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Implementation of Middle School Mathematics Teachers' Origami-based Lessons and Their Views about Student Learning

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In the case study, the occurrence of student learning types in the origami-based mathematics classrooms was investigated based on teachers' teaching. The study was performed in two stages. In the quantitative part of the study, the teaching of middle school mathematics teachers was observed to compare the different learning types based on their levels of constructivist-based teaching performances. Then, the stage was performed as qualitative part of the study. Qualitative data were collected through interviews, observations, and field notes in origami-based mathematics lessons and then analyzed. The participants' performances separated into three levels were analyzed and reported with the help of qualitative data. The findings of the study illustrated that the existence of learning types represented by students in the origami-based lessons differentiated based on the teachers' levels of constructivist-based teaching. In other words, it was observed that the middle school mathematics teachers illustrated different student learning types based on different level of performances about origami-based mathematics lessons. Hence, it can be stated that when origami takes place in mathematics lessons, student learning and use of origami effectively is directly related to the teachers. .

Key Words *constructivist-based teaching, learning types, middle school mathematics teachers, origami.*

INTRODUCTION

Teachers are common factors taking important role in student learning (Darling-Hammond, 1998). The answers of the questions of what teachers do and know are important to be examined since they have the impact on what is done and what students learn in the classroom (Fennema & Franke, 1992; Turner-Bisset, 2001). Moreover, teachers have essential role in making connection between learners and curriculum (Graham & Fennell, 2001). In the constructivist approach as the recently used learning philosophy in curriculum with the property of "knowledge is not transmitted directly from one knower to another, but is actively built up by the learner" (Sawada, Piburn, Turley, Falconer, Benford, Bloom, & Judson, 2000, p.3), the teachers are expected to perform constructivist-based teaching. In other words, they are responsible for providing learning environments making their students actively construct their understanding and knowledge. By constructivist-based teaching, the teachers perform teaching in the lessons by encouraging student reasoning, problem solving, students' active engagement, high level of student motivation, interaction, communication and using materials (Brooks & Brooks, 1993). In this

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process, they can also benefit from multiple representations including materials. However, the benefits of materials used in lessons depend on teachers' performance (Davis & Krajcik, 2005). In this respect, origami can be used as a kind of beneficial material and strategy taking place in mathematics lessons and, encouraging student learning but effectively usage of origami can be useful in case of teachers' usage them effectively.

When teachers watch children playing with materials, tools, drawing pictures and producing something related to lessons, children's works become meaningful, and special for them (Christie, 1990). Children play an active role about engaging in this kind of activities. They do not only create something such as art but also make sense of complex worlds, communicate and explain their ideas and feelings (Key & Stillman, 2009). In this respect, origami is important since it provides students opportunities to create arts and share their ideas with other people. It is also one of the most accessible arts since people require a piece of paper in order to make it (Wu, 2002). Origami can be defined as Japanese arts of folding paper into shapes representing objects. It can also be explained as form of visual or sculptural representation (Wu, 1999) and used to create two- or three-dimensional figures. Hence, it has benefits on mathematics, engineering, astronomy, manufacturing, robotics and biology (Cipra, 2001; Demaine, 2004). For example, it has been used in order to form folding pattern for a space-based telescope and airbags in automotive industry (Cipra, 2001), and design map and atlas (Miura, 2001) and a rigid robust pot (Nagashima, Ohara & Okumura, 2001). In light of the examples for the use of origami, Lang (2001) explained "some inhabitants of the boundary between origami art and science have used the techniques of origami to solve real-world structural or design problems" (p. 119).

Origami has useful roles in education since it can be used beneficially as an instructional tool in education by many ways (Boakes, 2008; Chen, 2006; Coad, 2006; Sze, 2005). Origami as a kind of tool or manipulative may enhance mathematical understanding, reasoning and transition from empirical thinking to more abstract thinking (Arıcı & Aslan-Tutak, 2015; Jones, 2010). Moreover, in origami activities, students are expected to use their brains rather than their hands (Chen, 2006; Levenson, 2005; Sze, 2005). Hence, they can take active roles in learning process physically and mentally. With this motivation, there have been lessons produced to combine mathematics with origami. They are named as origami-based mathematics lessons; that is, "teaching using an origami activity linking students' knowledge and skill during the folding process and with the resultant origami figure" (Boakes, 2006, p.32). They also offer many opportunities such as behavioral and socio-emotional gains, mental development and mathematical skills for students (Tugrul & Kavici, 2002; Valentini, 2005). Many research in the literature explain that these lessons encourage hands-on learning, following regular instructions, schema construction, spatial thinking, relational understanding, producing argument and concept mapping (Gay, 2000; Olkun, 2003; Sze, 2005). Lessons are organized and topics are taught with the help of real life examples in the curriculum prepared based on constructivist approach, the recent philosophy of the last curriculum. Therefore, origami-based mathematics lessons can provide opportunities by their effects on development of student learning, and being in relation to real life as it has been explained in many research in the literature (Boakes, 2009). Moreover, it can be stated that teachers have important role on student learning (Khoh, 2006) and quality of enacting the lessons since teachers can help learners acquire the needs and tasks on curriculum (Graham & Fennell, 2001). Through teaching process, they are responsible for making guidance to the students about how to learn, study, organize and construct their knowledge. Moreover, in the literature, although there have been many researches about origami and teaching (Boakes, 2009; Mastin, 2007), there have still been need to examine the impacts and connection of these terms. Therefore, the purpose of this study was to examine the effect of teachers as a factor impacting student learning, about the quality of origami-based mathematics lessons. Also, the effect of mathematics teaching quality of origami-based mathematics

lessons on student learning was explored. In other words, it was aimed to answer the following questions;

1. How did the middle school mathematics teachers' (MSMT) views about student-learning outcomes in origami-mathematics lessons differentiate based on their constructivist-based teaching levels?
2. Which kinds of learning types of learning model of origami did MSMT use in their origami-based mathematics lessons with respect to their constructivist-based teaching levels?

