Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi
Cilt 16, Sayı 2, Aralık 2022, sayfa 304-325. ISSN: 1307-6086
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 16, Issue 2, December 2022, pp. 304-325. ISSN: 1307-6086

Research Article

Secondary school mathematics teachers' understanding of materials and materials they create

Emine Nur ÜNVEREN BİLGİÇ[1], Ziya ARGÜN[2]

[1] Duzce University, Düzce-Türkiye, eminenurbilgic@duzce.edu.tr, http://orcid.org/0000-0001-9684-4192

[2] Gazi University, Ankara-Türkiye, ziya@gazi.edu.tr, http://orcid.org/0000-0001-8101-7215

Received : 27.06.2022 Accepted : 12.11.2022

Doi: 10.17522/balikesirnef.951308

Abstract – The study aimed to examine mathematics teachers' materials usage in instructional design and was carried out via qualitative paradigm of action research with eight teachers working at the Ministry of National Education. Eleven sessions were held in total and data were gathered through semi-structured interviews, written documents, video recordings and focus group interviews. The data were analyzed via content analysis and constant comparative analysis. The results revealed while manipulatives in pre-education could be only observed by students; in post-education they were experienced by students, with teacher acting as a guide.

Key words: teacher training, instructional design, manipulative, virtual material.

Corresponding author: Emine Nur ÜNVEREN BİLGİÇ, eunveren@sakarya.edu.tr

Introduction

In today's world, students should be able to collect necessary information, model, solve problems and moreover foresee possible mathematical situations when they encounter real-life problems. In this case, students are expected to construct the process during mathematics teaching. Teacher should only be the guiding individual. On the other hand, in this student-centered approach students end their problematic mathematical exercises they started themselves with a related mathematical situation through their own actions and efforts. Using information and communication technologies appropriately and efficiently is of great importance in this process and it is one of the components which will complete and facilitate

this program's implication. Therefore, teachers should bring to the class by planning well-structured activities. (The Ministry of National Education, 2013).

Materials usage is supported by several theories in education (Dienes and Golding, 1971; Piaget, 1971; Skemp, 1987). Learning theorists suggested that individuals are greatly influenced by their environment while constructing concepts in their minds; therefore materials play a crucial role at this stage (Post, 1988). Piaget (1971) stated that individuals construct concepts not as a copy of reality but as a reconstruction. Dewey (1938) claimed that the primary requirement of teaching programs should be real life experiences. Bruner (1960) stated that learning is a process rather than a product; while Dienes (1969) emphasized that mathematics teachers should construct and create the concepts in students' minds rather than transferring them. Piaget suggested that primary school students are at concrete learning stage; therefore we need to appeal to their sense organs with a number of concrete materials (İnan, 2013). Piaget (1971) claimed that mathematical information occurred in individuals through relating. This type of information is different from physical information which is gathered through observation of the outside world. According to Piaget, physical information can be constructed through observation or experiment; whereas mathematical information can be constructed through thought-based abstractions. Additionally, Bruner's (1966) learning theory suggests that in order for a meaningful learning to occur in an individual, there should be teaching based on individual's exploration and discovery of new relationships. Educational materials boost students' interest in lessons, facilitate learning and boost their motivation (Yalın, 2000).

Whatever the theoretical benefits of teaching materials are, using them requires a specific level of knowledge and skill. In this respect, teacher who has an important place in the teaching system organizes, manages and supervises other components in the teaching system, determined the tools to be used in teaching, applies teaching techniques and comments on the results (Abrami, 2001). If the teacher does not possess the skills to use these materials, s/he will not want to use them. Besides, whether or not using materials is not related to only knowledge and skills. The teachers need to believe their benefits and be willing to use them (Holmes, 2013; Haara, 2010). On the other hand, Domino (2010) states that if teachers receive training on material usage, they will be influenced to use materials in their own lessons (Marshall and Swan, 2005; McClung, 1998). Again, according to Bozkurt and Akalın (2010) and Moyer (2001) materials are tools which are used to make abstract concepts concrete and make teaching more effective in teaching environments (Cope, 2015; Hartshorn & Boren, 1990; Laski, Jor'dan, Daoust, & Murray, 2015; McClung, 1998; Moyer, 2001; Ojose & Sexton, 2009; White, 2012,

Holmes, 2013). Materials are used in order to materialize abstract concepts and teach more effectively (Boggan, Harper & Whitmire, 2010; Cope, 2015; Hartshorn & Boren, 1990; Laski, Jor'dan, Daoust & Murray, 2015; McClung, 1998; Moyer, 2001; Ojose & Sexton, 2009; White, 2012).

The present study also asked teachers' opinions on materials and examined materials that they used in their instructional design after a related education as well as in pre-education. On this subject, Domino (2010) stated that teachers' education would influence their materials usage in their classes. Therefore, this study is quite important for materials usage in teaching in the sense that it examines the influence of teachers' education on their teaching material design or views. It is expected to inspire researchers who will study on this field. Additionally, results of the study are expected to contribute greatly in teacher education and in-service teacher training.

So, an answer to the question of "How is the teachers' perceptions and (if there is any) experiences regarding material usage before and after materials design training in the process of teaching design?" was sought. In this context, the following sub-problems were answered:

(1) What are the perceptions of the teachers regarding materials design before the training?

(2) Did the teachers use materials in the process of teaching design before receiving training? If so, what kind of materials did they use?

(3) What are the teachers' perceptions regarding materials usage in the process of teaching design after receiving training?

(4) Do the teachers use materials in the process of teaching design after the training? If so, what kind of materials do they use?

