AN INVESTIGATION OF TEACHING PRISMS IN 5TH GRADES SUPPORTED BY EDUCATION FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

AN INVESTIGATION OF TEACHING PRISMS IN 5TH GRADES SUPPORTED BY EDUCATION FOR SUSTAINABLE DEVELOPMENT

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The purpose of this study is to investigate teaching prisms in 5th grades' supported by Education for Sustainable Development (ESD) by answering what 5th grade students think about the meaning of ESD in terms of recycling and packing waste, what the thinking strategies of 5th grade students for classification and nets of prisms are and what 5th grade students think about learning prisms using instruction supported with ESD. For this purpose, it was planned to support the prisms with the concepts of recycling and packaging waste. At the same time, students were made to use the concepts of prisms with recycling and associate them with daily life. The study was designed as a case study in qualitative research with content analysis. The results were compared by using documentation, observation and interview for content analysis. The study was conducted during the spring semester of the 2016-2017 academic year in a public middle school in Haymana district in Ankara, Turkey. For the study, one of the fifth grade level classes was used. The sample of the study consisted of 18 fifth grade students (9 female and 9 male), and 7 students who were interviewed at the

end of the study were selected through purposeful sampling method. The study lasted 8 class hours and approximately two weeks. The results of the study reveal students' thinking in prisms topic and their awareness of recycling and packaging wastes.
Keywords: geometric solids (prisms), recycling, packaging wastes, students' awareness and thinking

ÖZ

5. SINIFLARDA PRİZMA ÖĞRETİMİNİN SÜRDÜRÜLEBİLİR KALKINMA İÇİN EĞİTİMİ İLE DESTEKLENMESİ ÜZERİNE BİR ARAŞTIRMA

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Bu çalışmanın amacı, 5. sınıflarda prizma öğretiminin Sürdürülebilir Kalkınma için Eğitim (SKE) ile desteklenmesinin etkisini araştırmak ve öğrencilerin geri dönüşüm ve ambalaj atıkları açısından SKE'nin anlamı hakkında düşündüklerini, sınıflandırma ile prizma açınımları için düşünme stratejilerini ve öğrencilerin prizmaları öğretiminin SKE ile desteklenmesi hakkında düşündüklerini incelemektir. Bu amaçla, prizmalar konusunun geri dönüşüm ve ambalaj atığı kavramları ile desteklenmesi planlanmıştır. Bu sırada, öğrencilerin prizmalar konusunu anlamaları ile geri dönüşüm kavramlarını günlük hayatla ilişkilendirerek kullanmaları sağlanmaya çalışılmıştır. Araştırma, nitel araştırma tekniklerinden bir durum çalışması olarak tasarlanmış ve çalışma sonuçları içerik analizi ile elde edilmiştir. İçerik analizi için belgeleme, gözlem ve görüşmeden yararlanılarak sonuçların karşılaştırılması sağlanmıştır. Çalışma, 2016-2017 eğitim-öğretim yılının bahar döneminde, Ankara'nın Haymana ilçesinde bir devlet ortaokulunda yürütülmüştür. Araştırmada okuldaki beşinci sınıflardan biri kullanılmıştır. Araştırmada durum çalışması kullanıldığından katılımcılar 18

beşinci sınıf öğrencisinden (9 kız, 9 erkek) oluşmuş ve çalışma sonunda görüşme yapılan 7 öğrenci amaçlı örnekleme metoduyla seçilmiştir. Çalışma 8 ders saati olarak yaklaşık iki hafta sürmüştür. Çalışmanın sonuçları, öğrencilerin prizmalar konusundaki düşünme şekilleri ile geri dönüşüm ve ambalaj atıkları konusundaki farkındalıklarını ortaya koymaktadır.

Anahtar Sözcükler: geometrik cisimler (prizmalar), geri dönüşüm, ambalaj atıkları, öğrencilerin farkındalık ve fikirleri

To My Parents and My Grandmother

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LIST OF ABBREVIATIONS

2D	Two Dimensional
3D	Three Dimensional
ÇEVKO	Çevre Koruma ve Ambalaj Atıkları Değerlendirme Vakfı
CK	Content Knowledge
EE	Environmental Education
ESD	Education for Sustainable Development
MoNE	Ministry of National Education
NCTM	National Council of Teachers of Mathematics
PCK	Pedagogical Content Knowledge
PISA	Program for International Student Assessment
SD	Sustainable Development
SKE	Sürdürülebilir Kalkınma Eğitimi
SMK	Subject Matter Knowledge
TIMSS	Trends in International Mathematics and Science Study
UNCED	United Nations Conference on Environment and Development
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Education, Scientific and Cultural Organization
UNESCO-UNEP	United Nations Education, Scientific and Cultural Organization-United Nations Environment Programme

CHAPTER 1

INTRODUCTION

Mathematics contains abstract representations which can be hierarchical grown up of concept, skills and facts and systematic learning occurs (Sarwadi & Shahrill, 2014). Mathematical literacy which is related subject matter of mathematics is defined with knowledge of knowing and applying the basic mathematics in daily life (Ojose, 2011). In this case, a mathematically literate individual is defined as someone who has the ability to make estimation and interpretation of data, the ability to create solutions to problems, the ability to make numerical, graphical, and geometric inferences and the ability to use mathematical language. In educational aspects, mathematics curriculum includes geometry which is one of the important subjects (Marchis, 2012). According to Usiskin (1987), geometry consists of four dimensions: (a) visualization, drawing, and construction of figures, (b) study of the physical world, (c) use as a vehicle for representing non-visual or physical mathematical concepts, and (d) representation as a formal mathematical system. According to National Council of Teachers of Mathematics (NCTM, 2000), geometry presents advantages in terms of understanding real life situations and solving problems in algebra, measurement and rational numbers. In terms of individuals, the more knowledge of their environment they have (NCTM, 1989), the more knowledge of geometry and ability in geometric thinking and geometric problem solving they obtain (Fidan & Türnüklü, 2010; Han, 2007). In addition, geometry offers opportunities to interpret our environment and to connect other disciplines such as mathematics and science (Clements, 2003; Fidan & Türnüklü, 2010; NCTM, 2000). Moreover, geometry makes the world easy to understand, and it helps improving problem-solving skills (Habibi, 2012; Van de Walle, 2001). Furthermore, it has a language

which comes from real-world experiences (Clements, 2003) and contains special symbols, terminology and meaningful relations (Gökkurt, Şahin, Soylu, & Doğan, 2015). It is suggested that geometry defines the physical world (NCTM, 1989). According to this, the world refers to the three dimensional solid. Hence, visual information is necessary for human existence to interpret the world spatially (Jones, 2002). Also, in education, students have opportunities to improve their visualization skills by exploring solutions to mathematical and other problems (Jones, 2002), and they develop their spatial visualization ability during problem-solving process (Fennema & Tartre, 1985). According to Ministry of National Education, MoNE, (2013), if this relationship is formed effectively, meaningful learning is provided and knowledge is turned into permanent state in geometry among students.

According to Fujita and Jones (2007), memorization in teaching geometry and lack of examples lead to difficulties which students do not overcome, and students encounter difficulties in learning geometric skills. This is illustrated in international studies as a weakness in students' geometric achievements (Mullis et al., 1997). For instance, in the Trends in International Mathematics and Science Study (TIMSS) 1999 report, Turkish students were ranked 34th among 38 countries in terms of geometry achievement (Mullis et al. 2000; as cited in Clements, 2013). In other words, their scores were very low. In addition to these, when TIMSS 2007 reports were analyzed, Turkish students were not at the desired level and did not gain necessary knowledge (Mullis, Martin, & Foy, 2008). Based on the TIMMS national report of 2015, when results between the years 2007 and 2011 were compared, even though Turkish students increased their achievements in geometry, they were still placed below the average (MoNE, 2016). According to these, it is seen that if students cannot overcome these difficulties, this affects their future lives (Tall & Razali, 1993; Wu, 2013).

Geometry is must for students in elementary and middle school level in order to develop their understanding of shapes and of properties of shapes, to

combine geometry and real world situations and to produce solutions to problems in mathematics and other disciplines (Clements, 2003; Kilpatrick, Swafford, & Findell, 2001; as cited in Ubuz, Ustun, & Erbas, 2009). As a result of this, the field of geometry in Turkey needs to be given more importance in terms of both education and research.

According to NCTM (2000), "geometric ideas are useful representing and solving problems in other areas of mathematics and real-world situations, so geometry should be integrated with other areas if possible" (p.41). In this case, education can be thought as more than teaching or learning knowledge or some policies. In other words, education helps people improve her/his skills to keep living by accommodating other people. Since education is one of the basic needs of human, education also becomes more significant for sustainable development.

In the report 'Our Common Future'- Education for Sustainable Development (World Commission on Environment and Development, 1987), terms such as sustainability and sustainable development appear, and these are related to satisfaction of human needs. According to Wals (2012), sustainable development (SD) has variety of topics such as environment, society, economy or politics, and these topics are defined as protecting the land, the water, the air or the resources. According to Gough and Scott (2003), sustainable development has three types of approaches such as type 1 in which learning leads to change, type 2 in which social and political problems lead to environmental symptoms and type 3 in which learning is open-ended (as cited in Vare & Scott, 2007). In this case, according to Tilbury (1995), environmental education (EE) is significant in terms of presenting sustainable lifestyles for citizens. During EE, students have learning environment in which they can internalize sustainable practices by involving them in world problems (Tilbury, 1995). ESD which stands for Education for Sustainable Development has become an important element of making environmental policy and creating sustainable development strategies. According to UNECE strategy (United Nations, 2009), ESD aims to equip people with

knowledge of and skills in sustainable development, to make them more competent and confident while, at the same time, increasing their opportunities for leading healthy and productive lifestyles in harmony with nature and with concern for social values, gender equity and cultural diversity since education is perceived as an important tool to obtain achievement in sustainability (Hopkins & McKeown, 2002).

The seeds of ESD planted in the seventies at many international conferences on environmental education (EE), including the Man and Environment conference held in Stockholm in 1972 and the UNESCO-UNEP conference on Environmental Education held in Tbilisi in 1997, found a fertile soil of broad-based mutual concern for sustainability which was expressed at the UNCED Earth Summit in Rio de Janeiro in 1992. Chapter 36 of Agenda 21 (United Nations Conference on Environment and Development, 1992) emphasizes that education is a vital factor in the promotion of sustainable development and in the development of people's skills to deal with environmental and developmental issues (Gadotti, 2016). Chapter 36 of Agenda 21 (UNCED, 1992), which is called "*Promoting Education, Public Awareness and Training*", defines the four thrusts of ESD which aim to improve access to quality basic education, to reorient existing education to address sustainability, to increase public understanding and awareness of sustainability and to provide training for all sectors of the economy. Also, 40 issues of ESD which are related to reorienting the existing education in Agenda 21 were grouped into four sections as social and economic dimension, conservation and management of resources, strengthening the role of major groups and means of implementation (UNCED, 1997). In addition to these, ESD set sight on building more sustainable societies and more sustainable future with the help of coordination of education and public awareness (Wals, 2012). As a result, although ESD and EE have a close relationship, they are not the same. It can be said that EE makes a contribution to ESD in terms of pedagogy and content. Hence, for the future of ESD, it is suggested to develop a common vision, to democratically move forward, to give importance to training people, to

encourage innovations, to develop ESD leadership, to develop strategic plans, to establish action plans or to train teachers (Hopkins & Mckeown, 2002).

According to Alkis, (2008), Turkey has a large number of students and young people, so improvements and implementations of the main goals of environmental for sustainable development for all grade levels is significant. In Turkey environmental educational courses are elective for middle school students and content of course was prepared in accordance with the prototype curriculum of United Nations Education, Scientific and Cultural Organization, UNESCO. Also, sustainable development was added in science curriculum to enhance students' environmental sensitivity and to improve their sustainable life skills (MoNE, 2015).

Especially, ESD provides human with gaining awareness of education and environment. When the importance of different disciplines is considered, it is possible to support disciplines with each other (Blewitt, 2005; Checkland, 1999; Wals, 2012). In this case, geometry and ESD have a common context as representing real-world situations. Therefore, the purpose of this study is twofold: firstly, to design a prisms' teaching supported by ESD lecture and secondly, to explore students' responses to the lecture in terms of the planned objectives. The real-world situation is defined for this purpose. The start point is that prisms are all around us and packages (especially boxes) are examples of prisms that are used frequently for packaging. In this case, packaging wastes is one of the major patterns of unsustainable consumption since they cannot be used for recycling. Therefore, prisms topic represents geometry in this definition while packaging waste and recycling represents ESD. In other words, boxes exemplify both packaging wastes and prisms. After planned objectives are achieved, teaching prisms is expected to be supported by ESD in terms of recycling and packaging wastes. Hence, students both learn prisms and gain awareness about recycling.

1.1. Theoretical Background

Geometry can be perceived as a bridge between mathematics and other disciplines (NCTM, 1989; 2000). Thus, geometry is considered a common core of science and mathematics (Clements & Sarama, 2011). According to Clements and Battista (1992), geometry offers opportunities for individuals in order to understand and interpret the physical environment. Moreover, in geometry education, students understand not only geometric concepts but also mathematics in these concepts (NCTM, 2000). Hence, the role of geometry is important in teaching and learning mathematics. Since geometry provides students with understanding of shape and space (Güven & Kosa, 2008), it can improve students' spatial ability and reasoning skills (French, 2004). In other words, the geometry education supports opportunities to develop these kinds of abilities (Kaufmann, Schmalstieg, & Wagner, 2000). Spatial ability has important role for many aspects of individuals' life (Marchis, 2012), especially human intelligence (Kaufmann et al., 2000). Spatial ability is considered as fundamental for higher-level thinking, reasoning and creative processes (Sorby, 2007). Additionally, spatial ability is important in many fields such as computer graphics, engineering, science, technology, and mathematics, geosciences or architecture (Titus & Horsman, 2009). Additionally, there is a correlation between learning geometry and spatial visualization abilities of students, which is a sub-factor for spatial ability (Karaman & Toğrol, 2009) and also Battista (1990) emphasizes the importance of visualization skills. In this case, spatial ability of students can be improved by spatial orientation and spatial visualization tasks in order to succeed in geometry, volume, and measurement (Risma, 2013).

According to McCarty and Shrum (1994), since importance of solutions in environmental issues increases, recycling gains significance among governments. In this case, when some programs about recycling are applied by the governments, participation or engagement of members in society is also supported. For this, individuals are provided with environmental awareness (Ebreo, Hershey, &

Vining, 1999) by changing their attitudes which can be prerequisite for changing behavior (McCarty & Shrum, 1994; Arbuthnott, 2009). According to early researches (Henion, 1976; Balderjahn, 1988; Schwepker & Cornwell, 1991), environmental behaviors of responsible consumers include positive attitudes towards environmentally-conscious living. Thus, unsustainable ways should be replaced with sustainable ones in extracting and consuming resources (Svanstrom, Lozano-Garcia, & Rowe, 2008) by influencing conscious behaviors such as recycling (McCarty & Shrum, 1994). In this case, education has a vital role in order to achieve sustainability (Hopkings & McKeown, 2002). For this, ESD provides a vision of education by balancing prosperity with traditions, by respecting natural resources and by increasing communication to find common solutions (Zenelaj, 2013). Besides, ESD helps to form future societies by preparing the younger generation who are candidates to be responsible citizens in the future. In other words, students will have ability to participate in a democratic society and to help in shaping future society with sustainable concept. Thus, based on the concept of sustainable development, they have an important role in taking responsibility for not only themselves but also future generations (de Haan, 2006). Hence, it is important to link development of generations with sustainable development in education. In other words, neither education nor sustainable development can be considered independently (Hagglund, & Samuelsson, 2009).

1.2. Purpose of the Study

The deeper understanding in systems such as natural systems, design and management systems and information systems (Checkland, 1999) is significant for future societies. However, it is new for ESD in terms of connections, relationships and interdependencies with the whole system (Wals, 2012). As a result, ESD with other disciplines can be seen a mechanism which enables rethinking education (Wals, 2012). Hence, the initial aim of the study is to investigate teaching prisms in fifth grades supported by ESD by designing a

lecture in order to understand both students' thinking on prisms in terms of classification and nets and their awareness on recycling and packaging wastes.

Underlining this main idea the purposes of this thesis are; a. To design a lesson plan for teaching prisms supported by ESD lecture; b. To understand students' thinking about geometric shapes and c. To understand students' awareness of recycling and packaging wastes. Additionally, it is expected that participants will assess support of different topics each other.

1.3. Research Questions

The purpose of this study is to investigate teaching prisms supported by ESD in terms of fifth grade students' understanding. The primary research questions that this study will aim to answer are as follow:

1) What do 5th grade students think about the meaning of ESD in terms of recycling and packing waste?
2) What are the thinking strategies of 5th grade students for classification and nets of prisms?
3) What do 5th grade students think about learning prisms using instruction supported with ESD?

1.4. Definition of Important Terms

ESD is the acronym of education for sustainable development. ESD enables human to qualify for sustainable future (UNESCO, 2014).

Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products (EPA, 2017).

Packaging wastes means sales, external and transfer waste including reusable packaging that has reached the end of its life (ÇEVKO, 2017). In this

study, packaging wastes are exemplified by kinds of prisms, and attention is drawn to recycling.

Prisms can be explained as a multi-planar object, whose lower and upper floors are parallel and equal to each other and whose lateral surfaces are equal and parallel to each other according to Turkish Language Society. In addition, Van de Walle (2013) defined them as a cylinder with polygons for bases, and they can be classified as special cases of cylinders.

Rectangular prisms are mentioned as a cylinder with rectangles for bases (Van de Walle et al., 2013).

Square prisms are defined as a special kind of rectangular prisms with two square surfaces (Adapted from MoNE, 2018, p.305).

Cube is a square prism with square sides (Van de Walle et al., 2013).

1.5. Significance of the Study

If a mathematically literate person can use, do and distinguish mathematics in different conditions, mathematics curricula contain different main topics of mathematics to gain these abilities to this person (Ojose, 2011). According to Steen (1990), these main topics are dimensions, quantity, uncertainty, shape, and change. On the other hand, Program for International Student Assessment (PISA), (2013) presents these categories which are quantity, space and shape, change and relationship and uncertainty. According to PISA 2012 whose analyses were shared in 2013, shape and space include understanding of the relationship between shapes and images, understanding of the relationship between three-dimensional objects and two-dimensional ones and understanding of construction and representation of objects. Hence, individuals improve their understanding to produce and to interpret solutions for specific situations.

Also, Sandoval and her friends (2016) mention learning spatial geometry is supported by visual perception since figural properties have importance because of senses. If enough importance is not given on development of spatial ability and 3D geometry thinking, geometric solids can be the most difficult topic among geometric topics since some representations cannot be mentally manipulated by students (Fujita, Kondo, Kumakura, & Kunimune, 2017). In addition, in terms of theoretical knowledge, the processes of definition and validation have a significant role in mathematics since it represents the properties of objects. In defining geometrical concepts, geometry to overcome complexity of this process is linked to reality and experience (Mariotti, & Fischbein, 1997). In order to make it real, different toys and blocks with which children play can be used to exemplify two-dimensional and three-dimensional shapes and to provide in-depth understanding of geometric concepts (Franzella, 2007).

In Turkish education system, students encounter terms related to geometry from their early childhood years on, and they take geometry courses related to not only geometric shapes but also geometric solids, which can be exemplified as rectangular prisms, cubes, cylinders or pyramids (MoNE, 2015). In the middle schools, students start identifying rectangular prisms, cubes and their characteristics, nets and their surface area in fifth grade. Although students take geometry courses from elementary school years on, they have difficulties learning geometric topics (Yılmaz, Keşan, & Nizamoğlu, 2000).

If an individual aims to achieve sustainable development literacy, she/he should have some abilities such as interdisciplinary and trans-disciplinary research methods, contextual appreciation and analysis, and multiple perspectives for examination and improvement of knowledge (Dale & Newman, 2005). In this case, school curricula get important to provide major thrusts of ESD which are improving basic education, reorienting existing education to address sustainable development, developing public understanding, awareness, and training (UNCED, 1992).

There are some different ideas about the relationship between the ESD and EE. While some state that ESD is different than EE, some claim that ESD is similar to EE (Kopnina, 2012). Additionally, according to UNESCO (2005):

> ESD is based on the principles and values that underlie sustainable development, includes all three spheres of sustainability – environment, society, and economy- and no single discipline can claim ESD for itself alone, but all disciplines can contribute to ESD.