METHOD

Research Design

The method of the case study includes systematically gathering satisfactory information related to a significant person, social environment, case, or group in order to understand effectively how it operates or functions. Also, Stake (1995) defined the case study as "the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (p. 6). Specifically, multiple-case study as a kind of case study, was employed in this study since it helps researchers attain better understanding about a broader context from multiple cases (Berg, 2001). Multiple or collective case study means that the researcher may jointly study several cases with the aim of the investigation of a phenomenon or context (Stake, 1995).

Participants

The participants of the current study was selected based on criterion sampling strategy. The criterion was to be familiar with origami and how to use origami in the lessons. Based on these criteria, 20 volunteered participants who were middle school mathematics teachers in public schools in Turkey took roles in the study. These participants were teachers in fifth, sixth, seventh and eighth grade levels in secondary schools. Also they were almost six-year-experienced teachers and they have been teachers for approximately four years in their schools in eastern part of Turkey. The mathematics teaching periods of these teachers were observed and scored. Then, 6 MSMT were selected among these 20 middle school mathematics teachers (MSMT) with respect to their constructivist-based teaching levels to be observed and interviewed with the aim of examining the learning types taking place in their origami-based mathematics lessons. In other words, 6 of them were selected by criterion purposive sampling strategy among 20 MSMT. The criterion for sampling was being one of low, medium or high groups formed based on the scores about the teachers' constructivist-based teaching. The scores of 20 MSMT were separated into three categories: low, medium and high. Their constructivist-based teaching levels were decided based on the score of mean (M= 3.38) and standard deviation (SD= 0,53) calculated using the scores acquired from the instrument of Reformed Teaching Observation Protocol. According to the descriptive analysis, approximately 68% of MSMT scored between "$M \pm 1SD$" and defined medium level of constructivist-based teaching practice, approximately 16 % behind "$M - 1SD$" as low level of constructivist-based teaching and approximately 16 % above "$M + 1SD$" as high level of constructivist-based teaching. Two teachers from each group among these three different constructivist-based teaching levels were purposefully selected as participants for the qualitative part of this study. Also, for each group, one male and one female participant were identified with the aim of removing the effect of gender so there were six participants in the case study. The participants were named with respect to their levels and gender as L_M, L_F, M_M, M_F, H_M and H_F.

Instruments

The instrument of the Reformed Teaching Observation Protocol (RTOP) was used for the observations and the purpose of selecting participants to be interviewed and observed in origami-based mathematics lessons. In the literature, it was used to guide the classroom observations with the aim of identifying

the level of implemented reform methods in mathematics lessons. Also, it was used as an appropriate instrument to evaluate preservice teachers' constructivist-based teaching. The instrument has both quantitative and qualitative parts. The RTOP is composed of three sections. The first section provides to collect data about basic background information on teacher and class. The information about teachers and class such as the name of teacher, his/her year of teaching, date and duration of observation, grade level, subject and location of class is collected in this part. The second section, qualitative part, investigates contextual background and activities. At this part, the observer takes notes and writes descriptions of events and time of them. These sections provided data for qualitative part of the current study. It guided to collect qualitative data in terms of dimensions of the instrument but not strictly. The last section, quantitative part includes 25 items with three main categories: lesson design and implementation, content and classroom culture. The first category is lesson design and implementation with 5 items (e.g., the lesson was designed to engage students as members of a learning community). The second category of content has 10 items and 2 sub-dimensions. The first sub-dimension is propositional knowledge with 5 items (e.g., the lesson involved fundamental concepts of subjects). The second sub-dimension of content is procedural knowledge with 5 items (e.g., intellectual rigor, constructive criticism, and challenging of ideas were valued). The last category is classroom culture with 10 items and 2 sub-dimensions. The first sub-dimension is communicative interactions with 5 items (e.g., there was a climate of respect for what others had to say). The last sub-dimension is student/teacher relationships with 5 items (e.g., the metaphor "teacher as listener" was very characteristic of this classroom). The translation and validation study of the instrument was investigated with the study of Temiz & Topcu (2014). The items are scored with a 5-point Likert scale; a score of "1" meant when the particular behavior was not observed and a score of "5" meant when the particular behavior was very descriptive for the individual being observed (Sawada et al., 2000). Translation, reverse translation and adaptation studies of the instrument were performed by two English instructors, Turkish language teacher and two assistant professors having educational background in mathematics and science education (Temiz & Topcu, 2014). The alpha reliability of the Turkish adapted form of the RTOP was calculated at 0.90 for the first, 0.86 for the second category and 0.91 for the last category representing satisfactory reliability of them and consistency with the previous research of validation of the RTOP (MacIsaac & Falconer, 2001; Sawada et al., 2000). Based on the findings, a reliable and valid instrument in order to analyze pre-service and in-service science and mathematics teachers' constructivist-based teaching was provided to the literature by Temiz and Topçu (2014). The usage of this instrument enhanced the selection of various classroom experiences of constructivist recently accepted educational approach of Turkey rather than general characteristics such as lesson closure (MacIsaac & Falconer, 2001).

The data collected through quantitative part of the RTOP was used in determining constructivist-based teaching levels of 20 MSMT and selecting 6 MSMT among them to analyze the origami-mathematics lessons effectively in detail. Also, in order to obtain detailed information about the origami-based mathematics lessons, second section of the RTOP, the qualitative part was used. In other words, the qualitative part of the RTOP was used in order to provide insight into 6 MSMT's origami-based mathematics lessons. The data about the description of the lessons observed, the seating arrangements, notes related to happenings in the classrooms were collected by the RTOP. Also, field notes about students' listening to the teacher and others, students' communication across the room to their friends and facial expressions of everybody in the class were formed. Then, a semi-structured interview protocol including five questions (see Appendix) was conducted to 6 MSMT to collect data about their views related to their teaching of origami-based mathematics lesson. The semi-structured interview protocol was developed in the consideration of origami, objectives of the lesson and the standards of the constructivist-based teaching by the researcher. Also, the participants were asked to explain

particular teaching events taking place in the process of the observations. Moreover, while collecting qualitative data, Sze's (2005, p.2) six-learning-type of learning model of origami was considered.