Method

The study began with the researchers defining the problem situation by examining the literature. Then, an interview was done with the head of mathematics teachers' group in the most successful school in the present district about the problem case (Appendix, A). Content of the semi-structured interview was analyzed via content analysis. The analysis revealed 4 themes which are need for materials, materials' place and importance in teaching environment, types of materials and learning outcomes of materials. Learning outcomes at the end of the interviews were defined as explaining similar triangles, irrational numbers and real numbers; showing and explaining intercept of triangle medians, defining the relationship between roots and coefficients of second-degree equation with one unknown, calculating the number of different ways to choose r elements from n-element set; displaying and using features regarding modular arithmetic; interpreting distance using minimized or maximized drawing of an object;

interpreting an object's perimeter, area or volume; explaining a function's limit thorough examples, explaining the concept of derivatives by using physics and geometry models and guessing the area of limited region between a function's graphic and x-orbit through Riemann sum. According to these learning outcomes, lesson plans were developed with the contributions of four mathematics educators including the researchers. After this interview, problem case was defined clearly; 10 learning outcomes were defined within the framework of Mathematics Teaching Program; and an action plan was developed with the help of the interviewee teacher. After this step, the participants of the study were defined. To define the participants, firstly all the names of the in-service mathematics teachers were received from the District Directorate of National Education. Then all the teachers were informed about the study and asked whether they would like to participate in it. An introductory meeting was held with the twelve teachers who agreed to take part in the study. At the end of the introductory meeting, three teachers stated that they would not be able to participate because of private reasons. After the training sessions started, one of the teachers could not participate because of health problems and the final participant number remained as eight. In choosing the participants, criterion sampling was used as the training took ten weeks, the study was video-recorded and the participants were expected to display products.

The researcher held sessions on Thursdays between 17.00- 18.15 with the participants. These sessions were held in the computer laboratory in B Block room 2205 at X University, Faculty of Education. First session included semi-structured interviews with the participants (Appendix B). Next, the researcher informed the participants on "A Closer Look at the Concept of Materials" for two hours. Following sessions included ten weeks of training for ten learning outcomes. At the beginning of these training sessions, the participants were asked to hand in their relevant instructional designs that they shared with their students. The researcher gave training regarding the relevant learning outcome at the same session. At the end of the session, the participants were asked to design a teaching in accordance with the training they received. The participants were asked to hand in the second instructional design in next week's session (Certain participants asked to for longer time to hand in their designs). Semi-structured interviews were done with certain participants in order to acquire thorough information regarding their instructional designs.

Considering the research process, the study is liberating/constructive/critical action research which is one of action research types. The critical study (Norton, 2009) aims for the appliers gaining new information, skills and experiences as well as a critical point of view toward their own implications. Thus, the applier will consider their implications as a problem-solving process and examine their role in this process. Also, they will acquire the ability to review their implications critically and explain the frequently encountered problems rationally (Yıldırım & Şimşek, 2008).

Data collection

Multiple data gathering tools were used in the study. The reason for this was the effort to see through a supportive and integrated perspective. The data gathering tools which were used in the study were; semi-structured interviews, focus group interviews, written documents and video recordings.

The interviews were carried out with an interview form approach. Questions on the interview form were prepared by the researcher with reference to the literature (Kay & Knack, 2008; Domino, 2010; Marshall & Swan, 2005; Kamii, Lewis & Kirkland, 2001). The forms were examined by three different experts. The interviews forms were presented in the appendix. Intention of the first interviews before the training session was to define teachers' views on materials usage. Therefore, the teachers were asked eleven questions. The data gathered from these interviews were repeatedly read, coded and divided into themes by the researcher (Appendix B).

The researcher defined ten instructional designs related to these learning outcomes in accordance with the instructor's and mathematics teacher's opinions. The learning outcomes were based on Article 13 which stated the necessary points to consider while preparing a lesson plan in Instruction regarding Planned Practice of Education of the Ministry of National Education (2005). The participants were given the concrete manipulative materials below which were developed by prospective teachers within the scope of Special Teaching Methods class. In addition, the researcher prepared a number of worksheets using GeoGebra Software.

Figure1. Concrete manipulatives used in the study (wooden skewers, mode board, suction hook triangle plate).

All of the training in the study was carried out as a focus group interview. The interviews were video recorded. The focus group interviews used 5-question interviews form. However, beside the questions on the form there were attempts to go deeper with the occasional drill questions. The interview form is presented in the appendix (Appendix C).

Another data gathering tool on the study was the instructional designs of the teachers. These instructional designs were divided into two stages. These stages were 1) pre-training instructional designs and 2) post-training instructional designs.

One of the data gathering tools was video recording. These recordings included all the interviews and training. Consent of the participants was taken at the beginning of video recording. The recordings occurred in a way that would allow the participants and the researcher to be seen easily but not bother them.

Data Analysis

Video recordings gathered from the interviews and focus group interviews were transcribed. The researcher tried to reflect the pauses and moods of the participants (such as loud voice, laughing) as much as possible. The researcher presented these details in parentheses.

Written documents gathered from the interviews were put to content analysis by the researcher. Certain codes were defined and then these codes were transferred into themes. While defining codes and themes; open coding and axial coding, which are types of coding techniques of grounded theory.

Written document gathered from the teachers (instructional designs) were put to document analysis. The researcher digitized this data set according to certain categories from other data resources. Digitization process used "existent" or "non-existent" system. Thus, if the relevant category is present in a document, the value would be 1; while if no present, it would be 0 (Yıldırım & Şimşek, 2006). The categories of document analysis of the teachers' instructional designs were as follows:

(1) Is there concrete material in the instructional design?

(2) Is there virtual manipulative in the instructional design?

(3) Are the steps clear in the instructional design?

(4) Is there a Plan B in the instructional design (in case the students cannot learn)?

Validity and reliability

Persuasiveness in the present study was contacting the participants for ten weeks, various data (confirming the data via different data sources), and confirmation of interviews reports by the interviewees and evaluation of reports by two experts. The present study's transferability was elaborate explanation of the participants and study process and usage of purposeful sampling. The researcher gathered the data in similar processes. Additionally, consistency analysis was carried out through data coding and their relationships. With this purpose, the researcher described her role during the study. Additionally, data analysis process was explained elaborately and the data were coded twice.