Hence, a common vision and relevance to the curriculum for ESD aims to save pupils' lives, raise economic potential in the curriculum, give concrete examples of abstract concepts and add purpose to education. Additionally, educational system has a role in preparing citizens and enhancing global awareness (Zhang, 2010) by means of ESD (Gadotti, 2016) with sustainable future. According to McKeown, Hopkins, Rizi, and Chrystalbridge (2002), education has an impact on sustainability in terms of implementation, decision making and quality of life. In other words, with the help of educated citizens, education facilitates implementation of informed and sustainable development, the number of good community-based decisions, and life conditions and economic status of society, respectively.

In Turkish education system, environmental education has a specific curriculum that includes five different units which are balance between living and lifeless features, interaction between people and environment, effects of this interaction on this balance, limitations in natural resources, global environment issues and sustainability in balance and limited sources which make up this program's content. Besides, students experience different aspects of ESD in science education in elementary level. In elementary science education, there is a topic 'Living Features and Life' which includes negative effects of wastes on environment in the third grade, relationship between human and environment and environmental pollution in fourth and fifth grade, stems and systems in sixth grade, domestic wastes and recycling, chemical industry and biodiversity in

seventh grade and sustainable development, biotechnology and climate in eighth grade (MoNE, 2015).

All in all, the three dimensional objects are important in individuals' life (Baki, 2006). According to Thurstone (1950), spatial relations, visualization and orientation are the elements of spatial ability. In this case, spatial visualization is "a kind of ability to perform imagined movements of objects in two-dimensional and three-dimensional space" (Clements & Battista, 1992). As a result, there is a relationship between students' spatial ability and their geometric thinking in three dimensional objects (Pittalis & Christou, 2010). If students are not supported to develop spatial ability, they have difficulties in understanding real world and in solving its problems (Jones & Mooney, 2003, Güven & Kosa, 2008). While the world changes, the societies choose unsustainable ways to extract and to consume their resources. This choice leads to some challenges for individuals (Svanstrom et al., 2008). The term "*sustainability*", as original form "*sustainable development*", is perceived as an economic, social, and ecological concept in Agenda 21 (UNCED, 1992). According to Emanuel and Adams (2011), renewable energy sources, conservation, recycling, environmentallyfriendly land development, water management, and waste disposal are some terms which are included by sustainability. Since the recycling is one of the terms of sustainability, it aims to decrease the use of toxic substances and to reduce overconsumption of resources and energy (Glavic & Lukman, 2007). In addition to them, while NCTM (2000) recommends that the relationship between geometry and other disciplines be supported, UNESCO (2005) suggests that ESD be supported by all disciplines.

When support is mentioned, integration of different disciplines into each other or integrated-curriculum may arise. In this case, according to Beane (1991), curriculum in schools prepares students for life with unity and meaning because when individual confronts a problem, s/he does not think about which part of it is related to mathematics, science or history. As a result, integration is seen as

necessary. Besides, Fogarty (1991) mentions ten models for curriculum integration such as the fragmented, the connected, the nested, the sequenced, the shared, the webbed, the threaded, the integrated, the immersed and the networked. In addition to them, Kysilka (1998) states that integrated-curriculum has importance in connecting different disciplines. Also, Kysilka (1998) advises that concept of integration be clearly understood and then its curriculum planning be conducted.

In the light of these, the current study cannot be considered as an integrated-curriculum. Hence, it aims to provide some contributions to supporting different disciplines. In other words, in this study, it is expected that teaching prisms in 5th grades will be supported by ESD in terms of recycling and packaging wastes by means of boxes. Also, it aims to find answers to the thinking strategies of 5th grade students about classification and nets of prisms and their thinking about the meaning of ESD in terms of recycling and packing waste by providing them with recognizing the prism of rectangles, determining the basic elements, drawing the nets of the rectangular prism, deciding whether the different nets were related to the rectangular prism; and explaining the concepts of recycling and recovery and contributing to the reuse of recyclable materials. In addition to them, another aim is to find answers to 5th grade students thinking about learning prisms using instruction supported with ESD.

CHAPTER 2

LITERATURE REVIEW

The current study aims to investigate teaching prisms supported by education for sustainable development (ESD) in the 5th grades. Hence, the literature will start with the studies about prisms in education, and then, it will continue with studies about ESD. Each part also includes studies conducted in Turkey.

2.1. Studies about Prisms in Education

Prism is the most common term which individuals encounter in their daily lives in order to explain their environment (Baki, 2006). However, according to The Geometry Standards of NCTM's Principles and Standards for School Mathematics (2000), in the elementary grades, three dimensional geometry does not get as much attention as the two dimensional one. In other words, while two dimensional shapes are studied extensively, this is not the case for three dimensional shapes. In the study conducted by Roth and Thom (2009), the aim was to find out how students classify the three dimensional (3D) geometry in classification tasks. In the study, while students classified them with the same form of 3D objects without considering their different sizes and colors, this classification was not what teachers desired. However, as a result of the study, students' informal and formal geometry knowledge improved with the help of concrete materials. In the Koester's study (2003), students tried to explore three dimensional shapes with the help of simple materials such as paper and drinking straws, and they participated in two different studies. In the first model, they constructed cylinders and prisms by using rectangular papers and by folding papers, and then, they formed cones and pyramids by cutting circular papers. In

the second study, they used their knowledge which they obtained from the previous study to form three dimensional shapes by making use of straws. At the end, after exploring, students found their definitions by combining geometry and algebra. Thus, they constructed their definitions by using their words without memorizing. Moreover, there was a study carried out with students in order to explore their 3D geometric thinking profiles (Pittalis, Mousoulides, & Christou, 2010). This study was conducted by validating a theoretical model with 3D geometry abilities and by tracing a developmental trend between categories of students. At the end, while six different statistically significant factors which had high correlations among themselves for the former fold were obtained, four different profiles of students which could display four developmental levels of thinking in 3D geometry appeared. Hence, importance of spatial ability skills was emphasized. Besides, according to design research project done by Sack (2013), children's conceptual development in 3D cube structures was analyzed by using concrete models, conventional two dimensional (2D) pictures and abstract top-view numeric representations. In this study, Geocadabra Construction Box was used. At the end of the study, both children's conceptual development was achieved and interest and motivation of classroom increased. Also, individuality, independence, interdependence and open-mindedness were raised. In another study, Pittalis and Christou (2013) conducted the confirmatory factor analysis and the mixed method analysis to evaluate some abilities of 279 students from the fifth grade level to ninth grade levels in 3D representations. As a result of the study, they obtained two different abilities such as decoding which is the ability of representation, and coding which is the act of representation and four different types of behavior such as the 2D behavior, the intuitive behavior, the implicit-conventional behavior and the conventional behavior to display 3D shapes. Moreover, there was another study which aimed to construct an assessment framework about students' 3D geometric thinking of students (Fujita et al., 2017). In this study, existing research studies and data from students who studied challenging problems were used. In the study, manipulation of mental representations gained importance and assessment framework was used by

teachers for their students' 3D thinking skills. In addition to these studies, Hallowell, Okamoto, Romo, and La Joy (2015) explored reasoning skills of first-grade children in plane and solid shapes. In the study, shape- matching tasks including five 2D plane-shape items and five 3D solid-shape items were used. Despite some difficulties, increase in children's spatial ability and their visualization abilities were observed. In addition to previous studies, there are many studies about geometry teaching and learning. In one study conducted by Chen (2013), it was aimed to enhance the effectiveness of geometry teaching and learning by means of the problem-based learning model. At the end of the study, while students' knowledge of geometry was developed, providing high school mathematics with the geometry concepts was not achieved.

While there are studies related to students, some studies are about pre-service teachers and teachers. One of these studies is related to basic geometric shapes and solids. According to results of Marchis' study (2012), while some pre-service teachers could not define shapes, some did not know properties of shapes. In terms of geometric shapes, some did not draw representation of two-dimensional condition while some did not have idea about the drawing of their nets. In addition, in the case study conducted by Moss, Hawes, Naqvi, and Caswell (2015), it was reported that teachers who had lack of content knowledge and confidence in teaching geometry and their spatial reasoning improved those skills. In activities, participants tried to gain first-hand experience by doing mathematics with tangrams and cubes, and they tried to explore reflection symmetry by using magnetic pattern blocks and magnetic square units on a coordinate grid. Hence, authors improved professional development model with design research and Japanese lesson study in order to provide teachers with deep content knowledge in geometry and spatial reasoning.

In Turkish education system, Geometry and Measurement is mentioned as one of the content area in mathematics which means all elementary and secondary school students take geometry education in Turkey (MoNE, 2013). According to

Özçakır (2013), development of relations among geometric figures or shapes or prisms by considering their basic properties is important in the curriculum. While students in elementary schools do not recognize prisms in terms of their names and properties or their differences and similarities, they started doing this in middle school years (MoNE, 2013; 2015). For instance, at the fifth grade level, students distinguish rectangular prisms and their key features, draw nets and calculate the area of these nets. At the sixth grade level, students study the volume of rectangular prisms. At the seventh grade level, they draw three dimensional objects from different angles with different aspects. At the eighth grade, they gain knowledge about right prisms, right cylinder, right pyramid and cones (MoNE, 2013).

In terms of geometric solids, studies generally include different contents. Some studies conducted with pre-service teachers, includes the knowledge in terms of content knowledge, CK, (Altaylı, Konyalıoğlu, Hızarcı, & Kaplan, 2014; Bozkurt & Koç, 2012; Gökbulut & Ubuz, 2013) or pedagogical content knowledge, PCK, (Çakmak, Konyalıoğlu, & Işık, 2014; Gökkurt et al. 2015) or subject matter knowledge, SMK, (Tekin-Sitrava & Işıksal-Bostan, 2016) and misconceptions (Küçükaydın, & Gökbulut, 2013). When these studies were analyzed, pre-service teachers had limited knowledge in geometric solids in terms of generating definitions and examples and connecting the subject to daily life.

Besides, some studies in teaching geometry subjects were conducted with students by applying drama method. In Özsoy' s study (2003), this approach had effectiveness in facilitating the teaching of right prisms at eighth grade level students and in making the topic of right prisms easy to learn for students. Also, another study done by Günhan and Özen (2010) shows although students mentioned usefulness of drama-based lessons, these were not effective on the students' "*beliefs of self-efficacy*". Another approach in studies can be exemplified by using dynamic software programs. In these studies, teaching and understanding of geometric objects were easier and students' motivation got

higher (Gürbüz & Gülburnu, 2013; Şimşek, & Yücekaya, 2014, Uğur, Urhan, & Kocadere, 2016). On the other hand, although development of sixth grade level students' spatial ability was observed in the prism topic by using the three dimensional dynamic geometry software, its effect was not statistically significant (Şimşek, & Yücekaya, 2014). In a study in which both concrete materials and dynamic software programs were used (Yolcu & Kurtuluş, 2010), it was observed that sixth grade level students' spatial ability level improved in the experimental design.

In geometry lessons, concrete materials dynamic software programs can be used. For instance, quantitative part of the study on the effects of origami activities in teaching geometric objects (Şimşek, 2012) indicated that when content of lessons was enriched in order to be effective and useful, there was a positive and significant relationship between students' achievement scores and their attitudes towards geometry at a high level. Moreover, use of puppets as material in teaching solids was analyzed in terms of students' achievement (Yılmazer & Keklikçi, 2014). As a result of this experimental study, eighth grade level students showed success in learning geometric shapes. To add, another study was on the effect of use of Orff Approach which is used in music education in teaching geometrical objects (Aktaş & Kaya, 2017). In this study, it was aimed to gain students with mathematical ability by means of music education. Eighth grade level students participated in this experimental study, and they learnt geometrical objects through playing some materials such as musical tools and singing songs related to geometrical objects. As a result of the application, Orff Approach was beneficial in improving students' participation and achievement.

2.2. Studies about Education for Sustainable Development (ESD)

The environment became the key focus of local and global law and institutions (Kates, Parris, & Leiserowitz, 2005) since the environment is one of the four key items of people in the world which are peace, freedom, development and environment (National Research Council, 1999). In time, sustainable

development gains significance in terms of development and environment (Kates et al., 2005).

According to Alshuwaikhat and Abubakar (2008), it is important to pay attention to natural resources and to promote their sustainable use in terms of providing the survival and well-being of the world community. In this case, sustainability of environmental resources has an important role in supporting sustainable development. Moreover, Glavic and Lukman (2007) state that principles containing environmental and ecological, economic, and societal dimensions provide a framework to establish a more complex system for sustainable development. One of these principles is recycling to increase environmental performance by decreasing dangerous materials, energy and resource use. Despite some limitations, recycling can be mentioned as a more behavioral and lower technological solution to solid wastes (Ebreo, 1999). Also, when sustainability is considered as protection of environment, recycling draws attention with economic and ecological solutions in managing waste (Omran, Mahmood, Abdul Aziz, & Robinson, 2009).

Moreover, sustainable development aims to support individuals with environmental awareness (Ebreo, 1999). According to Bonnett (1999), sustainable development is a policy in a frame of mind by including everyday practices. In other words, it presents a perspective about personal or cultural development. In order to provide development in sustainability, Arbuthnott (2009) suggests that individuals are supported by changing their behavior by means of changing attitudes. Without considering education, gaining environmental awareness cannot be possible (UNCED, 1992; Hopkings & McKeown, 2002; Hagglund, & Samuelsson, 2009). In this case, when it includes basic characteristics of sustainable development, education for sustainable development has a significant place with respect to local, regional and global environments, and social and economic development (Siraj-Blatchford, 2009). Besides, in order to promote

sustainable development, a vision was needed, so ESD was defined by UNESCO (2002) for the *2005–2014 The Decade of Education for Sustainable Development*:

> Education for sustainable development (ESD) is a vision of education that seeks to balance human and economic well-being with cultural traditions and to respect earth's natural resources. ESD applies trans-disciplinary educational methods and approaches to develop an ethic for lifelong learning, fosters respect for human needs that are compatible with sustainable use of natural resources and the needs of the planet and nurtures a sense of global solidarity.

Although sustainability as a term had its origins in Middle Ages, it was first used in 19th century in agriculture, forest and fishing industry (Tıraş, 2012). Later, education was placed into the social dimension of sustainability (Sarıkaya & Kara, 2007). In addition, ESD aims to achieve social transformation (www.unesco.org.tr, 2016). To enhance this, it is advised to make changes in curriculum and design school buildings by considering sustainability (Kocabaş & Bademcioğlu, 2015; Taşçı, 2015). In addition, Since ESD aims more sustainable futures (Wals 2012) by changing minds fundamentally (de Hann, Bormann, & Leicht, 2010), all areas of education and education levels such as early childhood education, primary education, secondary education, higher, adult or vocational education - and formal, non-formal or informal learning settings contain ESD (de Hann et al., 2010; Bessant, Robinson, & Ormerod, 2015). Hence, while the number of these studies in education increases day by day in different countries, changes in curriculum provide effectiveness with this respect (Agut, Ull, & Minguet , 2014; Cutter-Mackenzie, & Edwards, 2013; Gresch, & Bögeholz, 2013; Kitamura, & Hoshii, 2014; Milutinovic, & Nikolic, 2014). Additionally, to provide changes, it is important to provide answers for how educators support students in ESD (Sauve, 1996; Sund, 2015). Besides, how reduction of solid wastes can be done is another significant point (Alshuwaikhat & Abubakar, 2008; de Vega, Benitez, & Barreto, 2008; Elfithri, Ghee, Basri, & Zain, 2012; Smyth, 2010).

Especially, the number of studies about ESD or sustainability in early childhood education is more than the ones in other fields. The reason of this can be that the mission of preschool stresses to educate and to develop not only the children's minds but also as a whole individual (Johansson & Samuelsson, 2003; as cited in Hagglund, & Samuelsson, 2009). In other words, ESD has an important role in early childhood education since today's early childhood contexts contain the most fundamental values of tomorrow's society in terms of sustainability (Siraj-Blatchford 2009). Furthermore, according to Davis (2009), environmental education and early childhood education have common points in terms of education in the environment, education about the environment and education for the environment. These phrases referred to relationship of children with nature, their understanding of environmental topics and adoption of children as a means of change around sustainability, respectively. Moreover, studies in early childhood education displayed a good adaptation to core principals of ESD and interpretation of place and responsibility of global citizens in terms of childhood. According to Hagglund and Samuelsson (2009), at least three areas which are preschool as an institution, pedagogy of preschools, and the training of preschool children for considering the sustainable development and early childhood education are important. According to Pearson and Degotardi (2009), their proposal focused on the importance of cultural values in practice of early childhood education, the globalization of early childhood education and interest in early childhood education. Education has a role which provides sustainability in terms of cultural beliefs and practices. Additionally, while globalization in early childhood education leads to developing future citizens of the world, real life problems provides children with practical applications of education for sustainable development.

In the study conducted by McNaughton (2010), educational drama in primary education was effective in learning and teaching ESD. According to the results of this study, students were candidates for being global citizens since they gained perspective by considering real world issues and by using body language

and nonverbal communication by means of reflection of their learning in ESD or creating learner-centered teaching (McNaughton, 2010). Besides, ESD can be perceived as a step in terms of equity and equality in secondary education. As a result, thanks to it, 31% of countries allowed girls to participate in secondary school education (Alexander, 2010).

In higher education, ESD forms informal and formal settings and provides better learning opportunities to develop future-oriented competencies (Barth et al., 2007). In a study from Japan (Kitamura, & Hoshii, 2014), it was mentioned that although school education contained environmental education, there were not effective connections between subjects and their perspectives of ESD. Hence, due to the change, teacher training is important in terms of giving teaching experience in practice. As a result, despite difficulties in financial and human resources, collaboration with local stakeholders and industry-academia-government and supporting the humanities with science were emphasized (Kitamura, & Hoshii, 2014). In addition to these, ESD gained an importance in decision making process (Gresch, & Bögeholz, 2013) and taking responsibility (Nikel, 2007). Moreover, de Haan (2006) developed a program to support the introduction of ESD and overview of the growing international significance of ESD in Germany by testing interdisciplinary learning, new forms of participatory learning and innovative structures. Eight sub-competencies such as foresighted thinking, interdisciplinary work, cosmopolitan perception, transcultural understanding and cooperation and planning and implementation skills were placed in the program, and their aims were to act and to solve problems. This program, at the end, had broad effect, and it was used in the current structure.

In addition to studies with students, perception of educators or teachers is important in terms of EE and ESD. In the Sauve's study (1996), it was mentioned that different conceptions of EE have effect on approaches and strategies in terms of defining and practicing EE in education. According to these, environment is perceived as nature, resource, problem, place to live and biosphere and

community project. These also affect the educational paradigms such as rational, humanistic and inventive paradigms. According to Sund (2015), how teachers provide students to be conscious and autonomous democratic citizens by the help of ESD was analyzed with interview. The study was conducted in Sweden where the national curriculum contains SD in many disciplines as being significant part of curriculum, and schools provide students with ongoing changes in ESD. Hence, this study is important in terms of teacher practice and teaching practice provided by ESD. According to the results, teachers can feel support or pressure from their principals. When they are supported, they work with more interdisciplinary collaboration, behave in a more democratic way in education and achieve good education.

In some studies, sustainability is analyzed in terms of reducing, reusing and recycling. In the paper written by Alshuwaikhat and Abubakar (2008), universities are compared with some smaller cities, and environmental management and sustainability at colleges and universities are perceived as necessary. In addition to them, contribution of universities to developments of society, use of resources and protection of the environment are mentioned. In another study related to campus life, it is aimed to construct the foundation for implementation of a recovery, reduction and recycling waste management program at the Campus Mexicali I of the Autonomous University of Baja California (de Vega et al., 2008). In the study, estimation of producing solid wastes, defining solid waste sampling and characterizing samples and analyzing the data are the stages of the study. As a result, the amount of solid waste produced daily on campus is 1 ton. Considering that most of that amount consists of recyclable material, 55% of this amount comes from buildings while 88% comes from gardens, and 85% comes from recreational areas. Then, it is advised that different strategies for reusing waste used paper be implemented. In Elfithri and his friends' study (2012), management of solid waste and recycling wastes at the Universiti Kebangsaan Malaysia is supported by developing the current system. According to study, because of unawareness individuals, it is aimed to

provide individuals with gaining awareness and practices of solid waste management. In order to achieve this, paper recycling boxes are placed in each office. As a result of the study, it is obtained that coordinators are unaware of paper recycling system. Also, while effectiveness of this system is agreed, management system should be improved in the future with the target of zero waste. According to Smyth (2010), waste minimization is provided in solid waste management programs in order to achieve campus sustainability at the Prince George campus of the University of Northern British Columbia. Thus, while campus produced between 1.2 and 2.2 metric tons of waste in one week, waste reduction, recycling and composting activities were used for more than 70% of wastes in the 2007–2008 academic year. In the waste reduction and recycling, the significant amount of materials is made of packaging wastes.

