mathematics

(2013)		gcd-lcm and fractions	(protractor, compass, ruler)	thinking skills.	
Konak (2009)-Thesis	6th grade (n=94)	algebraic statements, equalities and equations	bingo cards and workheets	students evaluated through bingo cards showed a significantly higher achievement compared to the students who were evaluated through worksheets and students who were not evaluated by any material but there was not any significant difference between these groups in terms of retention.	a mix of materials
Kontaş (2016)	7th grade (n=48)	circles and spheres	concreate manipulatives	manipulatives increased mathematics achievement in both the experimental and the control groups but the attitude towards mathematics significantly differed between these two groups in favor of the experimental group.	concrete materials related to mathematics
Kutluca (2009)-Thesis	10th grade (n=30)	second degree functions	Coypu, Derive and Excel	the learning environment included Coypu, Derive and Excel were successful in terms of increasing the academic performances of the students and their positive attitude towards mathematics.	materials using computer software and web sources
Malaş (2011)-Thesis	2th grade (n=30)	word problems	computer-assisted education activities and star strategy	there is statistically a significant increase in students' learning and problem-solving skills when computer-assisted education activities and star strategy was implemented.	materials using computer software and web sources
Oğraş & Bozkurt (2011)	7th grade (n=50)	circle and chamber	concept mapping and vee diagrams	teaching circles through concept mapping and vee diagrams have positive effects on the performance of students.	metacognitive materials
Önal & Göloğlu-Demir (2012)	7th grade (n=45)	reflection and rotation	vitamin program and Microsoft picture manager program	there is a positive effect of computer-assisted instruction on the students' geometry achievement. Vitamin program and Microsoft picture manager program software have positive effects on students' learning reflection and rotation topics.	materials using computer software and web sources
Özdemir & Küpcü (2010)	6th grade (n=40)	measurement (length perimeter, areas, volume)	individualized mathematics teaching material (imtm)	mathematics achievement of the experimental group using individualized mathematics teaching material (imtm) significantly differed from those students in the control group but the attitude scores of experimental group did not differ significantly from the control group.	metacognitive materials
Özdemir & Tabuk (2004)	7th grade (n=72)	circle and cylinder	Microsoft PowerPoint	there is a meaningful difference in the learning level and attitude of students involved in computer-assisted instruction compared to traditional instruction group.	materials using computer software and web sources
Öztürk, B. (2012)-Thesis	8th grade (n= 52)	trigonometry and slope	dynamics mathematics software-GeoGebra	students' mathematics achievement increased in the group using dynamics mathematics software GeoGebra although the difference between groups' achievements is not statistically significant. Also, mathematical thinking levels of two groups did not differ significantly.	materials using computer software and web sources
Öztürk, M. (2011)-Thesis	6th grade (n= 66)	ratio and proportion	traditional and innovative computer-assisted instruction software	the experiment group learned through innovative computer-assisted instruction software obtained higher scores than the traditional computer-assisted instruction software and the control	materials using computer software and web sources

				group.	
Özerbaş (2012)	7th grade (n=51)	cylinder	WebQuest	the attitude level in the experimental group was higher than the control group but there was not a significant difference between these two groups before and after the experiment in terms of achievement.	materials using computer software and web sources
Selçik & Bilgici (2011)	7th grade (n=22)	geometry-polygons	Computer-assisted geometry instruction (GeoGebra)	students in the computer-assisted instruction group showed higher achievement and retention levels than the control group.	materials using computer software and web sources
Şahin (2013)-Thesis	5th grade (n=56)	geometric structures	Concrete (unit cupes) and virtual manipulatives	a statistically significant difference between the achievement test scores and building and drawing geometric structures between the experimental and the control groups in favor of the experimental group.	a mix of materials
Şen (2010)-Thesis	6th grade (n=53)	probability	intuitive thinking controlled probability computer aided instruction software and vitamin program	intuitive thinking controlled probability computer aided instruction software is more effective in preventing misconceptions related to intuitive thinking in probability unit.	materials using computer software and web sources
Şengül & Körükcü (2012)	6th grade (n=60)	integers and integer operations	visual materials [(+, -) labels and board, numerical axis model, piston thermometer model)]	the use of visual materials in teaching is more effective in terms of mathematics achievement and retention levels of students compared to the conventional method of teaching.	concrete materials related to mathematics
Şimşek (2013)-Thesis	9th grade (n=68)	functions	GeoGebra	there was not a significant difference between the GeoGebra group and traditional group in terms of achievement scores and attitude towards mathematics but GeoGebra group attained higher achievement and attitude scores than the control group.	materials using computer software and web sources
Şimşek & Arıkan (2012)	education faculty junior students (n=83)	derivative	video camera and computer screen capture software	there is a significant difference between the experimental and the control group in terms of achievement test scores but, there is no significant difference between the two experimental groups.	materials using computer software and web sources
Taş (2016)-Thesis	6th grade (n=60)	geometric shapes	GeoGebra 5.0 software by using 3D glasses	students who learned using GeoGebra and 3D glasses were more successful and retained more than the students who learned just using GeoGebra and traditional group.	materials using computer software and web sources
Tatar, Kağizmanli & Akkaya (2014)	29 math. pre-service teachers	analytical analysis of circle	dynamic software-GeoGebra	the instruction conducted using dynamic software significantly increased the achievement of pre-service teachers and it had a positive effects on developing thinking skills, visuality, retention, learning in a short time, concretization and focusing the attention while learning the analytical analysis of the circle.	materials using computer software and web sources
Tataroğlu, (2009)-Thesis	10th grade	second degree	smart board (computer – projection – board	the use of the smart board did not make a significant difference between the experimental and the control groups in terms of	materials using computer