Findings and Discussions

Five categories were defined in total from the interviews with the teachers regarding the study's first sub-problem. These categories were Material perception, Its place and importance in teaching, Not using/being able to use materials, The Place the material is used and The Priorities in Designing and Preparing Material. The axial coding regarding these categories and sub-categories are shared below:


Course participation (K4)
Permanence (K3)
Binary coding (K1)
Far from memorizing (K3)
Individual learning (K3, K4)
Concretisation (K2, K4, K5, K6)
Role and Importance of Education (K1, K2, K4, K5, K6)
Facilitating reminders (K1, K5)
The meaning of the course (K4, K5, K6)
Abstract (K4)
Visuality (K2, K3)
Problem solving (K4)
Difference and evaluation criteria (K1)
Attention (K4)
Student profile (K4)
Avoiding design (K4)
Time anxiety (K3)
Number of learning outcome (K1)
Designing by student level (K3, K4)
Meaningful learning–Questions solving dilemma (K2, K3, K7, K8,)
Exhausting (K2, K3)
Professional inadequacy (K2, K3, K5, K8)
Parents and school administrations find
(Can) Not Using Material (K1, K2, K3, K5, K6, K7, K8,)
Examination system (K1, K2, K5, K7, K8,)
Enforcement of the discipline of students (K5, K6)
Design challenge (K2, K5, K6)
Age (K1)
Exam (K3, K8)
Career routine and inertia (K2, K8)
Material perception (K8)
Deficiencies in using technology (K3)

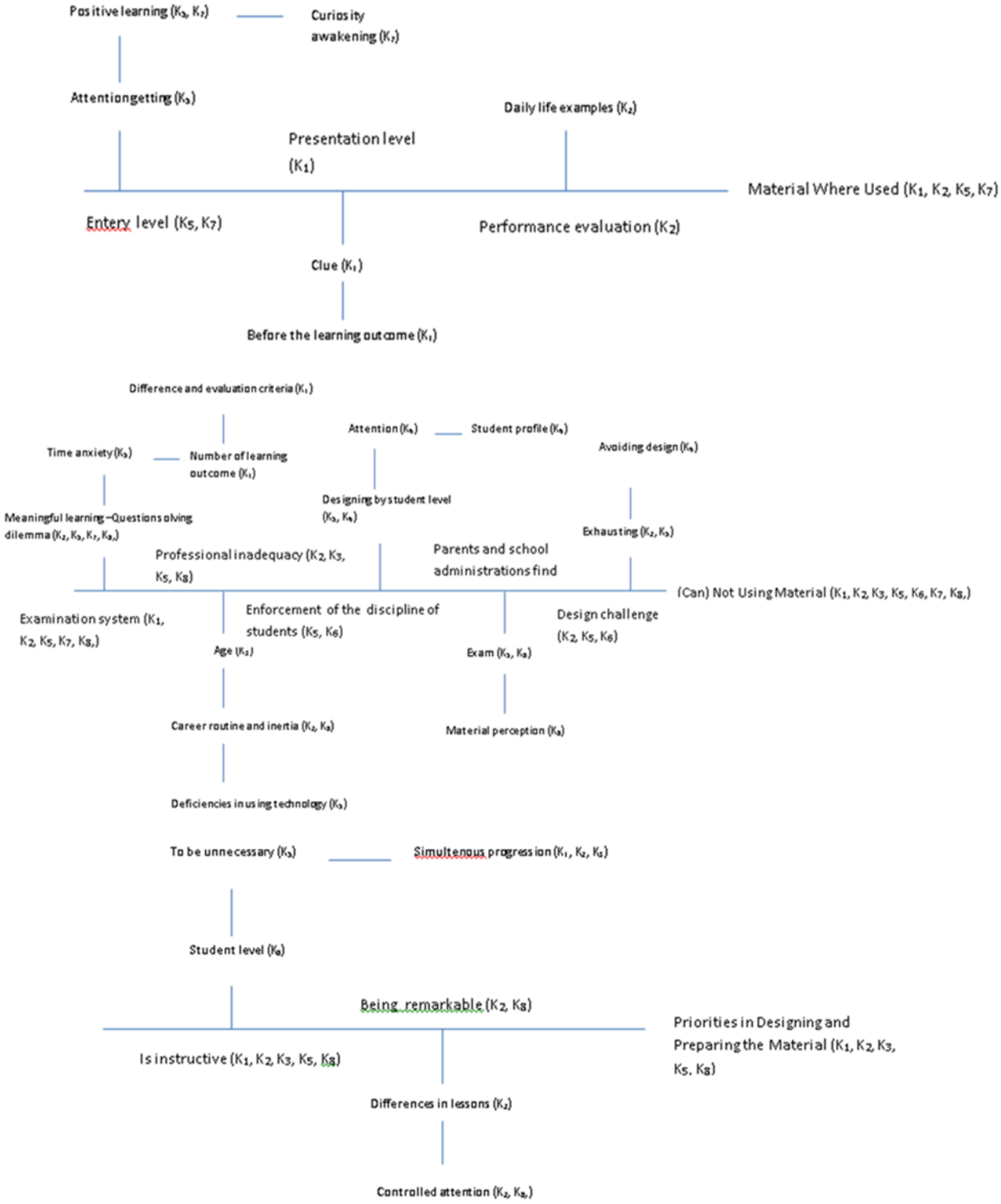


Figure2. Findings regarding the first sub-problem

The interviews revealed that the teachers confused the tools which are benefited from in materials design with the idea of how to put the material in teaching design. K3, one of the participants stated: "*I think material is a compass and a ruler. There are still students who can't use a compass or miter. These should be used in the classroom…*" With these statements, it is

clear that the participant cannot understand that teaching how to use teaching tools and the materials that are used in teaching the learning outcomes are different.

K1 mostly emphasized the importance of alternative materials which have simple designs and unique. In this context, K1 stated: "*Actually material is everything a teacher uses. For example, class notes or worksheets… But in general, big and special things are perceived as materials. In fact, everything in the classroom environment is a material. If the aim is to make the students understand, material is anything which is used to make it possible. For example, a piece of paper… I mean, like this… (Here s/he shows that the sum of the interior angles of a triangle is 180° with a triangle shaped paper). I don't know, anything that can clarify the subject. But I couldn't make it clear now… (laughs)*." On the other hand, an alternative material example could not be found from K1's pre-training teaching designs.

Preparation of teaching materials on a theoretical basis enables them to serve the purpose (Burak, 2018). If multiple environment appeals to multiple senses and contribute to the double coding of the content, it may help the individual to learn (Najjar, 1996). Double coding theory of Paivio suggests that stimulants are represented and coded verbally and visually in memory (Paivio, 1986). According to double coding theory, coding a notion in mind both verbally and visually increases the possibility to describe that notion visually and make verbal explanation of it when you encounter it again. Two of the participants stated that using materials in teaching design could be reconstructed even when students forget the notion. K1 explained this situation as: *"…When using materials, even if the student forgets the information, s/he can remember the material and find it herself/himself. I mean it is permanent. In this way, they can don't memorize…*"

A school administration or parents who view using materials in teaching designs as meaningless and a waste of time will demotivate the teacher in designing and using materials and cause the lessons to consist of only doing exercises. Regarding this issue, K8 stated: "*As students prepare for the exams, mathematics teachers implicitly have a mission of solving questions. When you talk about materials, others may think it is nonsense. Firstly the parents complain…*"

K7 stated that using relevant videos as introduction helped create a more sincere athmosphere and continued: *"…I usually make the students watch an interesting video about the topic. Also they get very happy. We get a more positive approach. Then I make them curious. Then I slowly move on to the lesson*." In general, participants took the responsibility to teach and did not create a teaching situation which would allow student to use the material themselves and build the information.