Data Collection

20 MSMT designed and implemented 40-minute mathematics lessons about a mathematical concept. Their teaching processes were assessed by using the quantitative part of the RTOP. These teachers were separated into three groups (low, medium and high) by the descriptive analysis of their RTOP scores. Then, one male and one female MSMT were selected from each of these three groups. After the completion of the participant selection process for the study, each case study participant (6 MSMT selected by the quantitative part of the RTOP) was contacted and a schedule for semi-structured interviews and observations was arranged. Each of these 6 participants designed origami-based mathematics lessons and implemented them in their classes in 40 minutes. The observation data were used considering the six-learning-type of learning model of origami in the process of the observations to provide insight to their teaching. Afterwards, they were conducted to semi-structured interview protocols. All interviews were audiotaped and all observations were videotaped in the present study and then, they were transcribed verbatim. Field notes were formed during and after each observation. With this motivation, the data from a variety of sources were collected in order to provide triangulation for the findings of the present study.

Data Analysis

Descriptive statistics were used in the process of selection of the case study participants (selection of 6 MSMT among 20 MSMT). Then, qualitative analysis was performed in order to search for meaning and understanding (Borg & Gall, 1989). Observation notes, field notes, and interview transcripts were compiled for within-case analysis and cross-case analysis. In this process, six steps suggested by Marshall and Rossman (1999) were considered to analyze qualitative data. These steps are organizing the data, coding the data, generating categories and themes, testing the emergent understandings as considering individual differences, searching for alternative explanations, and writing the report. In this study, the data were organized and analyzed by using Sze's (2005) six learning types of learning model of origami; hands-on learning, explicit instruction, higher order thinking, multimodal instruction, social learning and self-management-strategies as themes of the current study. Moreover, the elements of these learning types of this model were accepted as the codes of the study. The themes and the categories forming these themes are illustrated in Table 1. Then, they were compared with the present study's documents and confirmed or disconfirmed through triangulation with findings from the analysis of interviewees' responses, observation documents and field notes. Hence, emergent understandings based on individual differences were examined and identified. Afterwards, alternative explanations were examined using data collected through the classes of the MSMT representing different levels of constructivist-based teaching. In this process, deductive analysis technique was used since the categories and themes of the study were determined by the study of Sze (2005, p.2). Moreover, with-in and cross-case analysis were made because of the multiple case study design. In with-in analysis, each group of teachers' teaching practice and views were examined based on the research questions of the study. In cross-case analysis, the similarities and differences between each group of teachers were examined based on their teaching and views about origami-based mathematics lessons. Through data analysis process, it was observed that the most common theme was self-management. This theme with its categories took place in all cases since they were related to completion of the steps of making origami and producing a product with paper. On the other hand, the rarest themes with their categories observed in the lessons were hands-on-learning and higher order thinking. They took place in the classes of teachers having high level of constructivist-based teaching because their implementations of the lessons were student-centered and performed by including the categories of these themes. Then, all data from multiple sources were triangulated to ensure the trustworthiness of this study. This process

of analysis of the data provided a form of methodological triangulation to provide the validity of the analysis. In other words, the data were triangulated through the use of multiple types of the data (observations, interviews, field notes) by the researcher. Finally, the themes were used to answer the research questions of the study. In other words, they provided information about origami-based mathematics lessons and MSMT's constructivist-based teaching. Finally, all findings were reported using rich and thick data by direct quotations.

Table 1.
List of codes and themes based on Sze's learning types model of origami (Sze, 2005, p.2)

Themes	Codes
Hands-on learning	Concrete, manipulative, schema, scaffolding, open dialogue, deepen understanding, student-centered
Explicit instruction	Mastery, purposive, goal-directed, sequential teaching, error correction, repetitive, immediate feedback, outcome based
Higher-order thinking	Concept mapping, problem solving
Multimodal instruction	Kinesthetic, music, math, logic, intrapersonal, natural, spatial, visual
Social Learning	Ask for help, positive reinforcement, make meanings, global awareness, sense of belonging, sense of accomplishment
Self-management strategies	Discipline, self-control, observation skills, listening skills, attention skills, internal rewards

FINDINGS

In providing direct quotations, the letter of S refers to the statements of the students. Each lower case letter added to the letter of S represents different students.

The Case of Low Level Constructivist-based Teaching

L_M and L_F implemented origami-based mathematics lessons by guiding their students to make flapping bird and butterfly respectively.

L_M started the lesson informing the students about origami and flapping bird. Then, he gave a square piece of paper and told the instructions to the students and made the flapping bird with a piece of paper with the students. He made it using his hands by telling and performing instructions and then, the students followed him in a way like:

> "We fold the top corner of the paper down to the bottom corner, crease and open again and fold the paper in half sideways. Then, we turn the paper over to the opposite side, fold the paper in half, crease well and open, and then fold again in the other direction. Next, using the creases we have made, bring the top three corners of the model down to the bottom corner and flatten model. Thereafter, fold top triangular flaps into the center and unfold and fold top of model downwards, crease well and unfold…"

By following these steps, L_M and his students completed the steps of flapping bird by themselves without any discussion. The students only watched the teacher and talked with only him and did not communicate with their friends. In the process of forming the bird, the students carefully observed and listened to the teacher and paid attention on performing the instructions. In this traditional method used in the lesson, all students were controlled over with discipline. They were active in the consideration of physical movements but they were not challenged about mathematics in the instructions. There was not student-student communication in the lessons. They only followed the instructions and then, formed a

flapping bird with a piece of paper by themselves. In this type of teaching, the product and the result of instruction was flapping bird as the reward.

At the end of the lesson, a semi-structured interview protocol was conducted to L_M and he explained his views about his experience related to origami-based mathematics lesson and its effect on student learning.

> "I think origami is not an activity having positive effects on student learning. In my opinion, it is a game to spend spare time in the lessons. However, it is not a good game since it does not support any drill but it is funny and motivator for students to form an object. It helps me about supporting discipline in the lesson, and makes the students listen to me and be active participants in terms of physical improvement carefully. I do not think it supports student learning. Also, it is not beneficial to teach a concept related to mathematics."

The MSMT with low level of constructivist-based teaching could not use origami effectively since they could not make the connection between mathematical concept and origami. In other words, the teacher could not use origami to enhance students' mathematical understanding. He was also aware that it was not a beneficial lesson helping the students understand the objective of the lesson. He used origami as an ineffective game not supporting student communication, understanding and learning any concept but only listening and observing skills and physically active participation in lessons. In this case, it could be claimed that the lesson instructed by the teachers implementing the lesson with low level of constructivist-based teaching tended to improve only *self-management strategies* of their students. Moreover, the similar events were observed in the lesson of L_F and her students attained the same skills.