In Turkish education system, ESD is learnt in science courses and elective environmental education courses. As mentioned previously, all aim to enhance students' environmental sensitivity and to improve their sustainable life skills (MoNE, 2013; 2015). Thus, ESD gained importance as being interdisciplinary and totalitarian (Özdemir, 2010; Toran, 2016). As mentioned previous, in Turkey, studies on ESD generally include students in early childhood education. For instance, Toran (2017) reported that there were 17 studies related to early childhood education conducted between 2010 and 2016. Moreover, while variety of studies and teaching methods were provided for the early childhood education (Gülay, 2011), families had significant role in order to enhance environmental awareness and the significance of ESD for individuals (Erkal, Şafak, & Yertutan, 2011).

In addition, in primary level, it was mentioned that Turkish curriculum was in effective in terms of ESD and a regulation in formal and informal education regarding ESD was proposed (Tanrıverdi 2010; Unal, 2011). Moreover, according to the study conducted by Yilmaz, Boone, and Andersen (2004), they aimed to identify ideas of elementary and middle school Turkish students about

environmental issues in the national curriculum and to determine what characteristics such as gender, grade level, previous science achievement, socio-economic status (SES), and school location affect their views. In order to identify them, they developed a scale and applied it to 458 students from fourth grade to eighth grade. Hence, survey items were understood similarly by both female/ male students and elementary and middle school students. Also, if a student has high achievement in science courses, this student has more positive attitude toward environmental problems. Additionally, people with more positive attitudes are older female students and students with high family income in urban areas. In addition, in secondary education, students do not have enough knowledge about international developments about the environmental issues in Turkey, and they have lack of knowledge about some environmental facts (İncekara & Tuna, 2010). Furthermore, Teksöz (2014) stated that since the application of the curriculum of elementary science (3rd, 4th, 5th, 6th, 7th and 8th grade) curriculum which was prepared in 2013 started last year, no data on the results and applications related to sustainable development has been obtained.

Also, in studies about ESD, environmental awareness in education draws attention. For instance, Teksöz, Şahin, and Ertepınar, (2010), analyzed pre-service teachers' environment literacy and the study showed that pre-service teachers had positive attitudes towards environment, use of environment, and they cared for environmental problems. On the other hand, when Oğuz, Çakcı, and Kavas (2011), analyzed students' environmental awareness in the Department of Landscape Architecture, Environmental Engineering and Town and Regional Planning, they encountered that students did not keep abreast of environmental subjects.

All in all, ESD was placed into different courses such as Turkish, social sciences, science or life science (MoNE, 2015). For example, social sciences education program had effects on ESD (Kaya & Tomal, 2011). Moreover, activities in nature provide contributions in terms of ESD (Koçak & Balcı, 2010).

On the other hand, mathematics and geometry courses cannot support ESD as expected. In this case, teaching prisms supported by ESD in fifth grades will aim to investigate students' thinking strategies of classification and nets of prisms and their thinking about the meaning of ESD in terms of recycling and packaging waste. In addition to this, investigating this will help different disciplines support each other. To sum up, there is a gap in the literature about teaching prisms supported by ESD. As a result, contributions to literature about teaching prisms supported by ESD in fifth grades will be provided in order to obtain different thinking of prisms and to gain awareness of recycling and packaging wastes.

CHAPTER 3

METHODOLOGY

This chapter represents the research design and procedures of this study containing eight subtopics which are research design, population and sampling, data collection procedure, data collection tools, data analysis procedure, credibility of the study, quality and ethical issues and limitations. Overall, in this chapter, a general view of the methodology of the study will be given to highlight the main idea of it.

3.1. Research Design of the Study

According to Creswell (2007; 2013), qualitative research is an approach which is used explore and to understand the meaning of individuals or groups in terms of a social or human issue. In addition to Creswell, according to Flick (2013), qualitative research aims to describe details, to compare some cases and individuals and to develop a theory for empirical material.

For the research design of the study, case study was chosen to investigate teaching prisms supported by ESD in terms of fifth grade students' thinking strategies classification and nets of prisms and their thinking about the meaning of ESD in terms of recycling and packing waste. According to Shavelson and Towne (2002), if the research contains a descriptive question such as what happened or an explanatory question such as how or why something happened, case study is convenient to apply. Moreover, type of questions, extent of control over behavioral events and general conditions of the case to be studied are significant in deciding the type of research design for case study (Yin, 1994). Additionally, Creswell (2009) states the importance of case study since it contains up-close, in-depth and detailed analyses of the natural settings with contextual conditions. For

the case studies, it is necessary clear and detailed context of the case study (Denscombe, 2003) in order to get first-hand and in-depth understanding of the related situation by means of direct observations (Bromley, 1986). As a result, according to Yin (2004), the case study has strengths because of its ability to examine a case within its real-life context.

3.2. Population and Sampling

According to Frankel and Wallen (2006), sample is called a group from which data is obtained, and population is the group on which results are applied. In this study, the target populations of the study were defined as all 5th grade students attending public schools in Haymana, Ankara. On the other hand, the accessible population of the study consisted of 5^{th} grade level students enrolled in a public school in Haymana, Ankara because it was not possible to access the target population.

Because of the case study research design in which results of the study were not generalized, purposeful sampling was used in order to select the sample of the study. Also, when the needs of the study and obtaining more information about questions were taken into consideration; the suitable method was purposeful sampling (Creswell, 2013; Frankel & Wallen, 2006). In other words, it was a technique in qualitative researches in order to identify and to select the information-rich conditions (Patton, 2002). In this sampling method, participants were volunteers to participate in the study, to share their experiences, to reflect their opinions and to have knowledge about the topic (Bernard, 2002; Creswell & Plano Clark, 2011; Spradley, 1979).

According to Merriam (1998), some criteria were defined for sample selection. In the current study, participants were 18 students, 9 male and 9 female students, from one 5th grade class since members of this classroom made effort to collect batteries in order to provide their recycling. Also, the researcher was the mathematics teacher of this classroom. Hence, those students were selected

because of the application of the case study. Furthermore, based on different answers of students in the activities, 7 students were selected for the interview through purposeful sampling method which was useful in selecting participants who would be interviewed in the current study. These participants had different aspects or specific approaches in classroom discussions by giving different answers and examples, and they used specific terms about prisms or ESD in activity sheets. For instance, one participant was more interested in recycling. Two of seven interviewers had different ideas about the prisms (P7 tried to fold nets of prism to check whether it was folded or not or P12 who was the first one used the term *prism* before prisms were called with formal names). On the other hand, other two interviewers had difficulty in defining the nets of prism, but they had interest in sustainability and recycling. However, the last two participants did not have any different ideas about either prisms topic or recycling.

3.2.1. Context of the Study

In this part, the classroom where the study was carried out is introduced. This classroom where 25 students can easily sit had 18 students. Besides, it had enough space to walk among students when different seating arrangements of students were applied. There were 9 female students and 9 male students in the classroom. Additionally, there were 2 Syrian students, 1 female student and 1 male student in the classroom. Socioeconomic status (SES) of students was evaluated as middle and low. Also, students had been collecting batteries in order to recycle since the beginning of this semi-semester. However, since the number of paper recycling boxes was limited, students were unable to recycle paper showing sensitivity to battery recycling.

During the study, participants were divided into groups of four or five. In this formation, equality in the number of female and male participants and their achievement levels were considered. Also, all participants were able to see each other easily.

Figure 1. Context of the study.

Before the application, students were informed about the study. Also, they were informed when and what type of boxes they would bring in one month before implementation, and during this one month, students were regularly reminded to bring their boxes. Participants found boxes from the supermarkets which exemplified both kinds of prisms and packaging wastes. Then, these boxes which were used in the application were placed in one of the corners in classroom. During the application, they picked their boxes from the corner, and they worked with them in their groups. Then, they moved around the classroom in order to classify boxes or observe each other closely. Also, activity sheets were distributed by the teacher and participants completed them during the given time in the class hour.

3.3. Data Collection Procedure

The data collection procedure is introduced in two parts. In the first one, planning process and in the second one implementation process are explained in detail. Before collecting data to answer research questions of what 5th grade students think about the meaning of ESD in terms of recycling and packing waste, what the thinking strategies of 5th grade students for classification and nets of prisms are and what 5th grade students think about learning prisms using instruction supported by ESD, the process was planned, and then it was applied.

3.3.1. Planning Process

The data was collected in the spring semester of 2016-2017 academic year, and it was expected to last 5 class hours in one week. At the school, each lesson

hour lasted 40 minutes. In the study, environmental education curriculum, sustainable education curriculum, elementary science education curriculum, elementary mathematics curriculum and mathematics textbooks published by the Turkish Ministry of National Education were used. According to these, two objectives of the geometry topic in the curriculum and recycling were studied together.

According to mathematics curriculum, the studied objectives were that students were able to recognize the prism of rectangles and to determine the basic elements, and they were able to draw the nets of the rectangular prism and to decide whether the different nets were related to the rectangular prism. In the environmental education curriculum, the objective was that students were able to explain the concepts of recycling and recovery and to contribute to the reuse of recyclable materials.

Based on the objectives in curriculums, activity sheets (see Appendix B) were prepared and the implementation process was planned. Since the seating arrangement in the classroom was U-shaped, the remaining parts were used easily in the first two lesson hours. The boxes were collected in the middle of the class in order to send them for recycling after their classification. In the first hour, students explained the concepts of recycling and recovery in order to provide answer for what 5th grade students think about the meaning of ESD in terms of recycling and packing waste. Based on the objective, they were asked what recycling is, why recycling is needed, what packaging wastes means and which products can be recycled. According to the objective, students also discussed contributions to the reuse of recyclable materials. The meaning of reuse of recyclable materials could be matched with transformation of materials. Additionally, participants gave examples of recycling paper, packaging wastes, plastic and battery. Also, different examples were mentioned. After discussing questions, participants watched a video (http://www.cevkococuk.org, 2016). In this case, students were expected to compare their thoughts about related

questions before and after the video. In order to make comparison, the discussion environment would construct in the classroom. At the end of first hour, students would be divided into four groups, two groups with five students and two groups with four students in order to study with their group members in teaching prisms. The number of girls and boys in the groups and the success of them were close to each other. The students were going to classify the boxes for recycle. Hence, students made use of the boxes for the classification and the boxes were classified as kind of prisms such as rectangular prism, square prism and cube. However, students first made this classification according to their shape of surfaces, not their formal names. Students grouped prisms by measuring them with the help of informal ways or a ruler. Thus, students were also asked to bring a ruler with them.

In the second hour of the day, the aim was answering what the thinking strategies of 5th grade students for classification and nets of prisms are. Hence, the objective focused on the fact that students were able to recognize the prism of rectangles and to determine the basic elements. In order to achieve this, students would classify boxes. Different corners of the class were used for this. Firstly, participants decided the shape of surfaces by measuring the length of edges with informal or formal methods. To illustrate, they measured it with their pencils or with their rulers. As a result, it was expected there were rectangular or square shapes. If all shapes of surfaces were rectangle, this would be the first group. If all shapes were square, this would be second group, and if there were both rectangular and square shapes, this would be the third group. Then, second classification was done with respect to the number of corners, edges and surface of these boxes. For this, participants counted numbers, and they achieved the idea that boxes were in the same group. For the last classification, participants would decide the shape of bases of boxes by measuring the length of edges. After they decided kind of bases, formal definitions of prisms were given. In this case, it was expected that participants would use the formal names of prisms while classifying. After measuring, they again placed boxes in groups. In this case, the first group

contained rectangular prisms. The second one included square prism, and the last one involved cubes. For each classification, it was questioned whether boxes were in the right group, and if the boxes were in the wrong group, they were sent to the correct groups. After all the boxes were collected in their groups, students explained how they made this classification. Students were expected to show their work on the activity sheets which would be given two different papers (Activity Sheet 1, see Appendix B). In the first one, students solved the problem which included the relationship between paper and tree. Then, they defined recycling, packaging waste. Then, they answered why we needed recycling and which materials could be recyclable. In the second paper which was given before the last classification, students answered questions about classification of prisms, their names and the number of corners, edges and surface of prisms.

The aim of the second day was to prepare students to draw the nets of the rectangular prism. For this, students firstly unfolded some boxes by dividing them into pieces since they would construct nets of prisms. As mentioned previously, in order to send the boxes for recycling, participants mentioned that space saving was necessary, and they discussed how to save space and what benefits there might be. Also, this was matched with the importance of less consumption, continuation of life or protection of environment. At the end of the discussion, it was expected that participants would go for the open status of the box. This could be matched with the nets of prisms. Later, how to construct the nets of prisms would be discussed. In order to construct these, each group of students chose a box and constructed the nets of prisms by using its pieces with respect to examples related to the nets of prisms (activity sheet 2.1, see Appendix B). Thus, participants constructed five different nets in one kind of prism such as a cube, a rectangular prism or a square prism. After completing the construction of nets, each group presented their own kind of nets, and they tried to decide what kind of prism it could be. Then, the similarities and differences in the nets were discussed. Also, participants shared what difficulties they experienced in constructing nets or how they dealt with these. Then, all participants chose a box that could be used

without unfolding in order to draw the nets of prism individually. If they wanted, they could fold boxes. After drawing on activity sheet 2.2 (see Appendix B), participants were expected that they would match folding situation and unfolding situation of boxes. In this case, participants were expected to find no difference between folding situation and unfolding situation of prisms. As a result, participants discussed which situations could and could not construct a prism. According to this, if the shape formed a prism, participants could name them, and also they would explain reason of this matching name with kind of prism.

In the last hours, participants decided whether given shapes construct a prism or not in activity sheet 3 (see Appendix B). For this, there were five different shapes in the paper. While some shapes were nets of prisms, some were not because of different reasons such as inequality in length of edges or overlapped surfaces or non-overlapped edges. As a result, it was expected participants would explain their decisions with their reason on the paper. Also, they were asked to name the kind of prisms. At the end of first hour, participants shared their decisions and explained the reasons of this decision in the classroom environment. In the second hour of the day, participants would complete an activity sheet 4 (see Appendix B) in order to summarize what they experience and whether there was a relationship between classroom application and daily life. Hence, participants would answer questions such as how they started the lesson and what attracted their attention the most in the lecture, what kind of connection they had with their daily life, how they classified the boxes and what kind of boxes they used in our daily life. In addition to these, participants answered the questions what they paid attention to when classifying these boxes, why it was important and what benefits individuals were provided by using what we do in this lesson in our daily life. Also, participants were expected to write if they had other suggestions with their explanations.

All in all, participants were selected for the interview according to their answers, explanations and discussions in classroom. During the interview,

participants were expected to define prisms, to classify them and to define recycling and packaging wastes. Moreover, they exemplified packaging wastes, connected relation between nets of prism and kind of prism and explained needs for surface saving and recycling. Also, participants had special questions related to their answers, explanations and discussions in classroom.

3.3.2. Implementation Process

The implementation hours of the current study lasted more than 5 class hours because of some reasons. All teaching and learning activities were applied during the lessons. Interview was conducted after activities were completed.

During the implementation of the first two hours, the application steps changed since participants could not bring their boxes into the classroom on time. Thus, the application started with a focus on recycling. Hence, the objective that students were able to explain the concepts of recycling and recovery and to contribute to the reuse of recyclable materials was the focus. In the first class hour, participants were questioned about why they brought boxes into the classroom and what could be associated with these boxes. According to these, participants associated them with teaching geometry topics such as 2D shapes, 3D objects or measurement. Since they could not connect them with recycling, why they collected batteries in class was asked. In this case, some participants related boxes with recycling. After questioning about recycling and packaging wastes, they shared their knowledge about recycling, recovery and reuse of recyclable materials. Then, they watched a video about packaging of wastes and the process of paper recycling. With the help of this video in ÇEVKO's web page (http://www.cevkococuk.org, 2016), it was aimed that participants would have an idea about what objects are packaging wastes and how recycling of packaging wastes is done. After watching the video, participants discussed the terms and process of recycling again. Also, they continued their discussion about why we need recycling. Moreover, they shared examples of wastes which are recycled. During this activity, they shared their own experiences about recycling of papers

and batteries. In the second hour, they completed the activity sheet 1.1 (see Appendix B). This sheet contained questions about the definition of recycling, necessity of recycling, examples of wastes and definition of packaging wastes. Then, they discussed their definitions of recycling, packaging wastes, importance of recycling and examples of recyclable wastes, again. As a result, the aim of the activities on the first day was that participants would have an idea about recycling and packaging wastes and reusing them. In this course, it was expected to provide answers for the question what 5th grade students think about the meaning of ESD in terms of recycling and packing waste.

In the following two-hour class, the aim was to achieve the objective that students were able to recognize the prism of rectangles and to determine the basic elements. Thus, participants were firstly guided to distinguish and classify boxes in terms of their shapes of surfaces. In order to achieve this, participants decided the kind of shapes of surfaces on boxes by measuring. Instead of using a ruler, they measured the length of edges by using a pencil, pencil box or spanning. Then, they found shapes as rectangle and square, and they classified according to shape of surfaces firstly. There were three groups in the first classification. According to this, one group contained only square shapes on surfaces and another one contained only rectangle shapes on surfaces. There were both rectangle and square shapes on surfaces in another group. Then, these group names were formed with respect to the number of rectangles and squares on the surfaces. For example, the first classification group had both rectangular and square surfaces. The second group had only rectangular surfaces, and the third one had only square surfaces. In this activity, participants also gained idea about the surface, corner and edges by counting them. In this case, they constructed second classification groups. As a result, they recognized that these boxes were not different from each other in terms of the number of edges, corners and surfaces. Then, last classification was formed according to the base of prisms by participants. Before classifying, participants decided bases of boxes and shape of bases of boxes. They again benefitted from measuring with informal ways. After

boxes were classified according to their shape of bases, participants completed the activity sheet 1.2. This sheet contained questions about classifying prisms, matching examples of prisms on worksheets with the types of prisms and showing edges, corners and surfaces of prisms. Then, answers were discussed by participants and formal definitions of prisms were given. Hence, participants classified prisms in terms of rectangular prisms, cube and square prisms. Then, they distinguished differences between rectangular prisms, cube and square prisms. During these, participants defined basic properties of prisms. All in all, the aim of the activities of first two days was that participants would gain knowledge about classification of prisms, properties of prisms.

In the next class, students tried to draw the nets of the rectangular prism and to decide whether the different nets were related to the rectangular prism. Hence, in these hours, participants also tried to support teaching prisms with ESD through recycling and surface covering. Moreover, they tried to form different nets of boxes or prisms, and to match different nets with prisms. During this process, the importance and the need of surface covering of boxes were participants' focuses. In the first hour, participants were asked to compare the folding and unfolding status of the box in terms of its surface covering. For this, this example was given "*You tried to carry these boxes on a truck. Which is more advantageous for environment while carrying them- open or closed? What can these advantages be?*" After discussing results and dividing boxes into their pieces, participants completed activity sheet 2.1 (see Appendix B) which was about constructing nets of prisms. Also, they tried to call them with their formal names. They explained their experiences after constructing all nets of prisms. During this, they mentioned how to construct, what difficulty they had, why they had this difficulty and how to overcome.

Then, they started doing activity sheet 2.2 (see Appendix B) which was about drawing nets and matching it with suitable classification group. In this paper, participants tried to draw nets of their boxes by considering quality in

length of edges, overlapped edges and non-overlapped surfaces. Then, they tried to call them correctly and they tried to explain why they chose this name. In the activity sheet 3 (see Appendix B) which had questions about whether nets defined a prism or not, participants tried to associate nets with the right kind of prisms. Also, if the shape did not mention a kind of prism, participants explained its reason. Otherwise, if the shape did not form a prism, participants could name them. After doing the activity sheet, they shared their answer with other participants. As a result of two hour-class, the aim of these activities was that participants would gain knowledge about nets of prisms, differentiation of nets and the importance of less surface covering which provided space saving in order to save nature.