Although the participants had opinions of designing and preparing materials, they could not explain any materials they designed in their teaching designs in the light of these comments during these interviews.

The data from the written documents shows that the materials which the participants thought of using in their pre-training teaching designs were Manipulatives and Visuals. Th teachers were able to design only ten materials for all learning goals.Manipulatives consisted of sub-titles of Physical Manipulatives and Virtual Manipulatives. Additionally, the lack of a B plan in pre-training designs was evident.

Participants' materials using manipulatives in training sessions did not include a detailed planning regarding the aim, or stage of the material. As an example, teaching design of K3 is given below.

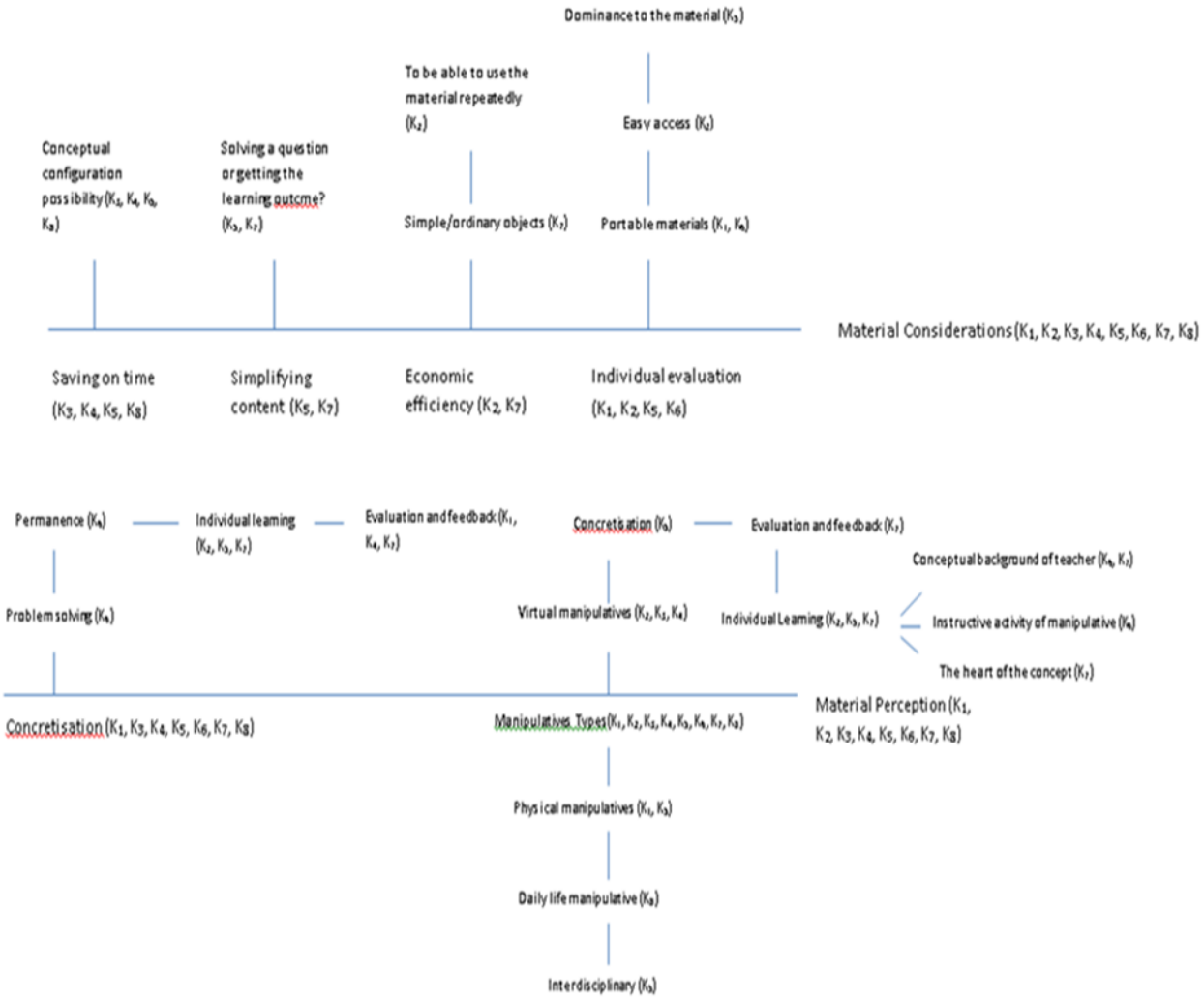
"*I enter the classroom. I show the students the floor of the classroom and ask them how it can be calculated. I teach the concept of circumference on the board. I ask them to calculate the approximate value of the floor. I pose the question "What is area?" After the students' feedbacks, I explain the concept. I explain the real life examples of the geometric objects I brought with me. I explain and calculate the area, volume and circumference of each material. Then I explain the difference between actual length and scale length.*"

Additionally, there was not a plan B in the case that students cannot achieve the learning outcomes or learn.

When the teaching designs were examined, it was clear that participants refrained from using computers and other educational technology and most of them were incompetent in using these technologies. K1, who learned how to use GeoGebra in higher education, could not present a construction protocol where the steps were clearly graded.

The basic matter in teaching designs should be to allow effective, deep and meaningful learning of students. In this regard, the participants' materials in pre- training designs could not go beyond visualizing or providing example. Besides, in the interviews with the participants, they stated that the teacher-centered materials (particularly virtual materials) benefitted teachers in terms of time, classroom management and helped them to teach more effectively. Teacher-centered materials are the ones which do not allow students to construct their own learning through trial-and-error. They can only reach conclusion via teacher's instructions. Teacher uses the materials and students passively observe it. All of the materials of the teachers were teacher-centered materials. Moreover, participants stated that students using those materials themselves was a waste of time, distraction and caused false or deficient learning.