The Case of Medium Level Constructivist-based Teaching

M_M and M_F implemented origami-based mathematics lesson by guiding their students making crane and frog respectively.

M_F started the lesson informing the students about art and its importance on life and then, explained the origami and the crane. Next, he gave the students a square piece of paper and formed a communication with students as follows:

M_F. I have distributed you a piece of paper. What is the shape of this paper?

S_a. It is square in shape.

M_F. Why is it a square?

S_b. It has four equal angles.

S_c. It has four equal edges.

S_d. The angles between the edges are right.

S_e. So, the edges are parallel.

M_F. Ok.

…

After this communication, the teacher began instructions of origami. While explaining the instructions, she made it with a larger sized paper by using her hands and telling instructions and then, the students followed her.

> "We fold diagonally to form a triangle and please sure the points line up. Next, use your thumbnail to make all creases very sharp and unfold the paper. Then, now fold the paper diagonally in the opposite direction forming a new triangle. Thereafter, we

> unfold the paper, fold it in half to the right to form a tall triangle and unfold again. Afterwards, we fold the paper in half bringing the bottom up to the top, form a wide rectangle and unfold again. Then, we bring all four corners of the paper together one at a time…"

While explaining instructions, M_F explained origami instructions emphasizing mathematical terms such as diagonal, triangle, and rectangle. In this respect, this teacher could design the lesson to provide the learning type of self-management strategies. She asked the students the key questions helping them participate in the lesson actively by understanding. There are some examples of classroom interaction including some of these key questions below.

Example 1:

M_F. What about the folded lines, can you explain?

S_f. Yes, they are perpendicular lines.

M_F. Why are they perpendicular?

S_g. They meet at right angles.

…

Example 2:

M_F. What kinds of shapes are there?

S_h. There are right triangles and squares.

M_F. Can you say something about lines?

S_i. There are parallel lines such as opposite edges.

S_j. Also, I see perpendicular lines meeting at right angles.

…

At the end of the lesson, they made the crane using a piece of paper with the students. The lesson was student-centered and implemented based on constructivist approach. The lesson provided opportunities about drilling and repetition of the learned concepts. The students used the previous geometrical knowledge through making origami. Moreover, they were active physically and mentally in the process of the lesson. While they were following instructions and answering the questions, they improved the skills of listening, observing and self-control. Moreover, there existed student-student communication. They helped each other about following and completing steps properly, finding the shapes such as angles, squares and understanding the concepts. Furthermore, the teacher observed the students while they were performing instructions and explaining answers to the key questions. When they made errors, she corrected their errors and gave them immediate feedback. For example, some of them could not identify the parallel lines. The teacher made them criticize these lines by considering the properties of these lines. The teacher said and directed them to think about parallel lines by asking "Why are the line segments forming the edge of the square parallel?" In this respect, the teacher could provide the learning types of *explicit instruction, multimodal instruction, social learning* and *self-management strategies* in the lesson.

After the lesson had been completed, an interview was made by M_F and she explained her views depending on her experience in origami-based mathematics lesson and its effect on student learning.

> "I think origami can be used due to its positive effects on the lessons, concepts and student learning. I want to explain these effects by giving examples related to my

> lesson that you observed. It made the lesson funny and increase the motivation of the students. The students formed the objects such as crane that we did in the lesson. This process made the lesson funny and helped the students participate in the lesson actively. They also helped each other about following steps and understanding its connection with the geometry. Hence, there was an environment in which social learning occurred. Moreover, the lesson was student-centered. Origami was used as a learning tool and helped making connection with other concepts in geometry. I designed origami activity and used in the lesson so that we made drill and repetition about what we have learned related to geometry. Furthermore, in group discussions, I gave the feedback about their following steps and connecting the concepts in geometry. Also, it was beneficial in the term of multiple intelligence. Students were provided opportunities with respect to the intelligence types of visual, kinesthetic, intrapersonal and so on. In my opinion, origami is a beneficial tool to help students remember previous concepts and provide opportunities to make drill about them."

In this case, the MSMT with medium level of constructivist-based teaching could use origami with some beneficial effects on student learning. She stated that origami could be used because it helped the students remember the previous geometry concepts and make drill about them. In other words, she suggested using it at the end of the lesson after the period of teaching some geometry concepts had been completed. Moreover, she used origami as a drill supporting repetition activities spending enjoyable time. The interview results illustrated that learning types of *explicit instruction, multimodal instruction, social learning* and *self-management strategies* were observed in the lessons. Moreover, similar events were observed in the lessons of both teachers in this group and the students attained the same skills.

The Case of High Level Constructivist-based Teaching

H_M and H_F implemented origami-based mathematics lesson by guiding their students making cube and box respectively.

The teachers in this group started the lesson informing the students about art and its connection with real life and wanted their students explain examples about usages of the art in the real life. Then, the teachers explained origami and its history and again asked the students to tell the examples about where the origami could be used in the real life. Next, they gave the students a square piece of paper and formed communication similar to the dialogue happened at the beginning of the lessons of the MSMT with medium level of constructivist-based teaching. In other words, the teachers asked the students questions related to the square and its property. Afterwards, these teachers showed their students how to fold the papers and explained some typical origami folding strategies. While showing these actions, they asked some questions and helped their students make connection with other concepts such as geometry and fractions by reasoning. H_M folded the paper into two equal parts horizontally and then, he started the interaction with the students as follows:

Example 1:

H_M. What about the folded lines, can you explain?

S_a. Yes, they are parallel lines.

H_M. Why are they parallel?

S_b. Because they never move closer to each other;

S_c. Each of these lines are apart from next two lines in equal distances.

H_M. Is there anybody who wants to add something?

S_d. If the lines are in equal distances, the areas between the lines are equal.

H_M. Yes, you are right. Remember the contents that you learned in the previous lessons.

S_e. Can we say that the unit fraction of this paper is $\frac{1}{2}$?

H_M. Correct. Then, can you explain how we fold this paper to form an object whose unit fraction is $\frac{1}{4}$?