In the last hour, participants explained what they learnt during this application, and they defined some terms such as prisms, kinds of prisms, recycling and packaging wastes by writing it on an activity sheet 4. Hence, activity sheet 4 (see Appendix B) was also applied in order to provide the relationship between courses and daily life and assessment of participants in terms of their understanding. At the end, they discussed their answers.

In the interview, after the application of the activity, seven participants answered questions about prisms and recycling. Also, they answered questions that include the teaching prisms supported by ESD and what they changed in their environment in terms of recycling. Participants who were interviewed answered the questions about their expressions about what they did differently or defined differently in the application.

3.4. Data Collection Tools

During the lessons, teaching and learning activities were recorded with a camera. Participants were observed by the researcher, and activity sheets were completed by the participants. In the end, selected participants with respect to their different answers and approaches in implementing process, 5 female and 2

male, were interviewed. Data collection was done through documentation, observations and interview that are explained below.

3.4.1. Documentation

According to Yin (1994), there are six sources of evidence such as documents, archival records, interviews, direct observation, participant observation and physical artefacts. In this case, documentation was one of the data collection tools in this study. According to Bowen (2009) documentation is used to provide data about the context, to obtain information about questions, to provide supplementary research data, to provide change and development, and to verify findings or corroborate evidence from other sources. In this study, activity sheets which contained subtopics of prisms and recycling were used to collect data.

Before the study, participants were informed about the content of the courses. In addition to this, course content and activity sheets were prepared according to the curriculum and textbook, and they were controlled and organized by the researcher/ mathematics teacher and advisors.

All activity sheets were collected from participants after they completed them. All the questions apart from activity sheet 4 were discussed in the classroom after all participants completed the answers. In this case, while some questions were discussed at the end of the lesson, some were discussed at the beginning of the lesson as a continuation of the previous lesson. Hence, participants who voluntarily shared their answers obtained feedback about their answers. Data about the answers of these participants was obtained from both the activity sheets and observation notes. Answers of the other participants were obtained after analyzing their activity sheets.

3.4.2. Observation

One of the data collection tools was observation in which the researcher directly observed and interpreted participants' behaviors and discourses simultaneously. In the content analysis, observation was used (Hsieh & Shannon, 2005) since its purpose in this study was to show connection between the results of documentation and interview during the teaching prisms supported by ESD.

Creswell (2013) mentioned the importance of observation protocol with two parts such as descriptive and reflective. However, teacher was the researcher of the study. Hence, lessons were recorded with a camera in order to see details in observation notes. Data from those records was transcribed.

In observations, it was expected to obtain whether there was somebody who gave different examples about recycling, who had different aspect about packaging wastes, who behaved differently in classifying prisms, who used terms about prisms or recycling first or who had different ideas about constructing or drawing prisms.

3.4.3. Interview

According to Frankel and Wallen (2006), interviewing has an importance for a researcher in order to control accuracy of impressions sourced from his/her observations, and its purpose can be defined as finding out what is in people's mind. In the current study, seven students were selected to be interviewed about their answers in the activity sheets, their different ideas and examples in the classroom and their approaches to sustainability and geometry teaching within the context of prisms topic. During the application, these seven students gave specific examples which were not used by other participants and they used different terms and approaches in the class. Additionally, although some had misunderstandings about especially prism, they tried to overcome them by themselves. Hence, interviews were used to identify and clarify participants' answers and approaches.

All interviews were face-to-face, and they were conducted in accordance with the participants' lesson program. Interviews were conducted individually during the school hours. Sufficient time, approximately 1- 1.5 minutes, was given to students and if they had difficulties, guiding questions were asked by the researcher. Besides, direct tips about the topics were not given during the interviews, but they were reminded of their answers that they gave in the activity sheets. Questions were repeated and explained when necessary. These seven participants' interviews were recorded, and then they were transcribed for analysis. The total duration of interviews was approximately 75 minutes (see Appendix C for the transcription of the interview).

3.5. Data Analysis

In this section, data analysis of the current study was explained. Data was analyzed using qualitative research methods. Data sources included students' documents, recordings, observation and transcriptions of interviews. Moreover, participants were expected to reflect on their thinking and explain the strategies that they used rather than giving the correct answers.

In order to interpret data in case studies, there are two analyses which are descriptive analysis and content analysis (Strauss & Corbin, 1990; Özdemir, 2010; Wolcott 1994). Since descriptive analysis was more superficial than content analysis, in the current study, content analysis, which is the most used analysis type in qualitative methods, was used (Özdemir, 2010) and the current study was supported by visual representations, written documents and verbal discourse (Krippendorff, 1989). Hence, in order to examine the related research questions, content analysis method in qualitative research method was used. Also, Stemler (2001) mentioned that content analysis is a strong way for data reduction or data categorization in the qualitative research since it contains systematic and replicable techniques for grouping words in categories. Moreover, Weber (1990) mentioned that content analysis enables researchers to characterize the focus of individuals, groups or social consideration. Furthermore, Mayring (2014)

highlighted that content analysis is a systematic way in order to analyze texts by categorizing data. Besides, Holsti (1969; as cited in Stemler, 2001) defined content analysis as a basic research tool due to some of its characteristics. In addition to them, Hsieh and Shannon (2005) displayed three distinct applications of content analysis in practice. While coding categories are sourced directly from the text data in the conventional content analysis, they are done from a theory or relevant research findings in directed content analysis. In the third one, summative content analysis is conducted by counting the keywords and comparing them with the interpretation of the basic context.

Also, Krippendorf (1989; 2004) stated that the roots of content analysis in qualitative approaches consisted of literary theory, the social sciences and critical scholarship, and he believed content analysis contained verbal, pictorial, symbolic, and communication data in order to make inferences. As this study contains observation, documentation and interview during teaching prisms supported by ESD, by using content analysis methods, the researcher had the opportunity to compare these three data sources and to improve deep change of understanding in students' sustainability attitude. In addition, the researcher has an advantage to develop another deep understanding about interdisciplinary approach in education because this design can help participants reflect on their own experience.

For the content analysis, open coding was used. A code refers to a word, a short phrase or a sentence to display the data (Saldana, 2015). In the open coding, large amount of data was converted to fewer content categories (Weber, 1990), and notes and headings were formed in reading the materials (Hsieh & Shannon, 2005; Elo, & Kyngas, 2008). In this case, coding was perceived as a method enabling researchers to construct families which had similar characteristics (as cited in Saldana, 2015). The Figure 2 below shows the basic process.

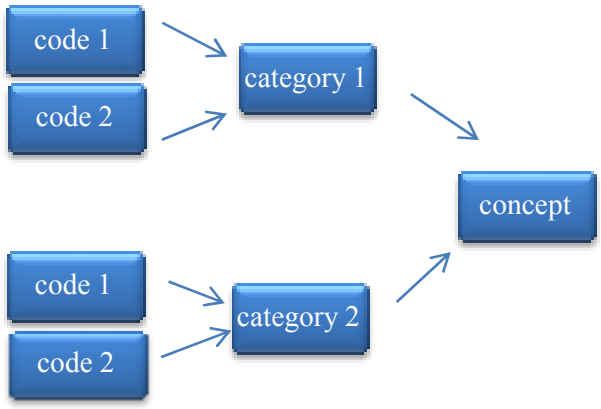

Figure 2. How to organize concept in coding (Adapted from Saldana, 2015, p. 13).

The first data source of this study was documentation which included activity sheets which were gathered from participants. These documents were also used to determine whether additional questions are needed during the interview. In order to analyze them, these documents were checked several times and open coding was used. Hence, important words or word groups or numbers were used to obtain necessary items. The activity sheets were sorted according to topics.

Observation notes and videotape recordings were the second data source. They were used together since the researcher was alone in the classroom, and during these times, the researcher could not observe all participants at the same time. Hence, videotape recordings were watched several times, and these recordings were matched with observation notes. Also, deficiencies in observation notes were completed by the help of these recordings. The third data source for the study was interview. As in analysis of the document, the same procedure was applied again in order to analyze the data from the interview. After the transcription of the interviews, open coding which was one of the techniques of analyzing textual content was done. It contained labeling concepts, defining and developing categories based on their properties and dimensions (Khandkar, 2009).

3.6. Reliability of the Study

According to Lincoln and Guba (1985), external validity, internal validity, reliability and objectivity are mentioned as the classic criteria for reliability in studies. However, qualitative research differs from quantitative one in terms of validity and reliability (Agar, 1986; as cited in Krefting, 1991). Hence, qualitative researches have indicators. These indicators are provided as reliability, transferability, dependability and confirmability which refer to internal validity, external validity, reliability and objectivity, respectively (Lincoln & Guba, 1985). Those items are explained in detail below.

Credibility as mentioned previously corresponds to internal validity, and there are some ways to construct credibility (Lincoln & Guba, 1985), which can be exemplified in the current study. Firstly, prolonged engagement was the one of them. It refers to spending time to get to know about the culture or social environment of the study environment. Since the participants were students and the researcher was their mathematics teacher, they were familiar with each other as the teaching environment that the study was conducted had been same for approximately one year. The second one is persistent observation whose purpose is to provide depth understanding and identification of characteristics and elements of problem or issue in details. During the study, participants answered the same questions and explained the same situations several times with different perspectives. Additionally, member checking was performed in order to ensure the accuracy of obtained data (Creswell, 2013). Triangulation was also used during the analysis. According to Denzin (1978), there were four types of triangulation which are use of multiple sources, methods, investigators and theories. In the study, multiple sources were beneficial for providing triangulation. For instance, documentations, video recordings and observations were used to reach the expected results of the research. Lastly, peer debriefing was used in order to enhance credibility.

Transferability indicates external validity in qualitative studies (Lincoln & Guba, 1985). In other words, it shows whether the results of the study can apply to different and new situations. However, according to Krefting (1991), because of situational uniqueness of qualitative researches, this is difficult. Another difficulty that is mentioned is that these studies are applied in limited number of environments and individuals (Shenton, 2004). In order to enhance transferability, there are some strategies (Krefting, 1991). One of these is sampling method. In this case, purposeful sampling was suitable for this study because participants served to the purpose of the study in interviewing. Another strategy is defined as giving detailed background information about the aims and context of the study. The aim of this strategy is to provide connections between participants' background and their learning outcomes. In addition, this strategy might help other researchers to develop new assumptions with respect to findings of the study. The last one is considering data rather than subjects. In other words, it is decided whether the content of study which can be classified as typical or atypical is suitable for participants' lives. In order to identify typical data, time sampling and member checking can be used. In the current study, time sampling was used during application since participants were repeated what they did or said previous papers and classroom discussions. Also, member checking was supported with interview. In this time, participants were asked about what they did and said and why they did. As a result of these, it was expected that there was a consistency between their doing and saying at different times.

Dependability addresses to reliability (Shenton, 2004) and relates to the consistency findings (Guba, 1981; as cited in Krefting, 1991; Lincoln & Guba, 1985). In order to enhance dependability, same strategies as in credibility can be used (Lincoln & Guba, 1985). Since this study could not be repeated in this class, all actions were recorded and transcribed. Then, these were watched, listened and reviewed several times.

Confirmability refers to objectivity (Lincoln & Guba, 1985). However, because of inevitable researcher bias, real objectivity is not supplied (Patton, 1990). Hence, triangulation is helpful to enhance confirmability. Besides, the aim and role of researcher was explained in detail to remove researcher bias.

3.7. Quality and Ethical Issues

In order to collect data, the researcher took all the necessary permissions. First of all, the researcher firstly applied to the Research Center for Applied Ethics at the Middle East Technical University. After obtaining permission from the university, she applied to Turkish Ministry of National Education ethical committee to get permission for the research in one of the public schools in Ankara. Both committees decided that participants of this study were not damaged mentally or physically.

In addition to these permissions, there were some procedures to conduct the study in terms of protecting the rights of the participants. In order to fulfill these procedures, forms such as parents' consent forms and informative forms about the results of study were prepared (see Appendix D). The aim of these forms was to inform participants who are younger than 18 old and their parents about the study and its effects. If necessary, the pseudonym names (P1, P2, etc.) were used for participants instead of using their real names. Hence, identities of participants and their privacy were protected (Creswell, 2013). Moreover, observation notes along with videotape recordings and interview were only used for the study, and they were kept confidential.

3.7.1. Researcher's Role

Since qualitative researches are interpretative ones (Creswell, 2013), researcher's concerns such as biases, values, and personal background have an effect on the interpretations of the researcher (Locke et al., 2014). As the researcher was the mathematics teacher of the participants, they were not affected

by the researcher negatively during the observation and filling documents. This situation also resulted in the fact that students behaved as usual in the classroom. At the beginning of the study, participants thought that video recordings were strange since the camera was placed on the teacher desk. However, after the study was explained, they easily got used to them.

Moreover, since the researcher who was the mathematics teacher of this classroom had an active role in the study. Thus, all of the lesson implementations and all the interviews were recorded in order to minimize her biases during data collection and their analysis. Additionally, during the study, the researcher had interaction with the participants. Hence, in addition to observation and interview, this interaction helped the teacher during the study.

3.8. Limitations of the Study

Firstly, this study was limited in terms of the sampling method since using non-random sampling method affected the generalizability of the study (Frankel & Wallen, 2006). 9. In this case, purposeful sampling methods were used to select the sample according to the needs of study in interviews. Another limitation of the study is sourced from the type of study. Because of being a case study, there were 18 participants in one of the fifth grade level classrooms. Hence, data was obtained only from one 5^{th} grade level classroom at a public school. On the other hand, the aim of the content analysis was to examine a situation in depth (Yin, 2013) instead of generalizing. Also, during this process, although the researcher tried to be objective, she might have behaved in a biased way since she is the mathematics teacher in this public school.

Furthermore, content of the study was limited. For instance, the current study included topics such as prisms in 5^{th} grade level geometry and recycling in ESD. In other words, while prisms were only considered for classification and nets of prisms, ESD was only considered for recycling and packaging wastes. Therefore, it was suggested to carry out the study on different topics with more

participants. Also, the content was restricted in terms of manipulative use which included boxes or packing wastes. In this case, this content could be supported with dynamic geometry software systems or other virtual manipulative. Moreover, the amount of time, which was only one week according to the yearly lesson plans during 2016/2017 second semester, was limited. As a result, the researcher did not have enough time for extra practices.

CHAPTER 4

FINDINGS OF THE STUDY

The purpose of this study is to investigate teaching prisms supported by ESD in terms of fifth grade students' understanding. Hence, the questions what 5th grade students think about the meaning of ESD in terms of recycling and packing waste, what the thinking strategies of 5th grade students for classification and nets of prisms are and what 5th grade students think about learning prisms using instruction supported with ESD were answered.

In this chapter, findings of the study and participants' views were summarized under three headings by considering the order of implementation. The first topic is related to ESD and included questions such as what recycling means for students and whether they have gained awareness of the importance of recycling after implementation courses. The second topic included how they classify prisms, what affects this classification and how participants define prisms. This part also consisted questions such as how to construct nets of prisms, how to draw them, how to fold them and the relationship between the nets and their surface coverage with surface saving. After studying with closed boxes at the beginning of the study, participants worked with the nets in the end. The last topic included teaching geometry supported by ESD focusing on participants of awareness of recycling and packaging wastes during the study. Also, these included students' understanding and their difficulties in current topics.

Detailed analysis of participants' performance in the tasks was presented on the basis of correctness and depth of the ideas they proposed. Their responses obtained in each section were documented, and some of those, which are writings of students in the activity sheets and direct quotations from interviews,

observations and video records, were shared. For data analysis, the main topic "Boxes" was analyzed in terms of its three aspects which are prisms, ESD and advantages of teaching prisms supported by ESD. Then, these were divided again into subtopics which are shown below (Figure 3).

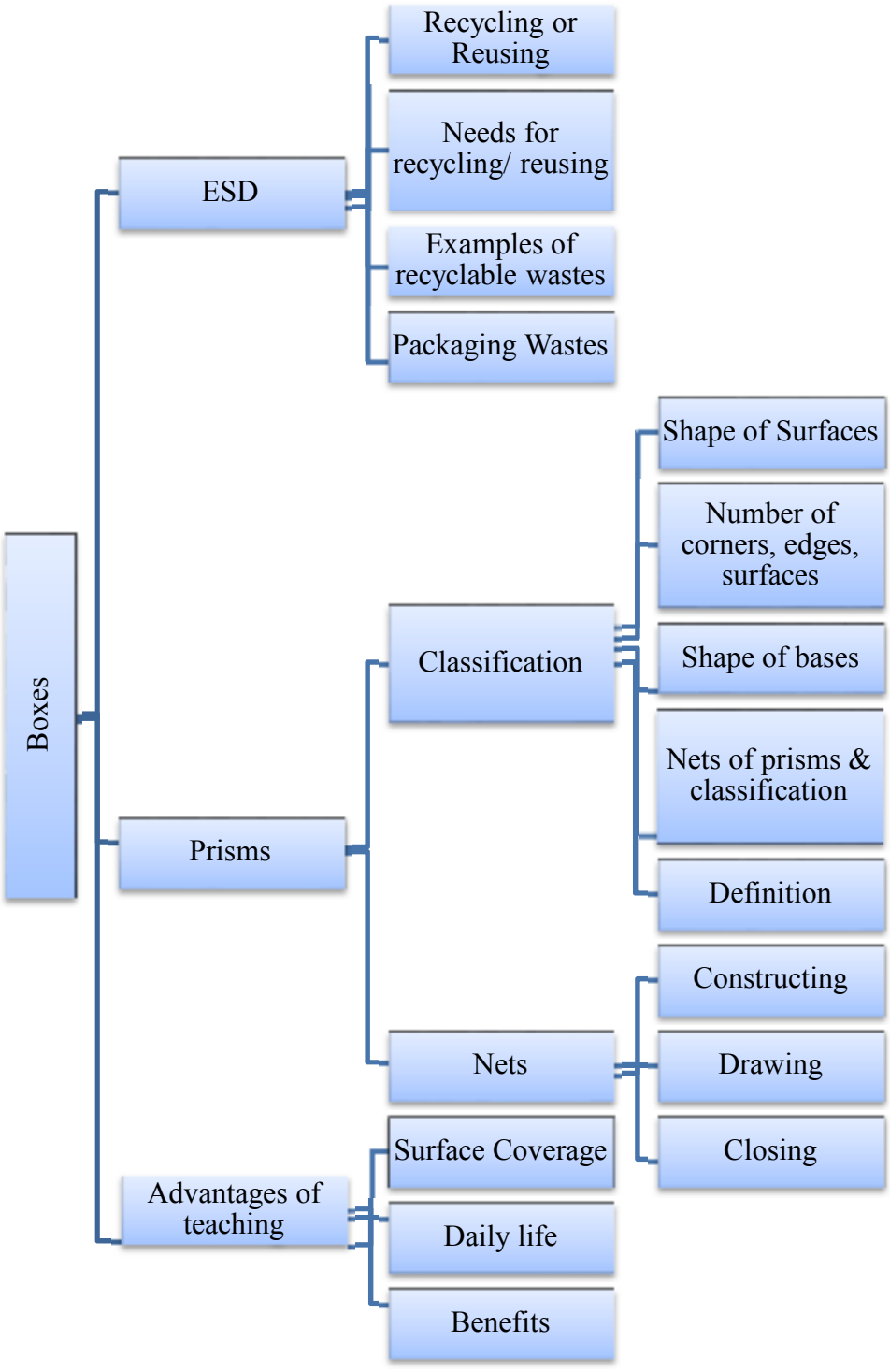

Figure 3. Implementation.

Figure 3 was created based on overall data analysis, and the categories were organized according to the obtained data. Based on the Figure 3, the study consisted of three main themes such as ESD, prisms and advantages of supporting, respectively. Also, while ESD is expressed under four subtopics which are recycling, reusing, needs for both of them, examples related to recyclable wastes and packaging wastes, prisms were analyzed under two subtopics in terms of their classification and nets and advantages of supporting was also analyzed with different aspects in terms of daily life, benefits, and participants' suggestions and their opinion.

4.1. Education for Sustainable Development (ESD)

In the current study, education for sustainable development focused on recycling and packaging wastes in order to answer what 5th grade students think about the meaning of ESD in terms of recycling and packing waste. For this, the objective that students were able to explain the concepts of recycling and recovery and to contribute to the reuse of recyclable materials was used. Additionally, at the end of the study, it was expected that participants would have an idea about the terms related to recycling, packaging wastes, and importance of recycling, and that they could try to make an effort to increase the amount of recycling and decrease packaging wastes.