Regarding the third sub-problem of the study, five categories were defined. These categories were; Material perception, Assessment of material, Plan B-Assessment of teaching design, (in)ability to use materials and personal assessments. Axial coding regarding these categories and sub-categories are given below:


Dominance to the material (K9)
To be able to use the material repeatedly (K2)
Easy access (K8)
Conceptual configuration possibility (K1, K4, K6, K8)
Solving a question or getting the learning outcome? (K3, K7)
Simple/ordinary objects (K7)
Portable materials (K1, K8)
Material Considerations (K1, K2, K3, K4, K5, K6, K7, K8)
Saving on time (K3, K4, K5, K8)
Simplifying content (K5, K7)
Economic efficiency (K2, K7)
Individual evaluation (K1, K2, K5, K6)
Permanence (K4)
Individual learning (K2, K3, K7)
Evaluation and feedback (K1, K4, K7)
Concretisation (K6)
Evaluation and feedback (K7)
Conceptual background of teacher (K4, K7)
Problem solving (K4)
Virtual manipulatives (K2, K3, K4)
Individual Learning (K2, K3, K7)
Instructive activity of manipulative (K4)
The heart of the concept (K7)
Concretisation (K1, K3, K4, K5, K6, K7, K8)
Manipulatives Types (K1, K2, K3, K4, K5, K6, K7, K8)
Material Perception (K1, K2, K3, K4, K5, K6, K7, K8)
Physical manipulatives (K1, K3)
Daily life manipulative (K8)
Interdisciplinary (K9)

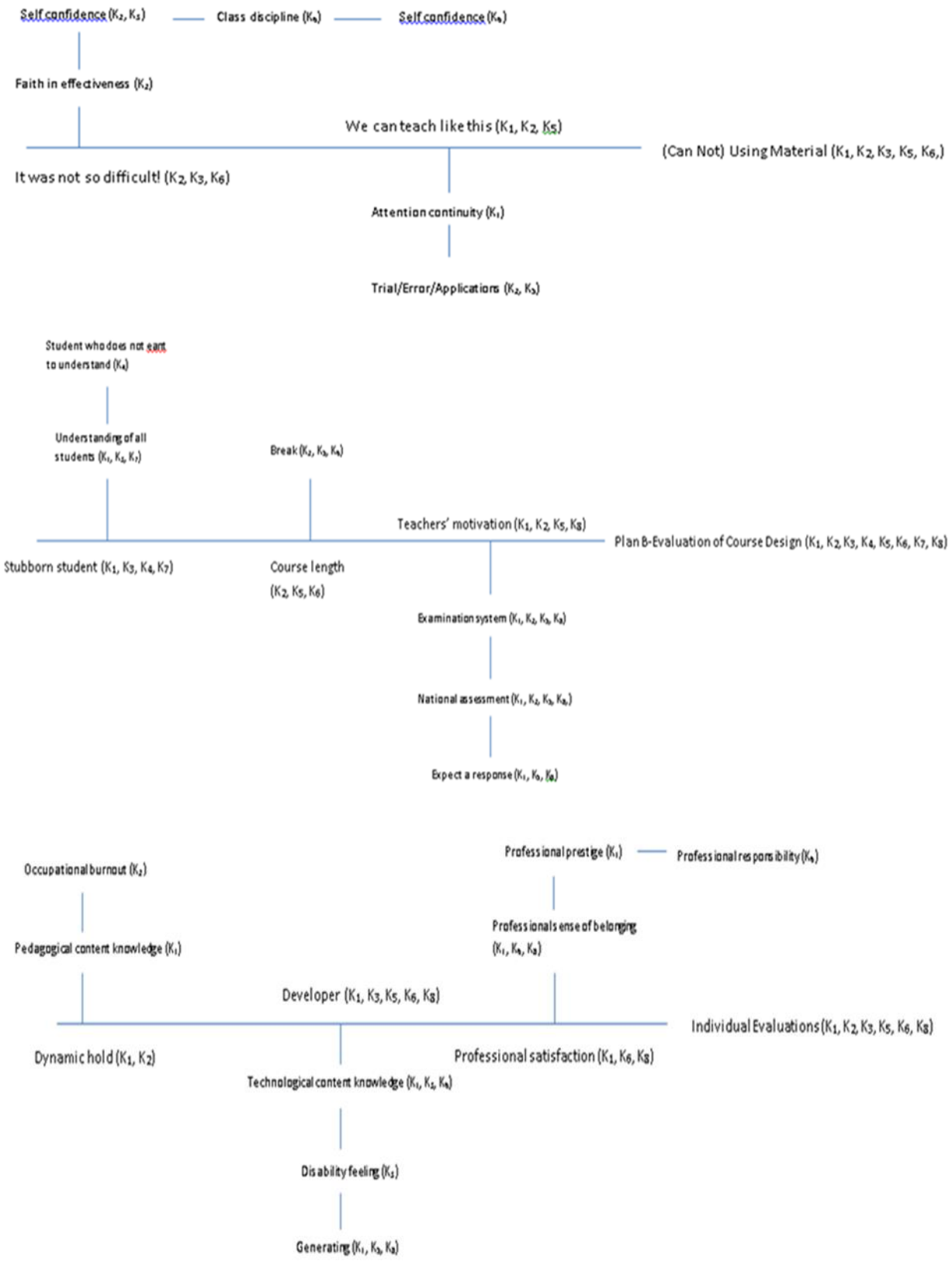


Figure3. Findings regarding the second sub-problem

K7 who emphasized the importance of highlighting the steps of the information that will be learned stated *"...Materials should be designed this way (median material. Actually, I don't*

know how to put it, (ummm) the closer a material is to the heart of a notion, the easier to use it. Because you can see the notion on the material, I mean those steps… Students should not why they take certain steps and construct. In this way, we can prevent them from walking away from the topic…"

Participants who have examined the materials in teaching designs stated that in these materials, students carried out their learning responsibility by sharing it with the teacher and that this situation differed from the participants' existing material approach. The reflection of awareness is evident in the pre and post training materials.

The participants' statements and teaching designs were examined in general, there are significant differences in their material perceptions; materials categorization, design, preparation and use compared to pre-training. They can now comment on material approach. They can categorize the materials in teaching, assess and criticize the materials they prepare.