	(n=124)	functions	connection) macromedia flash geometer's sketchpad, excel and graphmatica.	academic achievement and self-efficacy but there was a significant difference in favor of the experiment group in terms of the attitude of students towards mathematics.	software and web sources
Tezer & Kahraman-Deniz (2009)	8th (n=60)	equations with one unknown	interactive boards	students in the experimental group were more successful than the students in the control group in solving equations with one unknown.	materials using computer software and web sources
Tural-Sönmez (2012)-Thesis	6th grade (n=75)	fractions and decimals	web based mathematics games	Web-based mathematics games were more effective in terms of increasing mathematics achievement then traditional methods.	materials using computer software and web sources
Tuncer (2008)-Thesis	8th grade (n=51)	Pascal triangle and Binomial expansion	computer-assisted materials-presentations and stories, horse and bull toys.	students who learned the course using material were more successful and their learning was permanent than the control group.	materials using computer software and web sources
Tutak & Birgin (2008)	4th grade (n=38)	triangle, square and rectangle	dynamic geometry software cabri.	the computer-assisted instruction had a significant effect on the students' geometry achievement compared to traditional instruction.	materials using computer software and web sources
Ubuz, Üstün & Erbaş (2009)	7th grade (n=63)	line, angle, and polygon concepts	dynamic geometry environments Geometer's Sketchpad)	the group used the Geometer's Sketchpad significantly higher achievement than the traditional lecture-based instruction group while learning line, angle, and polygon concepts but there was not a significant difference between these two groups.	materials using computer software and web sources
Uysal-Koğ & Başer (2011)	8th grade	algebraic expressions and equations (factorization, equations one and two unknowns)	visual materials (animations metaphors , algebra tiles, concept cartoons, macromedia flash cs 5, swish max, ispring	visualization approach affected abstract thinking skills and learned helplessness of students positively.	a mix of materials
Uzun (2018)-Thesis	8th grade (n=52)	Linear Equations and Slope	GeoGebra	GeoGebra group significantly differed from the control group in terms of conceptual understanding and retention.	materials using computer software and web sources
Üner (2009)-Thesis	7th grade (n=92)	algebraic statements and equations	cartoons	the instruction including cartoons had a positive effect on the students' achievement, attitude towards mathematics and retention levels. Also, mathematics anxiety level declined compared to the traditional teaching techniques.	metacognitive materials
Yeniçeri (2013)-Thesis	6th grade (n=76)	fractions	virtual manipulatives (NLVM NCTM-illuminations, WisWeb, E-Lab and SAMAP)	the use of virtual manipulatives while teaching fractions revealed a significant difference in favor of the experimental groups.	materials using computer software and web sources
Yılmaz, Ertem, & Güven, (2010)	11th grade (n=51)	trigonometry	Cabri	Students who used Cabri showed a significant difference in terms of achievement.	materials using computer software and web sources
Yorganci & Terzioğlu (2013)	vocational school (n=60)	mathematics-I	computer projection and interactive whiteboard.	the use of A-migo-TU interactive whiteboard significantly enhanced the achievement and attitude of students.	materials using computer software and web sources
Yücesan			virtual learning	the computer-assisted instruction	materials using computer

(2011) Thesis	6th grade (n=48)	sets	materials (computer software)	had a significant effect on the students' learning compared to traditional instruction.	software and web sources
Zengin A. (2019)- Thesis	6th grade (n=42)	area and volume measurement	GeoGebra	the use of GeoGebra increased the achievement scores of students while learning the area and volume measurement	materials using computer software and web sources
Zengin Y. (2011)- Thesis	10th grade (n=51)	trigonometric functions and graphs of trigonometric functions	GeoGebra	students who used GeoGebra obtained significantly higher achievement scores than students in the control group but there was no meaningful difference between these groups in terms of attitude toward mathematics.	materials using computer software and web sources