At the beginning of the lesson, participants got informed about outline of current lesson, and then they watched a video. Before watching it, participants discussed the terms in topic. Also they were instructed to focus on these terms and processes in that video since they would discuss those after watching it (http://www.cevkococuk.org, 2016).

After the classroom discussion about the video, participants did the activity sheet 1.1 (see Appendix B). In the activity sheet, participants answered questions such as what definitions of recycling and packaging waste are, why recycling is necessary and which wastes are recyclable. Furthermore, in the video,

it was mentioned that 17 trees are cut for 1 ton of paper. In the first question of the first paper, participants were asked to calculate how many boxes were needed for 17 trees. Hence, the recycling was remarkable for participants. Moreover, the aim of some questions in activity sheet 4 (see Appendix B) and in interview showed similarity with the aim of activity sheet 1.

After the obtained data was evaluated, the following results were obtained. As a result, four main topics appeared in the analysis. The first one was the definition of recycling, and the second one was needs for recycling. Also, the third one was about examples of recyclable waste, and the last one was about packaging waste. The answers of participants were presented in these parts.

4.1.1. Is It Recycling or Reusing?

In answers, it was seen that participants thought that reusing is equal to recycling. Also, transformation of wastes was very frequent in the answers of participants.

As for the findings of documents and observation, recycling was perceived as life by one participant and as reutilization of creatures and objects by another participant. Furthermore, one defined it as making something new, and one responded that it was recycling of old things. While one participant stated that recycling was reusing batteries, two participants mentioned that recycling was reusing papers.

When P2 mentioned some steps of recycling process (Figure 41a, see Appendix A), she was the only person who could be affected from the video since this process was mentioned in it. Moreover, while one participant mentioned the kind of transformation for boxes, another one did this for wastes. In this case, there could be difference between both participants in terms of using terms.

According to one participant, recycling could be a kind of transformation. In this case, waste could be transformed into the newest object. However,

participants did not mention stages of recycling process. Moreover, two students described recycling as throwing wastes to recycling boxes. While one student preferred reutilization of wastes instead of throwing them away, one student underlined not only recyclable products but also its importance in order for the environment to turn green (Figure 41b, see Appendix A).

Also, three of them stated recycling could be done for products if their usages were completed. Of these three participants, only two mentioned that wastes were refurbished and one participant stated wastes were recycled with the help of recycling.

In general, six participants stated that if products lost their use, they could be recycled. Also, three participants thought wastes were sent to recycle bin. Moreover, one participant illustrated how batteries were collected for recycling in the classroom where students bring in used batteries for recycling (Figure 41c, see Appendix A). Additionally, definition of recycling in documentation and observation is shown in Table 1.

Table 1

Data Analysis Results: Documentation and Observation - What is recycling?

Recycling is	**Number of participants**
Life	1
Making something new (after losing products' use)	6
Transforming the oldest into the newest	2
Reusing (batteries, paper)	3
Recycling of paper	1
Sending wastes to recycling bin	3
Returning	2

When one participant mentioned that wastes were gathered in a special place for recycling, another stated that wastes were gathered in special boxes. Besides, while two participants underlined that recycling referred to

transformation, one participant defined it as reusing, and two participants defined it as returning.

In the interview, when seven participants were interviewed, they showed different aspects in definition of recycling. The answers were shared below:

> **P2:** After recycling, individuals can use the same thing. Also, recycling is necessary for the prevention of trees from being cut.
>
> **P3:** We support recycling in order to protect nature.
>
> **P7:** We prevent cutting trees and we aim to reuse the same thing.
>
> **P12:** Recycling was transforming the oldest into the newest one. As a result, we can protect papers.
>
> **P13:** Thanks to recycling, wastes are turned into products. Thus, environment and trees cannot be damaged.
>
> **P15:** It is the protection of nature and the prevention of trees from being cut.
>
> **P16:** It is our life. In other words, it is necessary to continue our lives.

As a result, one defined it as life. Also, while two identified it as reutilization, one defined it as transforming the oldest into the newest. Besides, two said that its duty was to protect nature, and one stated that recycling was transformation. Additionally, definition of recycling in the interview is shown in Table 2.

Table 2

Data Analysis Results: Interview - What is recycling?

Recycling is	**Number of participants**
Life	7
Reusing	1
Transforming the oldest into the newest	1
Protecting the nature	2

According to all, recycling was perceived differently by participants. In this case, some participants might have perceived recycling as transformation because of the Turkish meaning of recycling. Additionally, some might have expressed it as the protection of nature in order to support less consumption. Also, others might have connected recycling with an experience. In the next part, participants answered why recycling is necessary.

4.1.2. Is Recycling Necessary? Why?

When participants answered the question why recycling is necessary, ten different statements appeared, and some participants used more than one of these statements. In this part, participants had the perception that recycling had the same meaning as reusing.

When documents and observation results were analyzed, some different perceptions were obtained from the participants. According to these, seven participants gave importance to recycling in order not to cut trees (Figure 42a, see Appendix A). In this case, it was thought that participants were affected from the video about recycling of packaging wastes.

While two participants mentioned that it was necessary since individuals produced more garbage, two participants gave importance to it in order to make life easier, and it was helpful to humans (Figure 42b, see Appendix A).

Also, three participants supported it for protection of nature and environment, and one wanted the environment to turn green. In addition, one participant did not want nature to die and this participant thought that recycling was necessary for healthy and safe life. In addition, another one wanted recycling for regenerating and one did not want the products to be wasted.

Moreover, one participant wanted individuals to get sensitive about this topic, and two participants stated if wastes were not recycled, the amount of oxygen decreased. Another one added that ozone layer could be damaged without

recycling and one participant gave importance to the ozone layer and she mentioned the importance of oxygen for creatures (Figure 42c, see Appendix A). Additionally, reasons why recycling is important is shown in Table 3.

Table 3

Data Analysis Results: Documentation and Observation – Why is recycling necessary?

Recycling is necessary in order	Number of participants
To provide healthy and safe life	2
To make life easier	2
Not to cut trees	7
To protect nature/environment	3
To protect ozone layer	1
Not to decrease the amount of oxygen	2

Additionally, in classroom discussion, while one of the participants claimed that recycling is important in order to prevent toxic gas, another one valued it to save it from solar radiation.

In addition to documents and observation, seven participants answered why recycling was necessary in the interview.

> **P2:** Recycling is necessary to prevent trees from being cut.
>
> **P3:** We can protect nature.
>
> **P7:** We can prevent trees from being cut and we aim to reuse same thing.
>
> **P12:** We can protect papers.
>
> **P13:** Environment and trees cannot be damaged.
>
> **P15:** It is the protection of nature and it is the prevention of trees from being cut.
>
> **P16:** It is necessary to continue our lives.

According to the answers, one believed that it was necessary for the continuation of life. While one aimed to protect papers, four aimed not to cut trees. Also, one had the purpose of protecting nature while one did have the purpose of environment. These are also shown in Table 4.

Table 4

Data Analysis Results: Interview - Why is recycling necessary?

It is necessary in order	Number of participants
Not to cut trees	4
To protect paper	1
To protect nature/environment	2
To continue life	1

All in all, participants understood that recycling was necessary to protect nature and to provide continuity in life.

4.1.3. Examples of Recyclable Wastes

After participants answered how to recycle wastes, they gave examples for recyclable wastes. According to answers in the activity sheets (see Appendix B), participants were grouped based on the examples of recyclable wastes in their activity sheets. All of them used paper as waste for recycling.

While ten participants illustrated batteries since they gathered batteries in classroom for recycling, nine participants gave recycling of glass as an example. Also, eight participants mentioned plastic wastes, and four participants stated bottles, but they did not mention their types. Moreover, while two participants stated glass bottles, one suggested plastic bottles. In addition, two participants gave used oil as an example, and two mentioned boxes as an example for recycling. Furthermore, one for each exemplified tree, stone, frazzling objects and vegetables or food. These are shown in Table 5.

Table 5

Data Analysis Results: Activity Sheet 1-Q5- What are examples of wastes for recycling?

Example	Number of participants
Paper	2
Paper, battery, glass	2
Paper, glass, plastic	1
Paper, battery, bottle	1
Paper, battery, bottle, plastic	3
Paper, bottle, glass, plastic	3
Paper, battery, glass, oil	1
Paper, battery, box, oil	1
Paper, battery, box, glass, rock, tree	1
Paper, carton, frazzling attires	1
Paper, battery, glass, plastic, vegetable, food	1

According to these, participants mostly focused on battery and paper recycling. Additionally, while some of them gave glass and plastic as examples, some might have been affected by classroom discussion and gave vegetable, food and oil as examples. However, the reason why one participant gave rock as an example is unknown.

By carrying out observations in classroom, one participant asked whether all the creatures were recyclable or not. Then, some participants tried to exemplify how creatures were recycled if possible. Then, while one of them mentioned leaves falling from tree during fall and snakes molting, another one proposed that people could be recycled after death.

> **P6:** When snakes molted, this could be recycling.
>
> **P4:** People could be recycled after dying.
>
> **P16:** In fall, leaves drop from tree and then they transform. They could be used as plant-food.
>
> **P13:** After certain procedures, some products could be used as fuel in transportation.

This question of participant might have resulted in the fact that other participants wrote examples such as animals, plants, wood or vegetables and fruits in activity sheets. In addition, one participant exemplified carbon cycle as recycling. While giving examples, one participant, the first person to mention glass bottles were examples of wastes for recycling, drew the figure of a glass recycling bin in which glass bottles are collected for recycling (Figure 4.), in order to exemplify and introduce it.

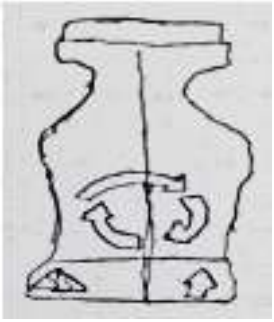

Figure 4. P15's drawing of glass recycle bin.

During the interview, participants exemplified wastes for recycling except paper. Their answers that are wood, fabric, dye, computer, food and animals were different.

P2: Packaging wastes, battery, glass and wood.

P3: Battery, glass, plastic, oil, wood, fabric and dye.

P7: Foods.

P12: Computer, bottle of coke.

P13: Oil, battery, packaging wastes and plastic.

P15: Glass and plastic.

P16: Glass, plastic, paper and animals.

In addition, one participant who drew the glass recycling bin said glass and plastic as an example, and also he answered whether he had interest in recycling because he was the only one who gave different examples such as glass in classroom discussion.

> **P15:** Recycling sounded interesting to me, and also my previous school had projects about it. For example, there were boxes which were owned by ÇEVKO and wastes were classified into suitable bins.

In this case, it can be proposed that participants' experience had an effect on their answers and their examples.

4.1.4. Definition and Examples of Packaging Wastes

Questions such as what packaging waste means and what examples can be given were asked. When answers were analyzed for packaging wastes, only seven participants gave examples, and only eight participants described it. Also, only two participants described and gave examples about packaging wastes. For all answers, nine groups were formed, and some contained definition of packages.

From the activity sheets, some results were obtained. Three participants described package as a protection shield for products and foods since food was wrapped with this matter (Figure 43a, see Appendix A), and consumers controlled whether the package was already opened before or not. While one identified that packaging wastes were lines on boxes, two said packaging wastes were recycling. Besides, one mentioned that it was a plastic bag in order to cover a package, and one said it was a box of product. Also, one participant thought that packaging waste was a waste material, and it was the source of pollution. Moreover, one participant stated that they are labels on different packets. These are shown in Table 6.

Table 6

Data Analysis Results: Documentation – Definition of Packaging Wastes

Packaging waste is	Number of participants
Protection shield for products and foods	3
Line on boxes	1
For recycling	2
Waste material/source of pollution	1
Plastic bag to cover package	1
Label on different package	1

Moreover, two participants exemplified that packaging wastes were toy packages, and another participant exemplified packaging waste as an object surrounding the surface of the battery. While four participants mentioned examples such as cartons, packets of chocolate and packages of balloons (Figure 43b, see Appendix A), one participant gave the same examples except packets of chocolate. These are also shown in the Table 7.

Table 7

Data Analysis Results: Documentation – Examples of Packaging Wastes

Packaging waste(s) is/are	Number of participants
Toy packages	2
Object surrounding the surface of the battery	1
Cartons, packets of chocolate and packages of balloons	4
Cartons and packages of balloons	1

In the classroom, after the video about recycling was watched, participants shared their packaging wastes examples, and they started with the definition of packet.

P11: Packaging wastes could be milk boxes, packets of toys or paper cups.

P16: Packets were results of control, and the packages cover the outer surface of the boxes.

P7: While packages protect items, packaging wastes were for recycling of packages.

According to results, the most of the participants did not have difficulty in exemplifying packaging wastes. However, they had difficulties in defining packaging wastes. In this case, it can be said that participants had idea about examples of packaging wastes, but they could not define them.

4.2. Teaching Prims

In this part, teaching prisms in the fifth grade level of mathematics courses was analyzed in terms of their classification and their nets. While learning prisms, participants used boxes such as rectangular prisms, square prisms and cubes. Especially, boxes which were brought into the classroom mostly demonstrated rectangular prisms and two boxes exemplified cubes. Hence, since the formal names of prisms and prisms as a term were not given, prisms were mentioned as boxes. After participants analyzed and shared their ideas about boxes, names of prisms and their relations with each other became clear. During the application, participants distinguished and classified boxes in terms of their surface shapes, the number of edges, corners and surfaces and the bases of prisms. Then, they constructed nets of prisms and drew them. Additionally, they differentiated their closed and open forms by analyzing different nets.

The aim of this part is to investigate the question what the thinking strategies of 5th grade students for classification and nets of prisms are. Hence, the objective is to recognize the rectangular prisms and to determine the basic elements in the first part. Then, the study continued in order to draw the nets of the rectangular prism and to decide whether the different nets belonged to the rectangular prism in the second part.

4.2.1. How Are Prisms Classified?

In this part, it was aimed that students would be able to recognize the prism of rectangles and to determine the basic elements. Participants classified prisms in terms of their shapes of surfaces, the number of corners, edges and surfaces and shapes of bases of boxes, respectively. Each participant had picked one box randomly from the corner of classroom where all boxes were gathered before they analyzed them. For this part, the activity sheet 1.1 (see Appendix B) was used firstly, and it contained the questions how classification was done, how many groups were formed, how boxes could be called, how objects matched with types of prisms and what the number of surfaces, edges and corners was. Also, some questions in activity sheet 4 were used at the end of this application, and these aimed to explain how classification of boxes had been done and what the important consideration(s) in classifying boxes was (were). Additionally, answers for the first paper were discussed by participants in the classroom, and these answers were analyzed in the next sections.

4.2.1.1. According to Shapes of Surfaces

In this classification, participants decided what shape of surfaces the rectangular and square boxes had. In analyzing the results of documents and observations, participants firstly answered what geometric shapes they saw on boxes after they analyzed their boxes. All the participants in the classroom mentioned that they had rectangular and square shapes, and all showed these shapes on their boxes. Then, they explained how they decided whether these shapes were rectangle or square. Some of the students shared their answers in the classroom as below.

> **P13:** I looked at every surface of the box, and then saw that this side was longer than the other. In other words, it had a long side and a short side, and this was valid for other surfaces.
>
> **P3:** I predicted…While this part looked like rectangle, other one looked like a square. For square, I felt its length of sides was

approximately equal to each other. However, for rectangle, length of the sides was different. Hence, I had rectangular and square shapes.

P7: Teacher, I want to share how I decided. I measured firstly. I used my pencil; this is its (pencil's) length. Then I measured all sides. As a result, there was equality in the length of opposite sides, but all sides were not equal to each other, so these were rectangle, and I had only rectangular shapes on my box.

Figure 5. P7 measures the sides of boxes with pencil.

P15: I used my pencil box, and I obtained rectangular shapes.

P2: When I measured by spanning, I had four rectangles and two squares.

P5: I measured with my finger. In this case, some sides are equal to each other in one part, but for the other, these are not. Hence, I have rectangular and square shapes.

Figure 6. P5 measures the sides of boxes with her finger.

While deciding the shapes of surfaces, participants made use of different materials such as pencil, pencil box in order to measure length of edges. During

decision period, it was observed that participants used informal measurement instead of formal one. Then, participants formed classification groups according to the number of surfaces of the same shapes. After the discussion, participants decided on three groups, and they called these groups of boxes as both rectangular and square shapes (the first group), only rectangular shapes (the second group) and only square shapes (the third group).

Later, students answered what their special names can be and why they can choose these names. For the first part of the question, there was a participant who mentioned that these boxes do not have a special name. While the term "*cube*" was used by three participants, "*prism*" was mentioned by two participants. When they showed the reason why they called it as such, they said they remembered these names from previous years. Moreover, rectangle was used by five participants, and square was stated by six participants. The reason of this can be the naming in the first classification which was done according to shapes of surfaces. Also, some participants used different names such as geometric boxes, length of rectangle, length of square and length of square- rectangle, half square, all square, all rectangle, all square all rectangle; some square some rectangle, short-long box perpendicular box, short-long-perpendicular box and vertical and horizontal boxes were used once. Students' answers might be based on the discussion related to naming for the first classification before this question.

For the second part, students discussed how they chose these names. While many students could not answer this question, one participant explained that she named the shape based on lengths of edges. From what she said, it was observed that this student used her estimation skills:

> I measured the lengths of the shapes by using my finger, and some lengths were different, some were the same. As a result, we classified these in the first group (both rectangular and square shapes). The name of these boxes had to be compatible with this group.

Before the next question, students were not given the formal geometric names of these shapes such as rectangular prism, square prism and cube by the teacher, and then they were asked to group the materials from real life. First example (cabinet) was rectangular prism, and the second example (dice) was cube. Finally, third example (refrigerator) was square prism.

Figure 7. Examples of rectangular prism, cube and square prism, respectively.

However, participants placed examples according to the first classification which contained shapes of all surfaces, not bases of boxes. According to this, examples such as cabinet, dice and refrigerator were matched with the second group, all surfaces of which were rectangular shapes, the third one, all surfaces of which were square shapes, and the first group, surfaces of which contained both square and rectangular shapes, respectively. In the end, six students could not answer, and they did not place them in any group because they mostly spent time on counting the surfaces, seven participants placed all examples in correct groups. Additionally, one of the students named the correct place for cabinet and dice but not the refrigerator. This might stem from the fact that the bases of refrigerator were not seen clearly.

4.2.1.2. According to the Number of Corners, Edges and Surfaces

In this part, sixteen participants answered how many corners there were on the rectangular prisms, cube and square prisms. Also, participants defined the number of edges and the number of surfaces of the rectangular prisms, cube and square prisms which were exemplified as cabinet, dice and refrigerator, respectively. (This is the second part of question 8 in the activity sheet 1.2). The expected answer from participants was that rectangular prisms (cabinet), cube (dice) and square prisms (refrigerator) had 8 corners. However, while some participants answered correctly, others had difficulties in defining the number of corners.

For the cabinet (example of rectangular prism), while one participant answered it had 4 corners, another (P10) said it had 7 corners, and P10 used the term 'diagonal line' instead of corner. They answered incorrectly since they did not count some corners. Also, one student said it had 13 corners while another one answered it had 18 corners. They might have counted some corners twice. Besides, ten participants answered correctly by saying the cabinet had 8 corners since after they counted the corners on one surface, they multiplied it by two. Although one participant (P6) did not write answer for numbers of corners, edges and surfaces on the paper, he marked their places on the given examples (Figure 8).

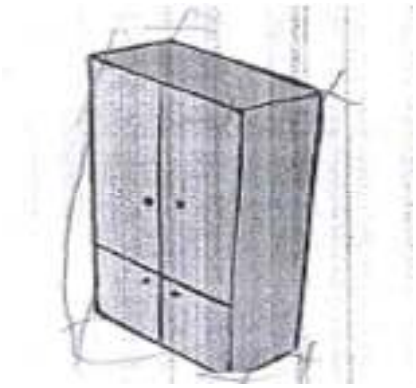

Figure 8. P6's markings for corners.

However, he did not mark all corners since he could not realize corners at the back. In other words, he marked corners in front of the cabinet which were seen at the first glance. Hence, he did not mark the corners which were placed at the back of the cabinet.