K5 who stated there should be emphasis on usefulness in materials design and preparation continued *"…It can be difficult to use these kinds of materials (modular arithmetic board), because your hand can slip or something. But you showed it on median in the second or third lesson. It was good. Then, the sticks were good. I mean, good as in it was clearly set. I mean, it won't go wrong in that minute. Okay, mode was also good. You used it well but I tried. I couldn't manage it as well as you did, for example. I think children can also fail if they tried…*" K5 stated in the detailed interview "*I understood what designing materials is with this training. I mean, it's not like I didn't know anything before that, but…(laughs) What they can use, to what extent? I don't know, where they would have problems? I mean, where is it in the learning outcome, I will highlight it. I didn't know these before. Probably others didn't know either. I am overcome by the urge to teach (laughs)…*" and emphasized the importance of materials in teaching design.

Considering the focus group interviews of the participants and their comments in detailed interviews, they commented constructively, within the scope of material approach, objectively genuinely on the materials used by the researchers in training. This is a considerable change of people who previously had limited assessments regarding materials.

Taking into account that materials facilitates students' learning process, it will be more likely for all or most of the students to learn if they involve in various materials. Whereas, K4 who states that there is a student group who refuses to learn, continues "*It doesn't matter how you teach to a student who doesn't want to understand, s/he will not understand. I think Plan B is unnecessary. You can teach from another angle on the same thing.*"

K6, who thought that materials using in learning-teaching environments will make classroom management more difficult states her/his awareness by saying "*I think all of us love our students very much and that we are very good at mathematics. I mean according to our students… But only loving and being good at mathematics is not enough, unfortunately. How we transfer that information is also very important. You made a presentation, at first. I mean, life environment, receiver language etc… Like system approach. I probably learned it at my undergraduate program but I don't remember it. Why? Because I didn't get any deep understanding on this topic. I mean, it is about how important it is… The deeper and more various the experiences, the more meaningful the learning… But how were we taught about this? Give example from around you and enrich it with concrete objects. But how? I started teaching. I tried to do it the first time. The result was a disappointment. Why? There was not classroom discipline. I don't*

even know why I did what in the design. I mean, there are no steps, to put it your way… (all the participants supports with agreeing mimics)But on a worksheet like this (similarity exercise) with steps suitable for concrete material, why would the student get distracted? Children also want to understand. But as they don't understand, they start to develop prejudice. We also develop them. We suffocate them with our love and knowledge. Our love and knowledge that should be useful cannot go beyond 'Look, also learn this type of questions' unfortunately…"
K1 who stated that using teaching designs effectively in education environments will change prejudice of both the teachers against their own job and students against their teachers said that training influenced her/him positively with these remarks, *"…I felt special about myself and my job in this process. Students will also respect more because we will make an unclear lesson clear. I think I will be happier then…*" K6 who questioned existing teachings because of the training s/he received stated that s/he was in a stage of having aims for the job by saying "*I started to like making plans. Now I worry about my own lessons (laughs). I mean, it is a little unfair for the children. I started to question myself, what else can I add? My spouse makes fun of me. S/he says that I am not a crazy mathematician (laughs)…*"

When the written documents are examined in detail, it is clear that the participants were more productive at material amount, dividing the teaching design into steps and including a plan B than their first teaching designs. Moreover, the participants used more and various materials. Besides K1's remarks stating "*I look at the one I designed previously and then I look at the latter (Laughs)… Design was hallow in the first one. I mean, ordinary…But the second one… I mean after you… It applies for others too, it seems (they laugh)… Seriously, I designed with a concern to teach. And with that, you aim to teach in those materials. What can I present at what stage, what can I do if they don't understand, etc. It is a good thing. You don't say I showed it and it just happened…*" show that the participants aimed to present a rich teaching content in materials in post-training.
Designs were divided into two main categories of "Manipulatives and Written Materials." Under these titles are;

(1) Manipulatives
(a) Physical manipulatives
(b) Virtual manipulatives
(2) Written Materials

K2 who emphasized the importance of using concrete materials in teaching environments stated "*When the student try it in her/his hand, discuss with the steps in the worksheet, of course s/he will understand better because s/he will construct modular arithmetic. I designed this material in such a way that you can construct it even if you don't know any rules. If you want to solve a watch problem or sum, do it. Students will produce the practice, let them do mathematics in the lesson…*"

Figure4. Concrete manipulative designed by K2 regarding modular arithmetic

The participants benefitted more from virtual manipulatives in post-training when compared to pre-training. However this was still inadequate, considering the recent support and importance in the Fatih Project. Participants were unwilling to use virtual manipulatives. K7 explains this situations by stating "*We have never used it until now. Smartboards came to the class. Okay… tablets programs, all of them are okay. Maybe some our friends have seen it at their undergraduate program but most of us either don't know at all or forgot… At first, we should be taught about the program. We need to practice. How can we do it all of a sudden by ourselves? We criticized Fatih Project. I mean, if it is applied like this, of course it is acceptable… (I'm not sure) if it is meaningful…*"

Whereas K2, K4 and K6's first teaching designs did not include virtual manipulatives, they chose to use these types of materials in their post-training teaching designs. Besides, they followed a staged pattern regarding the use of the manipulatives in their teaching designs.

Conclusions and Suggestions

Teaching materials are not just tools such as pencil, paper, class notes, compass, ruler, etc; a more complex design which are obtained by putting an educational responsibility in these tools (McNeil and Uttal, 2009). While the importance of this situation is known, the concepts of teaching material and tools were not clear for the participants and they used them interchangeably.

When the participants' pre-training teaching designs were examined, it was seen that they included very few materials. As the cause of this situation the participants claimed that they found materials design very challenging, classroom management issues might raise, technological deficiencies and inadequacy regarding materials design/preparation/usage/assessment.

Results revealed that the participants' opinions on not using / not being able to use materials in pre-training were changed in to using / being able to use materials in post-training. In other words, the participants stated that they would use materials more frequently after training. Additionally, they were more confident in materials design and using digital materials.