H_M. Consider the relationship between $\frac{1}{2}$ and $\frac{1}{4}$. (Teacher said this clue since no answer came from the students for the previous question.)

S_f. We can fold two folded parts of the paper into two equal parts again.

H_M. Correct.

…

After this communication, the teacher began to tell the instructions of origami. He followed the instructions to make a cube with a larger sized paper using his hands and telling the instructions and then, the students followed the instructions and observed him.

> "We fold a square sheet of paper at the diagonals and unfold it. Then, put the paper at both arrows together. Next, lay the triangles at the top and at the bottom on top of each other. Thereafter, fold upward the two corners on the right and on the left of the triangle to the top corner of it and we get two small triangles and one big triangle. Afterwards, have the top corners of the small triangles met and now we have hexagon…"

While explaining the instructions, H_M emphasized some mathematical terms such as diagonal, triangle, hexagon, rectangle, trapezoid and symmetry. He asked key questions helping the students participate in the lesson actively and understand the concept. For example, while following the instructions to make a cube, the teacher drew a figure attained through following the instructions and colored two triangular regions as in Figure 1. Then, the discussion was started by H_M as follows:

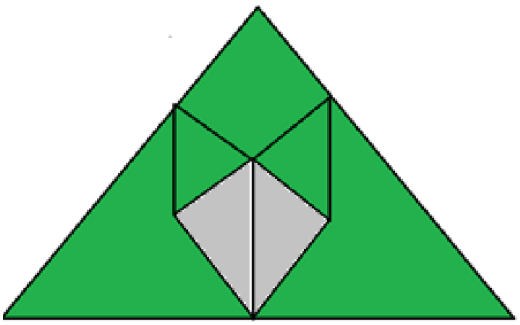

Figure 1. *Folded paper with two triangular regions*

Example 2:

H_M. Can you say something about this colored shape?

S_g. There are two congruent triangles.

S_h. There is a square with its diagonal from bottom corner to the top corner.

H_M. Anything else.

S_i. In the figure, the angle of the bottom corner is right. The line (white colored line in Figure 1) is the angle-bisector.

S_j. The angles at the bottom are complementary angles.

H_M. Correct.

…

After this communication, H_M and his students performed the remaining steps to form a cube and finished the steps. At the end of following process of instructions, all of them formed cube as a 3-dimensional object. The teacher encouraged his students to discuss the properties of a cube, and its general formula for area and volume. Then, the teacher wanted his students to color the surface area of the cube with a pen. Afterwards, he said them to take the cube apart and all of them formed an object as illustrated in Figure 2 and the discussion took place as follows:

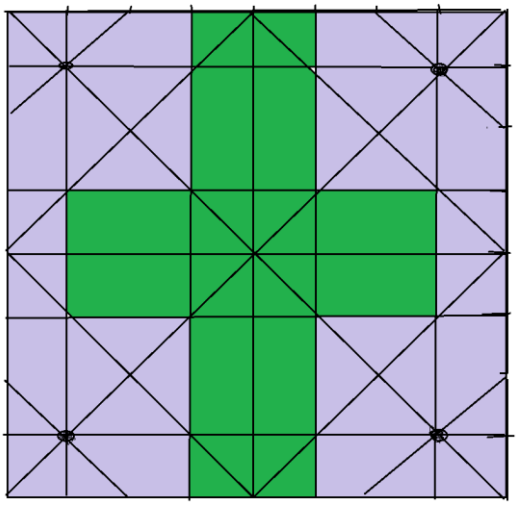

Figure 2. *Unfolded form of the paper used to make the cube*

Example3.

H_M. Can you say anything about the shape that you get?

S_k. There are triangles, squares and rectangles.

S_l. We can see the surface area of the cube and its open image.

S_c. We can find the surface area of the cube by adding the areas of colored rectangles, squares and triangles easily.

H_M. Can you find the ratio between the surface area and the area of the whole square paper?

S_e. If we determine the specific lengths on the figure, we can find easily.

…

This suggestion of a student was drawn on Figure 2 as a and x and then, the student solved this problem on the board. The students found an equation as $a^2 = 16\ x^2$. Hence, the ratio was found as 16.

The lesson was student-centered and implemented with respect to constructivist approach. The lesson provided opportunities about practicing of the learned concepts, problem solving, making relationship between concepts and learning new concepts. Furthermore, the students took active roles in understanding the concept by origami-based instructions. The teacher asked the key questions providing conceptual understanding of the mathematical concepts. The origami instructions

encouraged the students' schema learning. The students made the connections between the current and past knowledge and learned new concepts by relating them with previous ones. Also, he used the origami as a manipulative or concrete material as exemplified by above explanations. In the lesson, there were interactions that they shared their thoughts and knowledge related to the activity and the concept and problem solving strategies between students and students - teachers. These communications included explanations to help each other following steps and understanding the concepts. Hence, the origami-based mathematics lessons encouraged positive reinforcement between students. This communication was made using open-ended and encouraging questions to share and criticize their ideas. Moreover, the origami instructions encouraged problem solving skills. The teacher also implemented lesson with respect to elaboration theory. According to this theory, he taught the students basic skills and knowledge about origami and the concepts and then, provided opportunities for additional skills and knowledge until the expected ones were attained. In this respect, this lesson provided students opportunities about *scaffolding* and *schema learning*.

After the lesson had been completed, an interview was made by H_M and he explained his views based on his experiences and origami and its effects on student learning.

> "I think that origami is beneficial to use in mathematics lessons. The origami activities support student learning relationally. The students can make connections between new and previously learned concepts and experience problem solving activities effectively. Also, there are steps in the origami instructions and we follow them to form the objects. By following these steps, students can develop some skills such as observation, listening and attention. In performing these steps, I could observe and listen to students efficiently and give them effective feedback. Moreover, it can produce atmosphere in which students ask questions, help each other, learn new concepts and share their thoughts about following steps and making connection between concepts. Furthermore, the origami activities are useful because it provides students many opportunities having different types of intelligence since there are the activities encouraging the intelligence of visual, kinesthetic, intrapersonal and so on. I believe that the origami activities are good at teaching new concepts, making relationship between the concepts and motivating students to the mathematics."