In the example of prisms which was a cube represented by a dice, while one participant said it had 24 corners, one participant said it had 9 corners, and another one answered it had 7 corners. They had incorrect answers because they either had counted some corners twice or counted the dots on dice. For the same part, one participant incorrectly stated it had 4 corners since some corners at the back could not be observed. Moreover, nine of the sixteen participants answered correctly that the dice had 8 corners since they made use of boxes while counting them. In the example of refrigerator for square prisms, one participant said that it had 2 corners while one of them said it had 4 corners, and one participant said it had 6 corners since they did not notice invisible corners. Hence, their answers were not correct. Eleven participants mentioned correctly that it had 8 corners by counting or marking corners on the boxes. At the end of this part, the reasons why differences in the numbers of corners were different were mentioned by some participants below.

> **P1:** I did not count some corners on box since I did not see them. Hence, I thought the answer was fewer than 8 corners for all kinds of prisms.
>
> **P15:** I had incorrect answers since I counted some corners of the cabinet twice. Also, for the dice, I counted the dots on surfaces as corners. As a result, I thought it had more than 8 corners. However, I did not give any answer for the refrigerator since I did not see some corners at the back.
>
> **P7:** I found correct numbers for all examples since I marked the corners on the box.

Figure 9. The student marks the corners on the box.

For the number of corners, seven participants correctly gave answers as 8 corners for all because they either counted them on their boxes or multiplied the number of corners on one surface by thinking that both surfaces have the same number of corners. Also, participants stated the number of corners was more than 8 corners since they mentioned they counted dots or pieces on surfaces as corners of objects. Participants who stated the number of corners was fewer than 8 corners did not count the corners which were on the other side of objects since they did not see those corners. In terms of the number of edges, it was expected answer that rectangular prisms (cabinet), cube (dice) and square prisms (refrigerator) have 12 edges. However, while the correct numbers were shown, the mistakes were obtained for the number of edges.

When answers related to the cabinet (rectangular prism) were analyzed, there were 4 different incorrect answers which were 2 edges, 4 edges, 8 edges and 10 edges given by four different participants. They gave incorrect answers since they either could not count some edges or they could only count edges on one surface or two surfaces. Another participant incorrectly answered it by saying it had 15 edges since he counted some edges twice. Also, eight participants answered that the number of edges in prisms was 12 since they counted edges both on concrete material, box, and on paper, simultaneously. In the next example which was a dice for cube, 2 edges, 6 edges, 7 edges and 11 edges were given as answers for the number of edges by four participants. Also, two participants said that there were 9 edges. These six participants did not give correct answers since

they did not count all edges which were not seen on paper. Seven participants mentioned the dice had 12 edges since some either counted edges on boxes or some marked edges on boxes. In another example for square prisms, the refrigerator, because of unseen edges on paper, some participants gave incorrect answers. While one participant stated there were 2 edges and three participants said it had 6 edges, two participants said there were 8 edges. Also, eight participants answered correctly that it had 12 edges because these participants marked and counted edges on the boxes. In all of the answers about the number of edges, the reasons of differences in numbers of edges were mentioned by some participants below.

> **P1 & P2:** I did not count some edges on the box since I did not see them. Hence, I figured out the answer was fewer than 12 edges for all kinds of prisms.
>
> **P11:** I had incorrect answers since I counted some edges of the cabinet twice, so I found more than 12 edges. Also, for the dice and refrigerator, I did not count some edges, so I found fewer than 12 edges. As a result, I found more than 8 corners.
>
> **P5:** I found correct numbers for all examples since I counted edges on the box.

Figure 10. Counting edges on boxes.

For all, six participants gave correct answers for the number of edges as 12. The reason of different answers was that covers of boxes had two pieces, and participants tried to count them. While some participants counted some edges twice, some counted one surface and multiplied it by two. In addition, in the given

examples, one surface was formed by more than one piece, and participants counted them separately. Besides, while P14 used the term "*edges*" for rectangular prism, he used the term "*side*" for the other two kinds of prisms but he did not explain the reason.

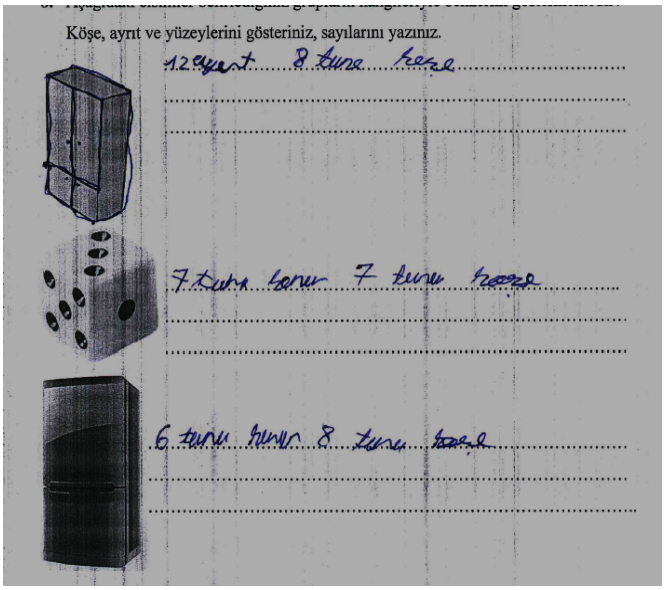

Figure 11. P14's answer regarding the number of edges, corners and surfaces.

As a result, he could not distinguish the difference between edge and side, or he thought that they were the same. When participants answered the question about the number of surfaces, expected answer was that rectangular prisms (cabinet), cube (dice) and square prisms (refrigerator) had 6 surfaces. However, while the correct numbers were shown, there were mistakes in the answers.

When answers for the number of surfaces in the cabinet were analyzed, while one participant answered that it had 4 surfaces since unseen surfaces of cabinet could not be counted, another participant answered it had 12 surfaces since all pieces on surfaces could be counted. There were nine participants who correctly answered, 6 surfaces, since some participants counted the surfaces on the boxes. For the dice, while one participant said it had 4 surfaces, one said it had 5

surfaces since they did not count all the surfaces. Also, another participant stated that there were 12 surfaces since all the surfaces were counted twice. Additionally, eight participants gave the correct answer as 6 surfaces because they marked surfaces on their boxes. In the example of refrigerator, two participants said it had 2 surfaces since they counted the surfaces on the front of the refrigerator on which there were two pieces. Two participants said it had 8 surfaces since they counted all the pieces which they saw. Additionally, eight participants gave the correct answer, 6 surfaces, because of counting surfaces on the boxes. The reasons of differences in the answers were mentioned by some participants below.

> **P1:** I did not count some surfaces on paper since I did not see them. Hence, I figured out the answer was fewer than 6 surfaces for all kinds of prisms.
>
> **P2:** I had incorrect answers since I counted all the pieces on the cabinet and refrigerator, and for dice I miscounted some surfaces, so I found out that the number of surfaces was more than 6 surfaces.
>
> **P12:** I found correct numbers for all examples since I wrote the numbers for surfaces on the box.

Figure 12. Writing the number of surfaces on the box.

For all, eight participants gave correct answer that is 6 surfaces as they could either count the surfaces or write the numbers on surfaces. The reasons of differences in numbers may stem from two aspects. While one reason can be that participants did not count or see the opposite surfaces, the other one might be the fact that one surface was formed by more than one piece.

4.2.1.3. According to Shapes of Bases of Boxes

Before the last classification, sixteen participants defined their surfaces of box as rectangular and square. Then, they decided what surface was the base(s) of the box and what kind of prism they had. Firstly, they decided their sort of prisms according to shapes of surfaces which was their first classification. Then, they were informed about how prisms are called or classified with an instruction which was if all the surfaces are square, it is cube, but if the bases of the box are rectangle, it is a rectangular prism, and if the bases of box are square, it is a square prism. In this case, it was aimed that participants distinguished differences between rectangular prisms and square prisms since they had similar opinions about cubes. Then, some students showed their ideas and while some had different surfaces such as rectangular and square shapes, some had the same shapes for all surfaces which are either rectangular shapes or square shapes.

> **P3 & P13:** I could not decide since I had different surfaces. If I choose this surface (square surface), this box is a square prism. However, if I choose this surface (rectangular surface), this box is a rectangular prism. In this case, how could we decide?
>
> **P7:** All the surfaces in one of the boxes which I found were square. In this case, we called it as cube. However, in this box, there were both rectangular and square shapes. Hence, I called it as rectangular prisms since I chose rectangular surface as a base.
>
> **P16:** My box was a rectangular prism since all the surfaces were rectangle.

In this case, when all the surfaces had similar shapes, participants did not have any difficulty to call them. On the other hand, when prisms had different surfaces, participants had difficulty calling them correctly since they could not decide which surface made up the bases of prism or box. As a result, participants had the same opinion about rectangular prisms and cubes, but their definition of square prism was problematic. Then, they were informed about differences between rectangular prisms and square prisms. In this case, if all surfaces of box

are rectangle, this is called a rectangular prism. If the box has both rectangle surfaces and two square surfaces, then, this is a square prism.

Later, they completed their last classification according to the shapes of bases of boxes. Thus, fifteen participants correctly classified their boxes in new groups.

> **P3:** After this, I called my box as square prism since there were rectangular and square shapes. If it only had rectangular surfaces, I would call it a rectangular prism.
>
> **P12:** My box was a rectangular prism since all the surfaces were rectangle.
>
> **P13:** My box was both rectangular and square. Hence, it was moved to another group since I placed it in the wrong group.

In this case, it was observed that participants could distinguish differences between prisms, and they could classify prisms in correct groups. However, one participant could not decide on the bases of her box. In other words, she had prism with either rectangular bases or square bases. Then, her friends advised that she measured the length of edges on bases. Thus, she found different lengths for edges, and the she decided it was a rectangular prism. Then, students were remembered the formal geometric name of these shapes such as rectangular prism, square prism and cube, and their specific properties were repeated by the teacher again.

All in all, answers for how many groups were formed for classification were analyzed. There were two participants who said there were two groups since they could not remember the group which contained the cube. Thirteen participants correctly mentioned three classified groups in prisms. In the next question, participants answered how these groups were formed.

> **P4 & P12:** I classified them according to names and objects.

While two participants stated that they classified them according to their names and objects, objects can be matched with shape of surfaces. In this answer, it was not understood clearly why participant classified them according to names. Also, names could refer to shape of surfaces.

> **P13& P16:** I did classification according to their corners, edges and surfaces.

After two said they did the classification according to their corners, edges and surfaces, it was asked whether there were differences between the number of corners, edges and surfaces. Participants answered that these numbers were similar for three kinds of prisms. Thus, they can benefit from the different length of edges and surfaces while classifying prisms.

> **P2:** I made use of differences or similarities of surfaces of the boxes, and I classified them.

Similar to P2, six participants made use of shapes of surfaces of boxes in order to classify boxes. It was observed that nobody used the statement "*according to their bases*" since this question was asked before prisms were classified according to their bases.

Then, the last activity sheet was analyzed, and the results were taken only from papers. In this paper, participants answered the previous question which was *How were the prisms classified?* again (this question in the activity sheet 4 was rearranged in the class hour since its original form had a different meaning). When the answers were analyzed, it was seen that nine participants mentioned they classified the boxes according to their surfaces, and three participants did this according to boxes' names and objects which may refer to shape of surfaces. This shows that participants did the first classification according to shapes of surfaces and the second classification according to the number of corners, edges and surfaces, but they did not do the third classification according to bases of boxes.

In the answer, the participant wrote some terms of geometry in order to answer how the prisms were classified (Figure 44a, see Appendix A). However, diagonal lines as a term were not used in the study. Hence, it might show that participant made use of the previous knowledge, but it was irrelevant to the current topic.

Also, two participants said that they classified boxes by means of scissors (Figure 44b, Appendix A) and three participants mentioned that they classified boxes by cutting. They expressed in this way since this question was answered on paper at the end of the study, and one of the last activities was constructing nets. While constructing nets, boxes were cut into pieces to construct nets and draw nets. In other words, these participants might have misunderstood that boxes were cut into pieces instead of the fact that prisms were unfolded.

In addition, participants answered the fifth question after it was reorganized in the classroom. The questions were reorganized as *What should be considered while classifying prisms?* and *Why is classification of prisms important?* (The original question was *What do you pay attention to while you are separating the boxes?*) When they were obtained from only papers again, two different groups were formed according to the perception of participants. While participants in the first group called this as classification of prisms, participants in the second group focused on substantiality of boxes or packages since they answered these questions at the end of application, and they could not decide whether it was about prisms or recycling. In the detailed answers of this question of the first part, while three participants classified boxes according to surfaces, two participants did this according to edges and corners. Besides, four participants stated that they did classification according to shapes of boxes, but two of them mentioned they classified them as square and rectangle. Moreover, two participants classified prisms in terms of their names and objects. In these answers, it was obtained that participants can focus on classification according to the shapes of surfaces in prisms and the number of corners, edges and surfaces of

prisms. Hence, they cannot be aware of the importance of bases of prisms for classification. While one took care of packages of boxes for classification, two of them highlighted that packages of boxes were not torn. In other case, they mentioned they could not study with them.

In the second part of this question in terms of importance, while one proposed that learning got easier, another one gave the importance for finding whatever we seek (Figure 45a, Appendix A). Also, three participants emphasized the importance of classification. Furthermore, one aimed to study prisms while one purposed to build prisms, and one showed the importance in terms of learning the shapes of prisms. In this case, this participant might have thought that classification of prisms helped him learn what shapes of surfaces prisms contained.

In this case, it can be observed that participants answered why classification was important according to their perceptions such as classification of prisms and recycling of packages (Figure 45b, Appendix A). Hence, they can associate classification of prisms with recycling in unexpected ways. These are shown in Table 8.

Table 8

The number of students who classified prisms

Classify prisms	**The number of students**
according to surfaces	9
according to names & objects	3
by means of scissors	2
by cutting	3

During the interview at the end of study, seven participants were interviewed individually, and their answers about how prisms are classified were shown in detail.

> **P3:** We classified them according to bottom and top surfaces. If they were rectangle, they were rectangular prisms. If they were square, they were square prisms. If all surfaces were square, they were cubes.
>
> **P7:** When we classified, we considered their surfaces (Then, which surfaces of prisms we considered was asked). We considered its bases.

Then, four of seven participants said that they classified prisms according to their bases, and three said they did the classification considering their special names. During this process, it was observed that participants could not give the answer at once. However, after getting some clues, they came up with the answers.

> **P2:** We studied classification of prisms according to their angles, corners, edges as first, and surfaces as second and bases as third and last. Also, we organized them with the help of estimation. Then, we named prisms according to their bases.

This participant mentioned the classification steps in the classroom, and then she needed some other ways about how we did and what the second one was. Also, she highlighted estimation since they made use of estimation in deciding the length of edges or differences between the surfaces of the box. Another one claimed that classification was done according to corner, edge and sides, and then it was reorganized according to shapes of surfaces of prisms. While one participant agreed with the previous one on the idea that suggested classification according to corner, edge and surfaces, he gave their names as cube, rectangles and rectangle - squares. One participant mentioned they did two classifications such as first and second one and during these, their surfaces had effect on classification. It was observed that they considered the first two classifications at the start of the study, and they might not have thought that prisms were classified according to the bases of prisms.

> **P13:** We classified prisms as rectangles, cube and rectangles - squares. While classifying, we considered their surfaces, corners

> and edges, but they were numerically equal to each other in all prisms. For instance, the number of surfaces in all prisms was 6.
>
> **P15:** We classified prisms as rectangular prisms, square prisms and rectangle- square prisms since this classification create opportunities in recycling of boxes.

It was clear that participants had difficulty in naming prisms. They could not consider the focus on the last classification, or since they classified prisms three times, they might have confused the terms with each other. Additionally, in the interview, while one participant mentioned that cube had a special situation since all the surfaces of it were square, one participant stated both edge and side could be used for prism because of their similarity. In this case, it was found out that participants can distinguish characteristics of prisms while calling them, but they can have difficulty in distinguishing some terms such as edge and term.

As a result of the interview related to this part, while four of seven participants mentioned the bases of prisms affected classification, three emphasized the surfaces of prisms along with corner and edges of prisms in classification of prisms.

4.2.1.4 Relationship between Nets of Prisms and Classification of Prisms

This subtopic was formed according to the results of the interview. In this case, seven participants answered whether the differences in the prism nets affect classification of prisms at different times by ordering the school numbers. Participants' answers were shared below.

> **P3:** Both prism and its net were analyzed for classification. On the other hand, we could not decide what groups this prism contained.
>
> **P3 & P13:** We could not classify prisms according to the nets of prisms.
>
> **P2 & P12:** If nets had been shown at the beginning, we could have placed prisms in different groups.

P16: We could decide the type of prisms after we formed the prism by folding the nets of prism.

P7: Classification did not change according to nets.

In this part, participants are expected to say that differences in nets of prisms do not change the type of prism since if all surfaces of prism are rectangle, it is called a rectangular prism while if all the surfaces of prism are square, it is called a cube, and if a prism contains both rectangular and square surfaces, it is called a square prism. As a result, five participants who were interviewed thought that prism nets might have had effect on classifying. In other words, they underlined that nets of prism could be misleading while deciding the type of prism. It can be seen that some participants thought that prisms and their nets were different from each other. In order to ensure the type of prisms, participants advised that they tried to fold nets. Hence, they could easily define the type of prism. In the answers, only one participant emphasized that classification was not affected by the folding or unfolding situation of nets of prisms. According to this participant, type of surfaces or bases can refer to the type of prism. In this case, it can be thought that majority of participants cannot focus on the kind of surfaces in defining the types of prisms.

4.2.1.5. Definition of Prisms

Definition of prisms was asked to seven participants in interview. All participants had difficulty defining the prisms correctly. Hence, while some mentioned they did not remember the definition, some stated they forgot it because they were too anxious while getting interviewed. Then, it is asked whether participants would define prism by means of a book if the book were a type of prism according to its characteristics. According to the results, five of seven participants chose the terms such as surfaces, corners and edges through numeric ways such as 6 surfaces, 6 corners and 12 for the definition of prisms.

P2, P3, P7, P12 and P13: These were the objects which had 6 surfaces, 8 corners and 12 edges.

While giving answers, it was observed that some participants memorized these numbers, but they could not remember them exactly. Hence, all participants who were asked this question tried to count them on the book.

It was observed that participants firstly used the number of corners, edges and surfaces in order to define prisms. However, they had difficulty defining them correctly without counting them since they could not match the numbers with the terms such as corners, edges and surfaces. In this case, they were asked to show it on a book. Then, they counted and showed the number of corners, edges and surfaces simultaneously. In addition to these, they had an idea about whether the book is a kind of prism. In this case, other 3D objects can also be a type of prism.

While one mentioned that prism was an object, one said that prism was the object with different sides. After another one had difficulty in defining, it was asked whether a book was a kind of prism or not. Then, he mentioned book was a kind of prism. In addition, another one mentioned they had surfaces, edges, sides and right angles. Moreover, three of them used the term side instead of edges while defining at the beginning. While four used both side and edge at the same time and one used only edge in defining prisms, one emphasized that both could be used, but edges were most frequently used for prisms. However, during the interview, none of these seven participants correctly defined prisms. The correct definition was that lower and upper floors of prism are parallel and equal to each other while lateral surfaces are equal and parallel to each other.

4.2.2. Nets of Prisms

During the application, the research question is "*What are the thinking strategies of 5th grade students for classification and nets of prisms?*" In order to give an answer for thinking strategies of 5th grade students for nets of prisms, another studied objective is to draw the nets of the rectangular prism and to decide whether the different nets belonged to the rectangular prism. Hence, three activity sheets were distributed related to the nets of prisms and each contained different

topics such as constructing nets, drawing nets and closing nets. For the first one, participants with quaternion tried to construct given nets with their boxes. One group had four different nets of cube and one had four different nets of square prism. Two groups had four different nets of rectangular prisms to construct. In the second one, participants tried to draw their nets of boxes and they matched their box and classification groups by explaining their reasons. In the last paper, participants explained whether given nets constructed prisms or not. In other words, participants decided whether they were folded or not. Hence, it was expected that participants could analyze whether the number of surfaces was 6 or not, whether the length of edges in opposite surfaces were equal or not and whether the surfaces overlapped each other or not. Some examples of the last activity sheet related to the nets of prism are seen below.

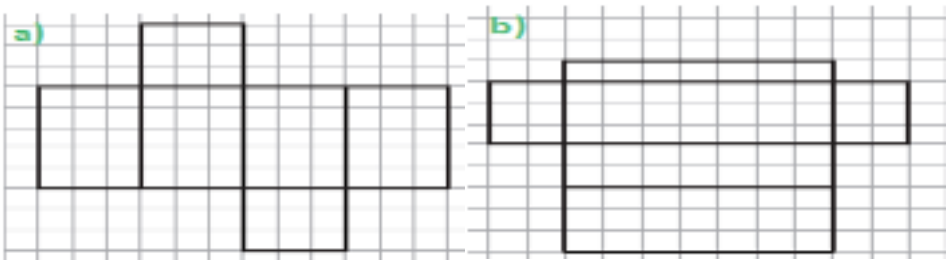

Figure 13. Some examples from last paper.