The pre-training interviews and findings of post-training teaching design show that some of the participants did not interact with software related to teaching and some others applied at their undergraduate program but they did/could not include it in their teaching, and even if they did, they used it to visualize. During and in post-training, the participants could use the software

called GeoGebra which was introduced by the researchers and included the accessible applications in their teaching designs. The participants explained this situation with inadequate usage of the smartboards and tablets in Fatih Project. This situations shows the necessity that it should be based on application in the existing teacher training programs and in-service teachers should be supported with in-service training according to developing and changing technology. The participants stated that material usage in teaching will positively affect learning in pre-training. However they experienced inadequacy and avoidance in the process of designing, preparing and using materials. Regarding this issue, it possibly stems from the fact that teachers' level of knowledge on materials usage in teaching is limited to their undergraduate program. This situation causes the teachers to lose the basis, instead of updating it because of them not being able to integrate theoretical knowledge into teaching environments.

Materials of the participants in pre-training were familiar to them from their undergraduate programs. So, it is possible that teacher candidates were not exposed to as many concrete materials and virtual manipulative as possible in the teacher training program.

Teacher candidates need to practice how teaching materials in teaching designs are used. During the study, it was seen that the participants could not arrange how to include concrete materials and virtual manipulatives in teaching designs. In this regard, it is possible that Teaching Technology, Materials Design and Methods of Teaching courses at teacher training programs had deficiencies in teaching and experiencing how to integrate materials into teaching.

The participants included concrete materials more than virtual manipulatives in both pre and post training. The participants stated that they felt inadequate in using virtual manipulatives in the interviews. This situation shows that teacher training programs and in-service training are insufficient at virtual manipulative usage and its integration into teaching design.

The participants who included materials in pre-training included only a teacher-centered, better presentation of the topic instead of allowing students to think and apply. In post-training teaching designs, they were able to integrate the material into teaching design and allow students to try. In this regard, teacher training programs may have deficiencies in providing the teacher candidates with a purpose to use the material.

Ortaöğretim Matematik Öğretmenlerinin Öğretim Materyalleri Hakkindaki Anlayişlari Ve Ürettikleri Materyaller

Özet:

Araştırmanın amacı; matematik öğretmenlerinin öğretim tasarımı sürecinde materyal kullanımlarının incelenmesidir. Eylem araştırmasının nitel paradigmasıyla gerçekleştirilen araştırma, Milli Eğitim Bakanlığı bünyesinde görev yapmakta olan sekiz öğretmenin katıldığı bir eğitim sürecinde gerçekleştirilmiştir. Katılımcılar ile birlikte toplam onbir oturum gerçekleştirilmiş olup veriler yarı-yapılandırılmış görüşmeler, yazılı dokümanlar, video kayıtları ve odak grup görüşmeleri ile toplanmıştır. Veriler içerik analizi ve sürekli karşılaştırmalı analiz yoluyla analiz edilmiştir. Araştırmanın sonucunda; katılımcıların eğitim öncesi öğretim tasarımlarında yer verdikleri materyallerin öğretmen kullanımına açık, öğrencinin yalnızca izleyebildiği yapıda olduğu görülürken; eğitim sonrasında öğrencinin yaparak-yaşayarak deneyimleyebileceği, öğretmenin sadece rehber olduğu materyallere yer verdikleri görülmektedir.

Anahtar kelimeler: öğretmen eğitimi, öğretim tasarımı, manipülatif, sanal materyal.

Acknowledgements

This article was produced from the doctoral dissertation named "Perceptions of secondary school mathematics teachers on teaching materials and examining the materials which they designed.", which was presented in the Department of Mathematics Education, Gazi University, Institute of Educational Sciences.

References

Abrami, P. 2001. Improving judgements about teaching effectiveness using teacher rating forms. *New Directions for Instutional Research*, *109*(1), 59-87. https://www.researchgate.net/publication/227630023_Improving_Judgments_About_Teaching_Effectiveness_Using_Teacher_Rating_Forms

Bellinio, J. (2012). *Multi-Sensory Manipulatives in Mathematics: Linking the Abstract to the Concrete*. Yale-New Haven Teachers Institute. http://www.yale.edu/ynhti/curriculum/units/2001/6/01.06.12.x.html (15.02.2016)

Boggan, M., Harper, S, & Whitmire, A. (2010). Using manipulatives to teach elementary mathematics. *Journal of Instructional Pedagogies*, *3*(1), 1-6. https://eric.ed.gov/?id=EJ1096945

Bozkurt, A., &Akalın, S. (2010). Matematik öğretiminde materyal geliştirmenin ve kullanımının yeri, önemi ve bu konuda öğretmenin rolü [The place and importance of material development and usage in mathematics teaching and the role of teacher in this subject]. *Dumlupınar University The Journal of Education Faculty, 27*(1), 556-558. https://dergipark.org.tr/download/article-file/55618

Cope, L. (2015). Math manipulatives: Making the abstract tangible. *Delta Journal of Education*, *5*(1), 10-19. https://www.semanticscholar.org/paper/Math-Manipulatives%3A-Making-the-Abstract-Tangible-Cope/7ea0bc8c432cea6a5b0411c3148da1e9a329bfdd

Cummings, T., & Worley, C. (1997). *Organization development and change*. Cincinnati: South-Western College.

Dennis, R. (2011). *The effects of the use of manipulatives on the comprehension of math concepts among fifth-grade students*. http://search.proquest.com/docview/915645190?accountid=14771

Domino, J. (2010). *The effects of physical manipulatives on achievement mathematics in grades K-6: a meta-analysis*. Doctoral Thesis, State University of New York: Departmente of Learning anda Instruction Faculty of the Graduate School of the University Buffalo, New York. https://eric.ed.gov/?id=ED522615

Haara, F. (2010). *Unveiling teachers' reasons for choosing practical activities in mathematics teaching*. Doctoral Thesis, University of Bergen, Norway. https://pdfs.semanticscholar.org/5495/969ba63cc03cf5b5f22f0b8759305f6b1547.pdf

Hartshorn, R., & Boren, S. (1990). *Experiential learning of mathematics: Using manipulatives*. ERIC Publications, ERIC Digests. https://eric.ed.gov/?id=ED321967

Huentick, L., & Munshin, S. (2004). *Teaching mathematics for the 21st century methods and activities for grades 6-12*. USA: Pearson and Merril Prentice.

Holmes, A. (2013). Effects of manipulative use on PK-12 mathematics achievement: A meta-analysis. Poster presented at the meeting of *Society for Research in Educational Effectiveness*, Washington, DC.