In this case, the origami-based mathematics lessons guided by the MSMT with high level of constructivist-based teaching was beneficial in student learning and motivated the students to learn and participate in the classroom activities. The observations and interviews showed that these teachers could successfully implement their lessons supporting all learning types. The examples and views belonged to H_M and explained above were similar to the findings acquired from H_F, the other member of this group. They explained that origami could be used in mathematics lessons because it was useful to make connection between the current and previous concepts and real life, teach new concepts, problem solving and making drill activities. Also, the origami activities were suitable to use not only in geometry lessons but also in mathematics lessons.

DISCUSSION AND CONCLUSION

In light of the findings related to the lessons of L_F and L_M, it was realized that they implemented origami-based mathematics lessons helping the students acquire only skills related to self-management strategies. This finding was also supported by observation and interview results. In this type of classrooms, the origami-based instructions did not affect the students' understanding and learning positively. This result was parallel with some studies (Boakes, 2006, 2009; Boulter, 1992; Boyraz, 2008). Moreover, these studies could develop heavily physical skills as encouraged by previous research (Chen, 2006; Sze, 2005). Also, the strategy used in these lessons was traditional method rather than

constructivism. This kind of teachers could organize the lesson supporting discipline, self-control, observation, listening and attention skills and internal rewards.

When the teaching periods of M_F and M_M were examined, it was realized that they implemented origami-based mathematics lessons helping the students acquire many skills related to explicit instruction, multimodal instruction, social learning and self-management strategies based on findings obtained from interviews and observations. It was clear that four of the six-learning types were successfully implemented by these teachers effectively. The students in these classes were actively participated in the lessons and considered the lessons funny, helpful for mathematical understanding and enjoyable consistent with the findings of the study of Boakes (2009).

With respect to the lessons of H_F and H_M, it can be stated that they implemented origami-based mathematics lessons including the examples for the themes of hands-on learning, explicit instruction, higher order thinking, multimodal instruction, social learning and self-management strategies. It was clear that all of the six-learning types were successfully supported in the lessons of this group as confirmed by observation and interview findings. It was observed that origami-based instruction happening in this way could have positive effects on student learning and understanding by developing various skills. This finding is encouraged by many studies (Arıcı & Aslan-Tutak, 2015; Chen, 2006; Coad, 2006; Çakmak, Işıksal & Koç, 2014; Sze, 2005). Furthermore, the strategy used in these lessons was student-centered and based on the constructivist approach. The teachers who could implement the lessons successfully consistent with constructivist approach could organize the lessons supporting many mathematical and learning skills.

It can be made some claims with respect to the findings of the classes in three different groups in the current study. First, the teachers with low level of constructivist teaching can implement origami-based mathematics that students do not participate in the lessons actively. They only follow instructions to make origami and form an object and improve just one Sze's learning type, self-management skills such as listening, observation and attention. Second, in the consideration of lessons of teachers with medium level of constructivist-based teaching, it can be stated that origami activities are useful to use at the end of teaching a concept and the lesson to make students engage in drill exercises. Moreover, these teachers may be successful in supporting Sze's student learning types such as explicit instruction, multimodal instruction, social learning and self-management strategies. Third, teachers with high level of constructivist-based teaching, it can be claimed that origami-based mathematics lessons can be beneficial to help students acquire mathematical skills such as problem solving and relational understanding. The lessons of these teachers can provide all of Sze's learning types successfully. When the findings of all three groups are examined, it can be claimed that origami-based mathematics lessons are beneficial with respect to the teachers' levels of constructivist-based teaching. In other words, the more successfully the teachers implement their lessons consistent with constructivist approach, the more learning types they can support in their origami-based mathematics lessons and the higher mathematical thinking abilities students can attain with the help of origami-based mathematics lessons. Moreover, when origami takes place in mathematics lessons, student learning and use of origami effectively is directly related to the teachers. The current study has showed that the teachers are essential in teaching and student learning because they have the power of affecting them directly as explained by Khoh (2006) and Graham and Fennell (2001). As it was observed in the current study, it could be stated that teachers were important to provide the occurrence of constructivist-based teaching and the learning opportunities of origami to the students. Therefore, the teachers should organize origami-based mathematics lessons effectively considering the characteristics of constructivism. In the literature, previous research (Arıcı & Aslan-Tutak, 2015; Chen, 2006; Coad, 2006; Çakmak, Işıksal & Koç, 2014; Sze, 2005) show that origami activities are beneficial to be used in mathematics lessons but the potential and the possibility of providing these benefits can be performed by the teachers.

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APPENDIX

1. What do you think about origami-based mathematics lessons?
2. What was the objective of your origami-based mathematics lesson?
3. What was the role of origami in your lesson?
4. How did you use origami in your lesson?
5. What were the effects of origami on your lesson?

Ortaokul Matematik Öğretmenlerinin Origami Destekli Matematik Öğretimleri ve Öğrenci Öğrenmelerine Yönelik Görüşleri

Genişletilmiş Özet

Bu çalışmada, origami kullanılarak gerçekleştirilen matematik derslerinde öğrencilerin öğrenme türlerinin ortaya çıkması, öğretmenlerin sergiledikleri öğretim performansları seviyelerine odaklanılarak araştırılmıştır. Araştırmanın nicel bölümünde, ortaokul matematik öğretmenlerinin (OMÖ) yapılandırmacı yaklaşım temel alınarak yaptıkları öğretim performansları belirlenmiştir. Sonrasında, nitel veriler kullanılarak öğretmenlerin öğretim performanslarına göre öğretimlerinin desteklediği farklı öğrenme türleri incelenmiştir. Nitel veriler, origami destekli matematik derslerinde yapılan görüşmeler, gözlemler ve alan notları ile toplanmış ve analiz edilmiştir. Araştırmanın bulguları, origami destekli derslerdeki öğrencilerin sergiledikleri öğrenme türlerinin, öğretmenlerin yapılandırmacı temelli öğretme düzeylerine göre farklılaştığını göstermiştir.