At the end of this part, it was expected that participants would be able to define characteristics of surfaces of prisms. Moreover, it was expected that that they would be able to consider differences and similarities of nets in drawing and calling them and that they would be able to distinguish whether the different nets were related to the rectangular prism.

4.2.2.1. Constructing Nets of Prisms

At the beginning of the lesson, boxes were separated into their pieces to construct nets. In this case, since covers of boxes had two pieces, it was advised to

However, when they folded pieces to construct a prism, they were not successful since the prism had blanks on surfaces. By using bigger pieces, they reached their aims and corrected their mistakes. Then, they explained the reasons why they made mistakes.

> **P13 & P16:** This was not folded in that situation. Hence, we could try another piece which was bigger than the other pieces.

Figure 20. The third group's constructing nets with correct pieces.

After two participants of this group (P13, P16) were interviewed, one (P16) explained the reason of this situation as the box had more pieces and we could not decide which one was used. Another one (P13) mentioned that the drawing of nets on paper was deceptive.

The fourth group of participants had nets of rectangular prisms like the third group. After deciding the type of their prism, they constructed the nets on their activity sheet one by one.

Figure 21. The fourth group's constructing nets with pieces.

It was observed they copied nets on the paper. While constructing nets, it was observed that participants of group had some confusion over the position of

According to these, the number of participants who explained how they determined the kind of prism in the net of prism that they drew is shown in Table 10.

Table 10

The number of students who matched their drawing and kind of prisms.

Matching	The number of students
according to surfaces	7
according to bases	4
When it is closed	2
All surfaces are rectangle	1
Matching correctly	5
Unanswered	1

As a result, it was seen that she could correctly match nets of prisms with the kinds of prisms. Totally, only five of the participants could match their explanations and drawings. This showed that some of the participants could not draw nets of prism correctly, and they could not call prisms according to their bases.

4.2.2.3. Closing Nets

In this part, participants tried to decide whether nets construct prisms or not. In the activity sheet 3, there are five different nets of prisms, and while some of them construct a prism, some do not construct a prism due to some reasons. In this case, the participants were expected to define whether these nets possess prisms or not. Moreover, if they do not construct prisms, participants are supposed to explain the reason. In the paper, questions did not contain naming prism, but this was mentioned in the application. However, some participants might have overlooked this warning, so they could not state the kinds of prisms. Nets (Adapted from MoNE, 2016, p. 446) are illustrated below, but some nets cannot construct a prism.

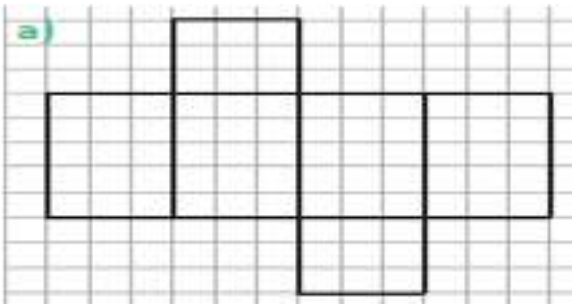

Figure 31. Net of square prism.

In Figure 31, participants were expected to call it as a square prism since it folded completely, and then its surfaces were parallel to each other and its bases are square. Nine participants said that when all surfaces were non-overlapping, edges overlapped each other, and there was no empty square. One mentioned below that it was a square prism, and all surfaces were matched.

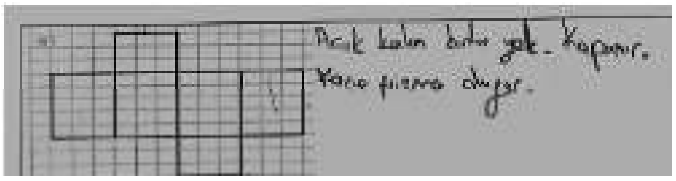

Figure 32. Participant's explanation for a.

Five of them stated that this did not fold since while one participant said all surfaces were not rectangle and two mentioned lengths of edges were not equal, two of them did not explain its reason. Hence, nobody used the term parallel surfaces.

In addition, while eight of them did not call it, three participants called it a cube and one participant called it a rectangular prism since they thought shapes of surfaces as square and rectangular shapes, but they did not count squares on a squared paper. Three of them called square prism correctly since they accepted that bases were square.

As a result of these, more than half of the participants could find an answer to the question whether it was a prism or not. However, fewer than half of them could not understand how to call prisms.

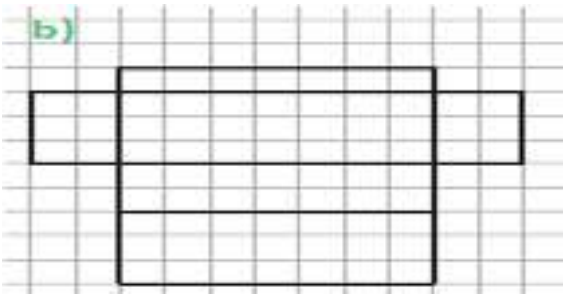

Figure 33. Net of rectangle prism with different lengths of edges.

In this Figure 33, it was expected that it did not fold completely because lengths of edges were different in one surface. According to this, one participant mentioned "*This could be folded since all surfaces were matched.*" In this case, participant could not consider equality of lengths and participant only focused on the surfaces which were parallel to each other.

Twelve of the participants mentioned this was not folded entirely, and so, this was not a prism. While two did not show reason, ten of these twelve participants stated lengths of edges were not equal in opposite surfaces. One explained that it was not folded since there was no equality.

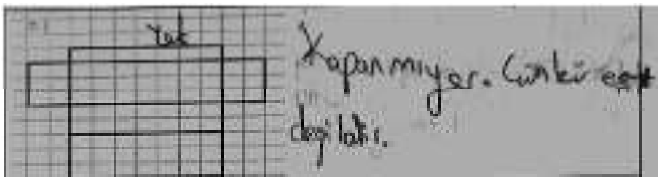

Figure 34. Participant's explanation for b.

Moreover, one mentioned this was the net of the cube. Also, three participants said this was a rectangular prism. Ten of eleven participants who did

not give any answer did not define what kind of prism it was. Additionally, they could say that it was not a prism since it was not folded. Thus, while more than half of the participants mentioned the reason why nets could not be folded correctly, some participants could focus on the number of surfaces, and some could not be aware of inequality of squares in terms of the length of edges.

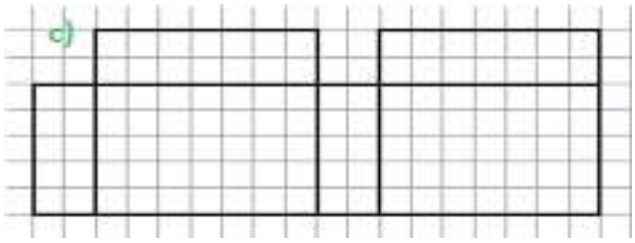

Figure 35. Net for rectangular prism, but pieces were misplaced.

In this Figure 35, expected answer was that it did not fold completely because two surfaces overlapped each other, and one surface stayed open. Two of them did not give any reason about why it was not folded, but they only said this was not folded. Also, three of them mentioned it was completely folded. They might not have thought that one surface of the prism was not folded and two surfaces were overlapped. In addition, ten of the participants stated this was not folded since six participants said that one surface was misplaced. Also, two participants claimed that there were unequal places. In this case, they might have mentioned in this claim that there was inequality in the length of edges, or there were non-overlapped edges or surfaces. Since they did not mark these places, it was not clear what they stated.

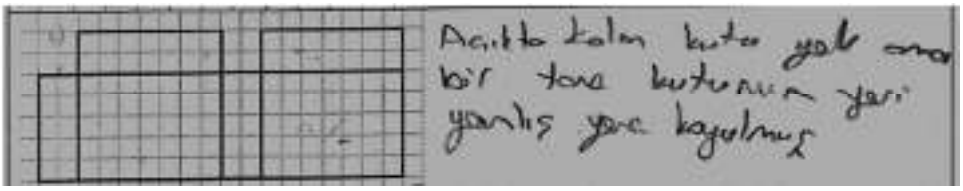

Figure 36. Participant's explanation for c.

Furthermore, nobody called this prism with its specific name, but nine of fifteen participants could display why it remained open. Thus, when more than half of the participants mentioned the reason why nets were not folded correctly, it was explained that there was no unit cube which was not matched, but one surface was misplaced. Also, some were not aware of overlapping surfaces.

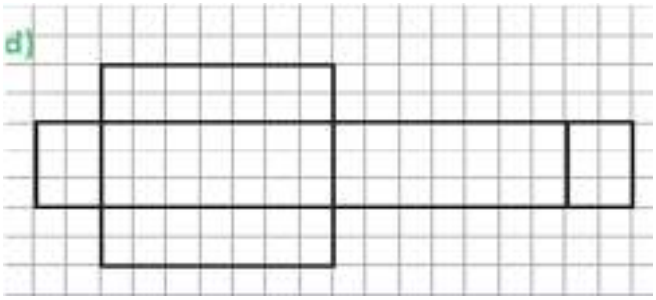

Figure 37. Net for rectangular prism, but pieces were misplaced.

In this Figure 37, the expected answer was that it was not completely folded because replacement for two surfaces was necessary. Three of them said it was folded. Ten of them correctly mentioned that this remained open since while six proposed replacements, three did inequality, and one did not state the reason.

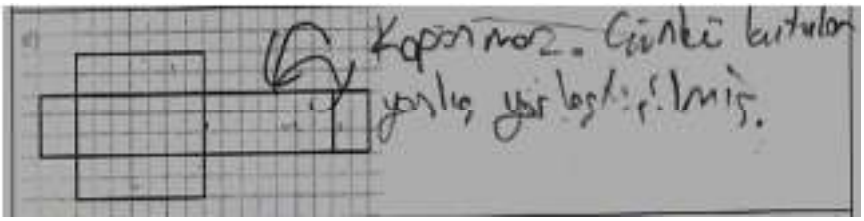

Figure 38. Participant's explanation for d.

Besides, while nobody gave its special name, ten of them could mention its reason that it was not a prism. Hence, while more than half of the participants mentioned the reason why nets could not be folded correctly, some were not aware of places of surfaces. In this case, the reason was shown that it was open since one surface was misplaced.

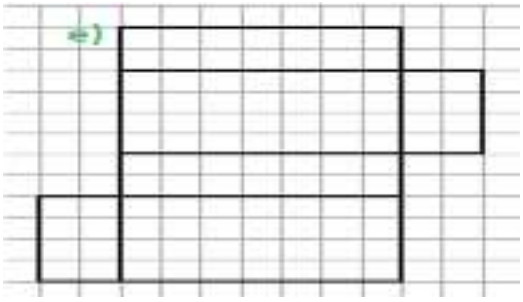

Figure 39. Net of rectangular prism.

In this Figure 39, it was expected that it was completely folded because edges and surfaces fitted each other. Thus, one mentioned it was open without giving any reason. In addition to them, twelve of fifteen participants said "*This completely folded.*" Also, five of these thirteen gave a reason why all surfaces and edges were equal and complete.

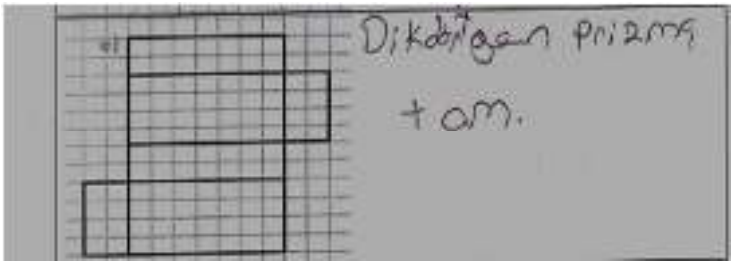

Figure 40. Participant's explanation for e.

While seven participants did not give any reason, only one called it a rectangular prism. Moreover, one of the participants called it a cube. While, seven defined rectangular prism, seven participants did not give its name. Hence, while almost all of the participants mentioned the reason why nets folded correctly or incorrectly, they made different but unclear explanations.

Table 11

The number of participants who showed correct reasons about nets

For	Expected answer	Showing correct reasons
A	Folded	9
B	Not folded (inequality in length of edges)	12
C	Not folded (overlapped surfaces)	9
D	Not folded (overlapped surfaces)	10
E	Folded	12

According to results in Table 11, more than half of participants matched nets of prisms and their folded and unfolded situations. Based on the results, some participants had difficulties in deciding whether nets were folded or not because of the same reasons in drawing nets of prisms such as not considering inequality of length of edges or overlapped surfaces.

All in all, for this part, five of the participants answered all five nets correctly. Four of them answered four of five nets correctly while three participants answered three of them correctly. Moreover, one participant for each gave the right answer for two of five and one of five nets, respectively. Also, one participant did not give the correct answer for any of them. For all, five of the participants gave correct reasons. According to the results of the nets, some participants might have understood that nets constructed a prism when the nets had six surfaces. On the other hand, other participants thought that having six surfaces is not enough to construct a prism. In this case, they focused whether length of edges was equal or not and whether surfaces overlapped each other or not in order to close nets.

Overall, analysis of prisms in teaching geometry in the current study was completed. The aim of the table below is to compare difficult and easy topics for participants in this part.

Table 12

Showing main topics and reasoning of students

Main Topic	Subtopics	Correct	Incorrect	Reasoning of students
Classification of prisms	Corners, edges, surfaces	6	10	Prisms have 8 corners, 12 edges, 6 surfaces
	Shape of surfaces	7	9	All are square, All are rectangle
				Some are square and some are rectangle
	Shape of bases	3	13	
Definition of prism	Definition (parallel bases)	0	7	
	Example/ characteristic	5	1	Book is a kind of prism
				There are 8 corners, 12 edges, 6 surfaces
Constructing nets of prisms		4(as team)	0	They are matched with nets in given papers. It was closed completely
Drawing of prisms		3	10	Edges have the same lengths.
				Some surfaces are parallel.
Matching of prisms	Drawing and explanation	5	8	Top and bottom bases define the kind of prism.
	Defining whether nets of prism close	12 (correct matching for more than half)	3	Edges are overlapped, and surfaces are not overlapped when nets are closed.

According to the Table 12, participants had more difficulties in classifying prisms (according to shape of bases), defining prisms and drawing nets of prisms. For classification, participants focused on the number of corners, edges and surfaces and kinds of surfaces. While defining prisms, although participants used the terms they used to classify prisms, they had an idea about the number of corner, surface of prisms and prism examples of from daily life. While drawing the nets, participants might not have considered the fact that the length of overlapped edges was equal, that surfaces were overlapped, and that bases of prisms were rectangle or square. On the other hand, participants had easier ways while constructing nets of prisms and matching prisms. While doing this, they considered the equalities in lengths of the edges, place of surfaces and overlapped edges and surfaces.

4.3. Evaluating the Results in terms of the Advantages of Teaching Prisms Supported by ESD

This part is the last part of findings of the data. In this part, the research question "*What do 5th grade students think about learning prisms using instruction supported with ESD?"* will be answered. Also, teaching prisms supported by ESD is analyzed in terms of advantages in surface coverage, advantages in daily life, and the benefits according to the participants and the participants' opinion about this kind of lecture. In other words, we will find out how we can use this support in daily life and what it changes in participants' lives. For this, results in the activity sheet 4 (see Appendix B) and reactions or answers of the participants during the interview will be evaluated.

4.3.1. Surface Coverage

In this part, participants were expected to associate the nets of prisms with surface coverage in terms of recycling and packaging wastes. Hence, participants were asked to compare the folding and unfolding state of the box in terms of surface coverage by using nets of them. As a result, participants gained perception

that the unfolded state of boxes was related not only to the nets of prisms but also to the advantages of environment. For this, the example below was given.

> You tried to carry these boxes on a truck. Which state of boxes (opened or closed) is more advantageous for environment in carrying them? What can these advantages be?

The aim of this example was that participants were encouraged for critical thinking. For instance, if they choose closed state of the boxes to carry them, these boxes take up a lot of space. In this case, they need more space, more trucks, more fuel, etc. As a result, it leads to environment pollution. On the other hand, if they choose opened state of the boxes, they need less space to carry. This also contributes to protection of environment. In the classroom's application, participants discussed which state was more advantageous in terms of surface covering. While some participants mentioned its aim was to recycle them, some remarked that these boxes covered fewer surfaces if they were opened.

> **P1:** We could open them in order to send them for recycling. Otherwise, it was difficult to place them for recycling.

> **P13:** If we cannot open the boxes, we may need more space to carry them. On the other hand, if we open them, we can carry more boxes on a truck. For instance, we opened boxes for nets of them and when they were added up, they covered less space.

Hence, the former participant focused on the reason why those boxes were sent instead of how they were sent, so he connected this with recycling. Then, the latter participant gave the expected answer and underlined saving space by connecting nets of prisms.

The question related to surface coverage was asked again during the interview. In this case, why we need unfolded boxes was answered by seven participants, and they were expected to associate nets of prisms with surface coverage. Answers of six participants are as below.

P2: When the boxes were unfolded, we analyzed how many pieces they contained and what kind of prisms could be constructed by folding nets.

P7: We understood the topics such as edges and recycling easily. Also, surface coverage and nets of prism might have relationship.

P12: We learnt the topic. We opened the boxes because of recycling.

P13: We aimed to classify them and analyzed their nets. In addition, they were used for recycling easily since the more boxes there were, the less space they covered.

P15: In order to find their weight. We could write the names of wastes on boxes in order to distinguish them.

P16: Our purpose was to gain knowledge about learning prisms, and we understood easily by dividing boxes into small pieces which were surfaces of prisms. It had advantage in terms of saving space. While boxes were folded, they covered more space. However, we placed more boxes or nets of prims in truck when we unfolded them.

None of these participants associated nets of prisms directly with the surface coverage. However, five participants connected surface coverage and nets of prisms after their relations with each other were asked. On the other hand, other interviewed participants highlighted that the purpose of opening boxes was related either only to prisms or recycling. While they discussed different aims in terms of surface coverage at start, three of them mentioned its importance on surface coverage. Hence, it can be understood that some participants could not have any idea about the relationship between nets of prisms and surface coverage.

4.3.2. Its Effects on Daily Life

In this part, fifteen participants answered questions about supporting mathematics lectures with ESD in terms of relationship between prisms and recycling in daily life and relationship of boxes with daily life. According to the answers in the activity sheet, some participants evaluated supporting mathematics

lectures with ESD in terms of only nature. In this case, it was seen that one participant who considered packages as garbage emphasized the amount of garbage (Figure 46a, Appendix A). Moreover, some participants had positive attitudes towards supporting mathematics lectures with ESD in terms of protection of nature (Figure 46b, Appendix A). Besides, three participants emphasized the importance of supporting mathematics lectures with ESD in terms of oxygen level. In this case, they could associate this support with science courses (Figure 46c, Appendix A). Also, one participant matched recycling with unused materials in daily life:

P4: If I do not use the materials, I use them for recycling.

In addition, while one participant did this with broken or damaged materials in daily life (Figure 46d, Appendix A), five of fifteen participants mentioned the relationship between supporting mathematics lectures with ESD and daily life in terms of recycling (Figure 46e, Appendix A). Thus, it was found that participants evaluated supporting mathematics lectures with ESD in terms of only sustainability. While they focused on recycling and wastes, they aimed to protect the nature. However, they did not associate this support with prisms or surface coverage. The answers about the relationship are shown in Table 13.

Table 13

Data Analysis Results: Documentation and Observation - What is the relationship between prisms and recycling in daily life?

Relationship between prisms and recycling in daily life in terms of	**Number of participants**
Nature/ Protection of nature	3
Level of oxygen	3
Unused materials	1
Broken/ damaged materials	1
Recycling	5

The second part of the question related to the kind of boxes in daily lives was answered by fifteen participants. It was expected that participants would underline the packaging wastes in the answers. However, different answers which are exemplified below were found out. While one participant mentioned that they brought brown boxes into classroom, another one expressed this by carrying patterned boxes (Figure 47a, Appendix A).