İnan, C. (2013). Influence of the Constructivist Learning Approach on Students' Levels of Learning Trigonometry and on Their Attitudes towards Mathematics. *Hacettepe University Journal of Eduction Faculty, 28* (3), 219-234. http://www.efdergi.hacettepe.edu.tr/yonetim/icerik/makaleler/219-published.pdf

Kamii, C, Lewis, B., & Kirkland, L. (2001). Manipulatives: When are they useful?. *Journal of Mathematical Behaviour, 20*, 21-31. https://www.sciencedirect.com/science/article/pii/S0732312301000591

Kelly, Ce. (2006). Using manipulatives in mathematical problem solving: A performance-based analysis. *The Mathematics Enthusiast, 13*(2), 184. https://scholarworks.umt.edu/tme/vol3/iss2/6/

Laski, E., Jor'dan, J., Daoust, C., & Murray, A. (2015). *What makes mathematics manipulatives effective? Lessons from cognitive science and montessori education*. SAGE Open, 1-8. http://dx.doi.org/10.1177/2158244015589588

Marshall, L., & Swan, P. (2005). *Developing mathematical thinking with the assistance of manipulatives*. The Mathematics Education into the 21st Century Project. http://www.mathnet.ru/php/conference.phtml?confid=43&option_lang=eng

McClung, L. (1998). *A study on the use of manipulatives and their effect on student achievement in a high school algebra class*. Salem-Teikyo University. https://eric.ed.gov/?id=ED425077

McIntosh, G. (2012). *Testing instrumentation validity for measuring teachers' attitudes toward manipulative use in the elementary classroom. University of Pittsburgh*. http://search.proquest.com/docview/1312423428?accountid=14771

McNeil, N., & Uttal, D. (2009). Rethinking the Use of Concrete Materials in Learning: Perspectives From Development and Education. *Child Development Perspectives, 3*(3), 137-139. https://onlinelibrary.wiley.com/doi/full/10.1111/j.1750-8606.2009.00093.x

The Ministry of National Education. (2008). *Öğretmen yeterlilikleri [Teacher qualifications]*. Ankara: Devlet Kitapları Müdürlüğü.

Moyer, P. (2001). Are we having fun yet? How teachers use manipülatives to teach mathematics. *Educational Studies in Mathematics, 47*(1), 175-197. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1054&context=teal_facpub

Munger, D. (2007). *Science blogs. Children learn and retain math better using manipülatives*. scienceblogs.com/cognitivedaily/2007/10/09/children-learn-and-retain-math/

Moyer, P., Bolyard, J., & Spikell, M. (2002). What are virtual manipulatives?. *Teaching Children Mathematics, 8*(6), 372-377. https://www.researchgate.net/publication/43952500_What_are_Virtual_Manipulatives

Ojose, B., & Sexton, L. (2009). The effect of manipulative materials on mathematics achievement of first grade students. *The Mathematics Educator, 12*(1), 3-14. https://www.researchgate.net/publication/265939371_The_Effect_of_Manipulative_Materials_on_Mathematics_Achievement_of_First_Grade_Students

Patton, M. (1987). *How to use qualitative methods in evaluation*. Newbury Park, CA: Sage.

Perry, B., & Howard, P. (1994). *Manipulatives: constraints on ınstruction*. https://www2.merga.net.au/documents/RP_Perry_Howard_1994.pdf

Shaw, J. (2016, 11 17). *Manipulatives enhace the learning of mathematics*. Education Place. http://www.eduplace.com/state/author/shaw.pdf.

Thompson, P. (1992). Notations, conventions, and constraints: Contributions to effective uses of concrete materials in elementary mathematics. *Journal for Research in Mathematics Education, 23*(2), 123-147. http://dx.doi.org/10.2307/749497

Thompson, P.. (1994). Concrete materials and teaching for mathematical understanding. *Arithmetic Teacher, 41*(9), 556-558. https://www.researchgate.net/publication/264119418_Concrete_materials_and_teaching_for_mathematical_understanding

White, K. (2012). *The effect of an instructional model utilizing hands-on learning and manipulatives on math achievement of middle school students in Georgia*. Lynchburg, Virginia: Liberty University, Lynchburg, VA.

Yalın, H. (2015). *Öğretim teknolojileri ve materyal geliştirme [Instructional technologies and material development]*. Ankara: Nobel.

Yıldırım, A., & Şimşek, H. (2006). *Sosyal bilimlerde nitel araştırma yöntemleri [Qualitative research methods in the social sciences]*. Ankara: Seçkin.

Appendix

Appendix A. Semi-structured Interview Form to Identify the Problem Case

Hello,

As part of my research, we are planning to conduct a study on our teachers' approach, usage, ability to design, prepare, develop and present materials. At this point, assessments which we will carry out with you are quite important to reveal the problem case clearly. The interview will be solely used for scientific purposes and recorded with assurance that it will not be shared anywhere else. If you consent to it, we can begin.

(1) Can you describe materials?

(2) What is the place of materials in mathematics education?

- If there should be materials, explain why.
- If there should not be materials, explain why.

(3) Do you use materials in your teaching?

- If you use them; for what purpose, what type of materials and how often do you use them?
- If you do not; why not?

(4) Can you make an evaluation of materials usage in our country's mathematics education?

Thank you.

Appendix B. Interview Form

Hello,

Dear teachers, as part of my research, your opinions on materials and materials in mathematics teaching are of great value to me. Therefore, this interview will be solely used for scientific purposes and recorded with assurance that it will not be shared anywhere else. If you consent to this, we can begin our interview.

(1) What does materials usage mean to you?

(2) What are your opinions on materials usage in educational environment?

(3) What re your views on materials usage in mathematics teaching?

(4) Do you use materials in your lesson designs? If you do/ do not, why/ why not?

(5) What is the number of materials you used in a teaching design?

(6) What type of materials do you use?

(7) Is there a material that is unique to you?

(8) What are the steps you follow in designing a material?

(9) What are the things you pay attention to while designing a material?

(10) When do you use the material in your teaching design?

(11) What do you do when you cannot achieve your goal with the material?

Appendix C: Focus Group Interview Form

(1) How do you design your teaching for this learning outcome? Explain.

(2) What do you think about this design? Share.

(3) What are your views on the materials in the design? Explain.

(4) How do you assess this material from a student's point of view? Explain.

(5) How do you assess this design from a teacher's point of view? Explain.