Öğretmenler, öğrencilerin konuyu anlama ve öğrenmelerinde önemli bir role sahiptirler. Yapılan çalışmalar, öğretmenlerin sahip oldukları bilgilerin ve sınıftaki eylemlerinin derslerde ne yapıldığını ve öğrencilerin sınıfta neler öğrendiklerini etkilediğini göstermektedir (Turner-Bisset, 2001; Fennema ve Franke, 1992). Ayrıca, öğretmenler, öğrenciler ve müfredat arasında bağlantı kurmak için gereklidir (Graham ve Fennell, 2001). Derslerde kullanılan materyallerin de öğrenci öğrenmeleri üzerine katkısı da önemli derecede öğretmenlere bağlıdır. Bu bağlamda origami gibi öğrenmeyi destekleyen ve öğrenci öğrenmelerinde faydalı olan bir etkinlik olmasına rağmen, origaminin bu etkisi ancak öğretmenlerin onu derslerinde etkili kullanmalarıyla mümkün olabilir.

Öğretmenler öğrencileri materyallerle veya araçlarla ilgilenirken, resim çizerken ve derslerle ilgili bir şeyler üretirken izlediklerinde, öğrencilerin bu çalışmaları anlamlı hale gelir ve onlar için özeldir. Böylelikle, öğrenciler bu tür etkinliklere katılma konusunda aktif rol oynarlar. Ayrıca, burada sadece sanat yapar gibi bir şey üretmezler, aynı zamanda karmaşık dünyaları anlamlandırır, fikirlerini ve duygularını anlatır, açıklarlar (Key ve Stillman, 2009). Bu açıdan origami, öğrencilere sanatsal bir faaliyetle ilgilenme ve fikirlerini diğer insanlarla paylaşma fırsatı verdiği için önemlidir. Ayrıca, insanların bunu yapabilmeleri için yalnızda bir parça kağıda ihtiyaç duydukları için en erişilebilir sanatlardan biridir (Wu, 2002). Origami, nesneleri temsil eden şekillerin kağıtların katlanmasıyla oluşturulduğu Japon sanatı olarak tanımlanabilir. Ayrıca, origami, şeklin görsel ya da model olarak üretilmesini sağlar (Wu, 1999) ve iki ya da üç boyutlu figürler oluşturmak için de etkilidir. Bu nedenle matematik, mühendislik, astronomi, üretim, robot ve biyoloji gibi alanlarda da kullanıldığı görülmüştür (Cipra, 2001; Demaine, 2004).

Origami, eğitimde yararlı rollere sahiptir, zira eğitimde bir öğretim aracı olarak farklı şekillerde kullanılabilir (Boakes, 2008; Chen, 2006; Coad, 2006; Sze, 2005). Bir çeşit araç ya da materyal olarak da düşünülebilen origami matematiksel anlamayı, sorgulamayı ve soyut düşünmeyi geçişi de desteklemektedir (Arıcı ve aslan-Tutak 2015; Jones, 2010). Ayrıca, origami etkinliklerinde, öğrencilerin düşünce ve fikirlerine elleriyle katlayarak yaptıkları şekilden daha çok odaklanmaları beklenmektedir (Chen, 2006; Levenson, 2005; Sze, 2005). Böylelikle, öğrenciler öğrenme sürecinde fiziksel ve zihinsel olarak aktif roller üstlenebilirler. Buradan yola çıkarak origami matematik derslerinde de kullanılmış ve bu tarz dersler bu çalışmada origami destekli matematik dersi olarak ifade edilmiştir. Ayrıca, bu tarz dersler "katlama sürecinde ve sonuçta ortaya çıkan origami figürü ile öğrencilerin bilgi ve becerilerini birbirine bağlayan bir origami aktivitesi kullanarak öğretim" olarak açıklanmıştır (Boakes, 2006, s.32). literatürde yer alan çalışmalar, bu tarz derslerin öğrencilere davranışsal ve sosyo-duygusal kazanımlar, zihinsel gelişim ve matematiksel beceriler gibi birçok fırsatlar sunulması (Tugrul ve Kavici, 2002; Valentini, 2005) ve yaparak öğrenme, şema oluşturma, talimatları takip etme, uzamsal muhakeme, ilişkisel anlama, argüman üretme ve kavram haritası oluşturma gibi becerileri desteklediğini

belirtmektedir (Gay, 2000; Olkun, 2003; Sze, 2005). Ortaokul müfredatının dayandığı felsefi yaklaşım olan yapılandırmacı yaklaşıma dayalı olarak hazırlanan derslerde konuların gerçek hayattan örneklerle desteklenmesine önem verilmektedir. Bu nedenle, origami destekli matematik derslerin, literatürdeki birçok araştırmada açıklandığı gibi öğrencilerin öğrenmesini desteklemesi ve gerçek yaşamla ilişkilendirilmesi rollerinden dolayı önemlidir. Ayrıca, origami destekli derslerin öğrenci öğrenmeleri üzerindeki bu etkilerinin gerçekleşmesinde öğretmenler önemli bir etkendir (Khoh, 2006) çünkü öğretmenler müfredatı öğrencilere aktaran köprülerdir (Graham ve Fennell, 2001). Derslerdeki sorumlulukları, arasında öğrencilere rehberlik etmek ve onların öğrenmelerini sağlamak, öğrenmeyi ve bilgileri yapılandırmayı öğretmek yer alır. Dahası, literatürde, origami ve öğretimle ilgili birçok araştırma olmasına rağmen, origami destekli derslerin etkilerini ve bağlantılarını incelemeye ve bu tarz derslerin nasıl gerçekleştirileceğine odaklanan çalışmalara hala ihtiyaç vardır. Bu nedenle, bu çalışmada öğretmenlerin origami destekli matematik derslerini gerçekleştirme performanslarının öğrenci öğrenmeleri üzerindeki etkisini araştırmak amaçlanmıştır. Diğer bir ifadeyle, origami destekli matematik derslerinin matematik öğretim kalitesinin öğrenci öğrenmesine etkisi araştırılmıştır. Bu amaçla, çalışmada aşağıdaki soruların cevapları araştırılmıştır;

1. OMÖ'nin origami destekli matematik derslerindeki öğrenci-öğrenme çıktıları hakkındaki görüşleri yapılandırmacı-temelli öğretim düzeylerine göre nasıl farklılaşmıştır?

2. Origami öğrenme modelindeki hangi öğrenme türleri, OMÖ'nin yapılandırmacı yaklaşım temel alarak gerçekleştirdikleri origami destekli matematik derslerinde gözlemlenmiştir?

Vaka çalışması yöntemi, belirli bir kişi, sosyal ortam, olay veya grupla ilgili bilgileri tatmin edici seviyede sistematik olarak toplamayı içerir. Bu şekilde, bu konularda ayrıntılı ve derinlemesine bilgi bütüncül bir şekilde toplanabilir. Ayrıca, Stake (1995), vaka çalışmasını "tek bir vakanın karmaşıklığını ve özelliğini, vakanın önemli koşullarıyla birlikte faaliyetlerini anlamaya yönelik çalışma" olarak tanımlamıştır (s. 6). Ayrıca, bir vaka çalışması çeşidi olarak bu çalışmada kullanılan çoklu vaka çalışması, bu çalışmada araştırmacıların birden fazla vakadan daha geniş bir bağlam hakkında daha iyi bir anlayış elde etmelerine yardımcı olduğu için kullanılmıştır (Berg, 2001). Çoklu ya da toplu vaka çalışması, araştırmacının, bir olgu ya da bağlam araştırması amacıyla birkaç vakayı birlikte ele alabileceği anlamına gelir (Stake, 1995).

Düşük seviyede performans sergileyen matematik öğretmenlerinin dersleri (LF ve LM) ile ilgili bulgular ışığında, bu öğretmenlerin öğrencilerin sadece öz yönetim stratejileri ile ilgili becerileri edinmelerine yardımcı olacak origami destekli matematik dersleri uyguladıkları anlaşılmıştır. Bu bulgu gözlem ve görüşme sonuçlarıyla da desteklenmiştir. Bu seviyede öğretimin gerçekleştiği sınıflarda, origami etkinliğini gerçekleştirmek için belirtilen talimatların takip edilmesi öğrencilerin anlamaları ve öğrenmelerini önemli ölçüde etkilemediği görülmüştür. Araştırmada elde edilen bu bulgu literatürde yer alan bazı çalışmaların sonuçlarıyla paralellik göstermektedir (Boakes, 2006/2009; Boulter, 1992; Boyraz, 2008). Dahası, bu araştırmalar daha önceki araştırmaların bulgularında da belirtildiği gibi fiziksel becerilerin origami etkinlikleriyle geliştirebildiğini göstermektedir (Chen, 2006; Sze, 2005). Ayrıca, bu derslerde kullanılan öğretim stratejisi yapılandırmacı yaklaşımda kullanılan stratejilerden ziyade geleneksel bir yöntemdi. Bu seviyede performans sergileyen öğretmenler, origami derslerinde destekleyici disiplin, öz kontrol, gözlem, dinleme ve dikkat becerileri ve iç ödülleri gibi konularda öğrencilere çeşitli fırsatlar sunabilmişlerdir.

Orta seviyede performans sergileyen öğretmenlerin (MF ve MM) öğretimleri incelendiğinde, gözlemlerden ve mülakatlardan elde edilen bulgulara da dayalı olarak öğrencilerin, açık öğretim, çok modlu öğretim, sosyal öğrenme ve öz yönetim stratejileri ile ilgili birçok beceri kazanmalarına yardımcı olan origami destekli matematik derslerinin uygulandığı belirtilebilir. Altı-öğrenme türünden dördünün bu seviyede yer alan öğretmenler tarafından başarılı bir şekilde uygulandığı ve bu öğretmenlerin öğrencileri tarafından da verimli bir şekilde elde edildiği görülmüştür. Bu seviyede

gerçekleştirilen derslerde kullanılan strateji öğrenci merkezli olmuştur. Orta düzeyde öğretime sahip olan öğretmenler, kavram haritalama, problem çözme ve uzamsal muhakeme dışında kalan pek çok matematik ve öğrenme becerisini etkili bir şekilde destekleyecek şekilde derslerini organize edebilmişlerdir. Bu sınıflardaki öğrenciler derslere aktif olarak katılmış ve dersi eğlenceli, faydalı ve zevkli olarak değerlendirmiştir. Bu bulgular Boakes'un (2009) çalışmasında belirtilen bulgularla benzerlik göstermektedir.

Yüksek seviyede performans sergilenerek gerçekleştirilen origami destekli matematik dersleri (HF ve HM) incelendiğinde, bu derslerde uygulayarak ve yaparak öğrenme, açık öğretim, mantıksal düşünme, çok yönlü öğretim, sosyal öğrenme ve öz-yönetim gibi temaların sergilendiği öğrenci davranışlarına ait örneklere rastlanmaktadır. Altı öğrenme türünün tamamının, gözlem ve görüşme bulguları ile teyit edildiği gibi bu grubun derslerinde başarılı bir şekilde desteklendiği gözlemlenmiştir. Bu şekilde gerçekleşen origami destekli matematik öğretiminin, öğrencilerin çeşitli becerilerini geliştirmelerini sağlayarak öğrenmeleri ve anlamaları üzerinde olumlu etkilerinin olabileceği belirtilebilir. Bu bulgu literatürde yer alan birçok çalışma ile desteklenmektedir (Arıcı ve Aslan-Tutak, 2015; Chen, 2006; Coad, 2006; Çakmak, Işıksal ve Koç, 2014; Sze, 2005). Ayrıca, bu derslerde kullanılan strateji, öğrenci merkezli ve yapılandırmacı yaklaşıma dayanmaktadır. Çalışmanın bulgular ışığında, dersleri yapılandırmacı yaklaşımla başarılı bir şekilde uygulayabilen öğretmenler, çeşitli matematiksel ve öğrenme becerisini destekleyecek şekilde derslerini organize edebildikleri belirtilebilir. Ayrıca, origami etkinlikleri yapılandırmacı yaklaşıma uygun bir şekilde gerçekleştirildiğinde bu tarz derslerde öğrenci öğrenmelerinin yanı sıra matematik derslerinde gerekli çeşitli düşünme becerisinin gelişiminin de desteklenebildiği ifade edilebilir.

Anahtar Kelimeler: *Origami, Ortaokul matematik öğretmenleri, Öğrenme türleri, Yapılandırmacı yaklaşım*.