In addition, one participant stated used boxes, and one answered all the boxes. Also, one participant defined boxes as square, rectangle and cube. Additionally, three participants used the word "*packing*" in order to answer question (Figure 47b, Appendix A). Furthermore, nine participants said that they brought boxes from the supermarket (Figure 47c, Appendix A). These are shown in Table 14.

Table 14

Data Analysis Results: Documentation and Observation - What kind of boxes were used?

Boxes were	**Number of participants**
Brown	1
Used	1
From supermarket	9
Packaging wastes	3
Rectangle, square, cube	1
Shaped	1
All kinds	1

According to Table 14, it was seen that more than half of the participants focused on the physical features of the boxes instead of packaging wastes. In this case, while some participants tried to connect boxes and prisms, some could do this for recycling. Additionally, participants focused on where they brought from boxes instead packaging wastes.

In the interview, seven participants were questioned about the changes in their daily lives after their experience in the course:

> **P2:** I liked having a lesson in this way, but there was no change in my daily life.
>
> **P3:** I liked this. Hence, I got more careful, and I tried to separate wastes for recycling sometimes.
>
> **P7:** I liked, and so I tried to waste less paper.
>
> **P12:** I enjoyed it and I tried to behave more carefully. However, I did not warn people and my environment about recycling.
>
> **P13:** I liked this course. Then, I separated wastes and I warned individuals in my environment about recycling.
>
> **P15:** It was fine.
>
> **P16:** I felt its positive effects. I separated wastes. Moreover, I searched about not only recycling, but also recycling of living features.

As a result, it was observed that this application had effect on lives of some participants in terms of gaining perception about nature and its sustainability. However, while some of them perceived it only as an engaging course, some did not have any change in their lives.

4.3.3. Benefits and Suggestions

For this subtitle, participants were expected to answer what benefits of this support could be and what suggestions could be made. In this part, it was expected that participants would gain learning experience about teaching prisms supported by ESD. Additionally, participants shared their opinions on teaching prisms supported by ESD.

When documents were analyzed with respect to content, P2 mentioned its importance for exams. In other words, when P2 took some exams, she faced questions about such kind of topics (Figure 48a, Appendix A). While one

considered its benefits in terms of classification of prisms, another participant considered prisms and recycling together. Moreover, four participants emphasized the benefits in terms of recycling, and seven participants mentioned their aims in terms of learning (Figure 48b, Appendix A).

While answering questions, some expressed their aims. For example, they evaluated supporting mathematics lectures with ESD in terms of the relationship between daily life and recycling in terms of generalizability (Figure 48c, Appendix A). In other words, they stated recycling was done by everyone, and it was valid for every waste. Also, some connected relation between prisms and furniture in their houses in terms of classification (Figure 48d, Appendix A). To illustrate, they decided what classification group contained door or television. The answers about benefits of this kind of support given by participants are displayed in Table 15.

Table 15

Data Analysis Results: Documentation and Observation - What are benefits of this kind of support?

It is beneficial for	**Number of participants**
Learning	7
Classifying prisms	1
Recycling	5
Exams	1

According to these, participants had ideas about the benefits of learning which were evaluated in terms of recycling, prisms, exams or learning of different topics. In this case, it is observed that they could associate the topic with their environment.

Additionally, participants suggested ideas in order to develop mathematics lectures supported by ESD in different topics. While nine participants remarked

that they did not have any suggestion or addition, one participant gave advice to people in terms of recycling (Figure 49a, Appendix A).

Also, two participants highlighted its understandability with this way. Moreover, P16 preferred forming connection with daily life through recycling fruits and vegetables (Figure 49b, Appendix A). Furthermore, one mentioned if different applications were supported by this, it would be more fun. Lastly, another participant suggested similar applications could be done on fractions (Figure 49c, Appendix A). However, more than half of participants did not give any ideas about this. These are shown in Table 16.

Table 16

Data Analysis Results: Documentation and Observation – What do you add or suggest?

Adding & Suggestions in	**Number of participants**
Understanding recycling	1
Teaching fractions	1
Understandable lessons	2
Connecting different topics	1
Connecting daily life topics	2
No idea	9

As a result of this part, it was observed that participants had fun during the practice, and they wanted to apply this in learning different mathematics or geometry topics. Also, according to their answers, while they developed limited knowledge in recycling, they could have permanent knowledge about prisms. Additionally, some participants could connect this application with their daily lives in different aspects. The table below summarizes the approach of participants in this part.

Table 17

Reasoning of participants for teaching prisms supported by ESD

Subtopic	General ideas of participants
Surface coverage	Taking up less space leads to saving the nature.
Daily life	The awareness of participants of recycling and packaging wastes increased.
Lessons	The lesson was more attractive and meaningful.
Benefits & Suggestions	This provided permanent knowledge about concepts and this kind of support should be made with different topics.

In addition to these, participants were expected to answer what their opinions on supporting mathematics lectures with ESD were. While nine participants highlighted recycling, four participants underlined the selection of boxes. One participant emphasized supporting mathematics lectures with ESD in terms of relationship of recycling with garbage and another one emphasized recycling by remarking the importance of not consuming trees (Figure 50a, Appendix A). Others only mentioned recycling. Also, two participants explained how to start lesson by bringing boxes into the classroom. Moreover, one stated that some elements of prisms such as edges were marked on the boxes (Figure 50b, Appendix A).

Although the courses started with recycling, it was observed in these answers that the beginning of the lesson differed from person to person since participants focused on different parts of the subject. Additionally, three of the participants mentioned that this did not catch their attention. Moreover, while two of them emphasized that this application was attractive, one suggested that the most attractive thing in lessons was rectangle (Figure 50c, Appendix A). Furthermore, P4 state that all were different, and they were all important for her. While one highlighted recycling as being attractive, another one mentioned recycling and prisms were attractive (Figure 50d, Appendix A).

Besides, P16 mentioned that a ton of trees is cut for only one paper. However, the correct statement is that seventeen trees are cut for one ton of paper. In this case, she might have had difficulty in remembering this information (Figure 50e, Appendix A). The answers about participants' attention are represented in Table 18.

Table 18

Data Analysis Results: Documentation and Observation - How was class started and what attracted your attention*?*

The reason of attention is/are	**Number of participants**
Recycling	11
Recycling and prisms	1
Classifying boxes/ defining properties	4
Recycling for protection of trees	1
1 tone paper= 17 tress	1
No attention	3
Attractive lesson	2
All were different	1

According to these results, more than half of the participants focused on either learning prisms or purposes of recycling. Fewer than half of them highlighted both topics. In other words, there were not any answers about how they used mathematics in the protection of environment.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

This study showed results in order to investigate teaching prisms in fifth grades supported by education for sustainable development. To reach this aim, participants were observed during eight class hours. They studied on activity sheets and some were interviewed at the end. Moreover, participants' answers or approach were analyzed according to three main topics which were education for sustainable development, prisms in teaching geometry and its advantages in supporting. The results of the study displayed what 5th grade students think about the meaning of ESD in terms of recycling and packaging waste, what the thinking strategies of 5th grade students for classification and nets of prisms are and what 5th grade students think about learning prisms using instruction supported with ESD. Results of the study were explained in previous chapter in detail. This chapter includes discussion of the findings, potential implications of the study and suggestions for future research.

5.1. Discussion of the Findings

5.1.1. About Teaching Prisms

In the current study, participants tried to classify prisms, to define prisms and to understand nets of prisms by folding and unfolding prisms and by drawing them. During these, they benefitted from concrete materials such as boxes which were examples for packaging wastes. There were similarities as well as differences between the current study and the study by Roth and Thom (2009). These similarities were about changes in informal and formal geometry knowledge of participants who used concrete materials while classifying prisms.

Based on the observation notes in the study, although participants had concrete materials, they firstly tried to show their knowledge which sourced from memorization of knowledge in previous years. Then, after they started making use of materials, they tried to achieve meaningful understanding and learning. The reason of this might be that participants made concrete learning through material and they found answers to the questions by trial and error method. Although participants highlighted the similarity of numbers of surfaces, edges and corners in all kind of prisms, they continued stating these as distinctive property in classifying. The order of topics in classification might be a reason for this. In other words, participants' expression would be different because the classification started with the surfaces of prisms. If the prisms would be classified with respect to their numbers of surfaces, edges and corners, all boxes would be in the same groups. Similar to Koester's study (2003), participants explored definition of prisms without memorizing it. Although participants did not use the expression like "*parallel bases*", they made an effort to give numbers of different parts of the related prisms such as the number of surfaces, corners, edges and examples for kinds of prisms like a book. The reason of this situation might be that the implementation had started with the classification of the prisms by exploring the shape of surfaces and then by counting the number of surfaces, edges and corners instead of the definition of the prism first. In addition to these, participants tried to develop their spatial ability skills, conceptual developments in 3D structures, matching 3D shapes and 2D planes and their visualization abilities like in some studies (Pittalis et. al., 2010; Sack, 2013; Pittalis & Christou, 2013; Fujita et al., 2017; Hallowell et. al., 2015). However, when compared to current study, talking about the development of students' abilities is not possible. Although some participants had difficulties in constructing and drawing nets of prisms, these developments had effect on their understanding nets of prisms in constructing, drawing and folding nets to construct prisms. The reason of these difficulties might stem from the fact that participants did not consider the equality in length of edges and units in edges. In addition to these difficulties, participants did not consider whether the surfaces would overlap during the drawing. These

difficulties might be resulted from participants' lack of experiences in drawing nets (Piaget & Inhelder, 1948) or they might not imagine nets of prisms (Cohen, 2003). Despite difficulties in folding and unfolding the nets of prisms, the fewer participants tried to overcome this with trial and error and then they tried to explain reasons of their difficulty. Besides, the number of participants that constructed relationship between classification of prisms and nets of prisms is the least. In this case, some participants mentioned that they might place prisms in different classification groups. Then, they exemplified that a net might be called a rectangular prism in unfolded state of the box, but this net might be called a square prism in folded state. The reason of this might be similar to difficulty in constructing and drawing them. Additionally, participants might have not considered the parallelism of bases in prisms and they might have perceived that unfolded state of the box was different from the folded situation.

In previous studies, different applications were observed in teaching prism such as supported by the drama (Özsoy, 2003; Günhan & Özen, 2010) and the use of Orff Approach in the teaching of geometrical objects (Aktaş & Kaya, 2017). At the end of these studies, higher motivation, higher interests, higher participation of students were observed, and the meaningful teaching and learning environment were constructed. In the current study, similar to previous studies' results, it was observed that teaching prisms supported by ESD was beneficial to participants to support their motivation and interest, to increase their participation and to provide individuality, independence, interdependence, cooperation and open-mindedness while expressing themselves in implementation. Additionally, they understood the importance of solidarity. For instance, when some participants had confusions in counting the number of surfaces or corners of prisms, others advised them to try new ways or they showed opportunity to overcome this confusion by helping their counting. Hence, they had the chance of finding their own mistakes and of dealing with their difficulties. Also, participants experienced peer learning environment.

5.1.2. About ESD

In the current study, similar to Kates et. al., mention (2005), it was found out that protection and development of environment are important in terms of sustainability of environment. Additionally, more than half of the participants had new perspectives on ESD and they were sensitive to the environment, to the recycling and to the packaging wastes and to the overconsumption. These changes were supported for more sustainable future (de Hann et. al., 2010). At the end of the current study, it was possible to observe some changes in participants' awareness of sustainable future, but it might not be possible to say that it was enough. For instance, some participants alerted some classmates to turning the lights off in class if it was not necessary or to unplugging the smart boards in leaving classroom in order to prevent overconsumption of electric. Additionally, some participants tried to decrease the overconsumption of paper and to increase the amount of recycled paper. In the current study, it was observed that findings of studies in different grade levels had similarities in terms of representing formal and informal learning environment (Alexander, 2010; Gresch, & Bögeholz, 2013; Nikel, 2007). It was observed that participants benefitted from their daily life experiences in order to give examples and ask different questions for ESD. Hence, it could be concluded that participants learned in a meaningful way because they used their pre-knowledge in order to learn a new topic. For example, during discussing the process of paper recycling, participants said that waste oil, waste glass or waste batteries might be recycled. Based on the results of the current study, participants gave these examples since one had waste glass recycling boxes in his previous school, some had waste batteries recycling box in their class and another one watched an advertisement about collecting waste oil project. In addition to these, participants supported their formal and informal settings in terms of decision making process, responsibility and equity and equality. To illustrate, some students who were withdrawn in individual studies tried to take responsibility in group works and they tried to share their ideas in order to prevent mismatching during folding nets in group works. Also, while some students had

tended to talk simultaneously, they have waited each other for completing their talking in decision making processes. This might be important in learning the terms such as equity and equality. Moreover, like McNaughton (2010), participants had opportunity to express their learning, to consider real world issues and to improve prudential attainment, and to use nonverbal communication by the means of learning- centered teaching during the implementation. During the study, participants exemplified the real world issues by considering negative effects of drought, deforestation, disasters caused by humans or damages in ozone layer. Then, they mentioned that recycling might prevent these. In addition to these, participants had a tendency to apply trial and error method by using their prior knowledge and to learn by doing for some activities.

According to Barr et al., (2001), recycling and reusing are different terms, and they have different definitions. However, in the study, participants had confusion about the terms recycling and reusing. During the study, participants had the idea that they were similar approaches, and they gave their examples and definitions based on the same idea. For instance, according to some students, recycling was either transformation of the oldest thing into the newest one or reusing of the things after sending them to modernize. The limited number of participants who mentioned recycling process in activity sheets showed recycling and reusing might be different terms. Additionally, King et al., (2006) mentioned if recycling provides more energy than other methods such as repairing, reconditioning and remanufacturing, it is preferable, and so recycling is better than wasting. In specifying the necessity of recycling, participants supported recycling for the protection of nature, continuation of life and protection of trees since participants constructed relationship between recycling and paper. In addition to these, some participants highlighted the necessity of recycling in terms of decreasing the level of toxic gas and solar radiation. This also showed that participants benefitted from prior knowledge and knowledge from different disciplines such as science. Furthermore, de Vega et al., (2008) represented the examples of recyclable wastes such as paper and cardboard, plastics, organic

wastes like food waste, leaves and grass, tree branches, metals, glass, hazardous wastes like batteries and construction/demolition in their study. Also, while some examples such as rocks were grouped as a recyclable waste for which there did not exist a local market in the city of Mexicali, some types of plastic or organic wastes were grouped as non-recyclable waste. These examples had similarities with participants' answers such as paper, plastic, waste oil, rocks and vegetables or food in the current study. In giving these examples, participants benefitted from both their daily life and classroom discussion. Based on the results of discussion in classroom environment, examples were differentiated from the first participant to last participant and these examples were showed similarities towards the last participants. The packaging wastes were defined by the European Parliament and Council Directive (94/62/EC) as "*any packaging or packaging material covered by the definition of waste*". For the economic sustainability, collaboration of stakeholders and participation of citizens are necessary for the efficient and effective recycling process of packaging wastes (Ezebilo & Animasaun, 2011). In the current study, fewer than the half of participants did not have any meaningful definition of packaging wastes. However, more than half of them gave the examples what these were and some words such as slashed, old materials or garbage were highlighted. In this case, they experienced a difficulty in defining them. The reason of this difficulty might be resulted from the participants' difficulty in defining the terms like recycling and reusing.

5.2. Implications of the Study

The results of the study showed that geometry can be associated with the concrete world by leaving the abstract world in prism teaching. At the same time, it was ensured that the use of packaging waste, which is a prism sample, for the purpose of raising awareness of recycling, and the prism teaching was associated with the solution of environmental problems. Both disciplines have been tried to be served in line with the requirements of the age. The findings of the study suggest that teaching prisms in fifth grades is supported by ESD since this offered

opportunities for participants to connect courses with daily life and forming discussion environment in order to share their ideas freely. This kind of supporting might lead to variety of learning activities in teaching and learning. This variety might be supported in not only learning activities but also gaining different perspectives and ideas. These activities might enhance students in terms of understanding some concepts more deeply and applying these into different situations by generalizing ideas. Moreover, definition of concepts about prisms and recycling should have more importance during learning in this study. During this, while informal definitions are highlighted, formal definitions should be a part of the study. For instance, participants stated these definitions by using their own words and by comparing alternative definitions, and they made them understandable with their explanations. Otherwise, some definitions are meaningless on paper. Moreover, participants might have opportunity for self-expression during discussions, if they might not do this by writing on paper. Also, for some cases, they might understand the importance of trial and error method instead of memorizing formulas or solution ways. Furthermore, participants should have opportunity to correct their mistakes. By the means of boxes which were used as prisms and packaging waste, discussions on boxes may also be useful in terms of classification, definitions or counting numbers of edges, corners or surfaces or examples of recycled wastes, and also participants' estimation ability. These might be the advantage of using concrete material since some participants might learn by touching upon a material. Besides, since participants associated these with their daily life, they can find answers for "*Why do we learn these?*" or "*Where do we use these?*" These were clear when participants asked questions and found answers related daily life. Hence, participants have opportunity in terms of facilitating their knowledge and applying these, and participants should have connection among different courses. This kind of support in teaching might have effect on not only students but also teachers. In this case, this might enhance teachers' understanding in definition of concepts as formal and informal. Also, this might allow teachers to construct variety in learning and

teaching environment by collaborating with other teachers and by supporting students' learning with different aspects.

In the application of the current study, it was observed that students were active in learning, and they had an engaging learning environment. After the application, it could be concluded that they had some changes in their understanding of prisms and recycling. Additionally, participants might have had the idea that courses were related to each other and these could contribute to each other. During the study, it was observed that participants benefitted from their prior knowledge which sourced from science courses in exemplifying importance and necessity of recycling and participants mentioned that this kind of supports might be generalized for other courses such as science or English. Also, during learning, it was easy to observe and to define participants' misconceptions and difficulties in their understanding. While students expressed their ideas, some also understood their mistakes and overcame their difficulties. Hence, this was beneficial for both students and teachers.

5.3. For Future Research

The study has some recommendations for future research. Findings of this study are restricted to the specific content area, prisms and recycling. Future research can contain other content areas in terms of both geometry and education for sustainable development and tasks of study, and interview questions can be developed. In the current study, participants advised that this kind of support might be repeated in learning fractions and basic operations. Additionally, this study can be carried out by using the dynamics software programs with concrete materials to provide participants with folding and unfolding nets of prisms. Besides, this can be conducted in outside of the classroom. As a result, participants might have opportunity to construct a relationship between nature and continuity of life with learning mathematics or geometry. Moreover, similar studies can be conducted with pre-service teachers in order to gain knowledge about how they perceive this teaching, what understanding /awareness they will

gain at the end of study, how they define prisms, how they classify prism, how they fold or unfold nets of prism or how they define recycling. In addition to these, pre-service teachers might have idea how they teach these topics or how they continue learning by doing. Besides, participants can be questioned about how they perceive world as 3D object or a member of the universe, what they consider about real world issues and how they solve them. In this case, the kind of support in teaching can be shaped according to understanding of participants.

A limited number of students from a fifth grade class in middle school participated in this study. Hence, this study can be re-applied on more participants. Also, these participants might be chosen from different districts since individuals have different life styles and they have different perception of living. In addition, this study can be conducted in different contexts with participants from different grade levels. In other words, these kinds of supporting with different contexts can be prepared for students at preschool level, at elementary school level or at secondary school level. While this study displayed opportunity to observe participants with eight class hours, another implication can be applied longer than 8 class hours in order to obtain more detailed information about participants' understanding and changes in their daily life. Or participants can be observed during their middle school years by applying this kind of supporting in teaching different disciplines in order to explain effects of these applications. In other words, how this support affects participants' understanding and what it changes in their lives will be observed. Participants who learn with this kind of support in teaching can be compared with participants who learn with classic teaching and learning methods in terms of their ESD perception and effectiveness of learning.

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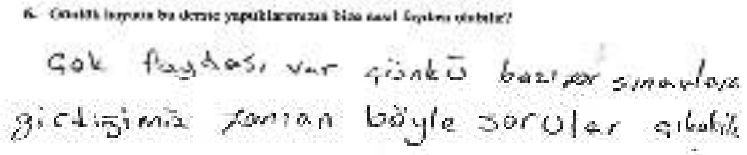

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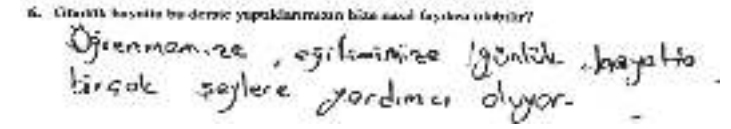

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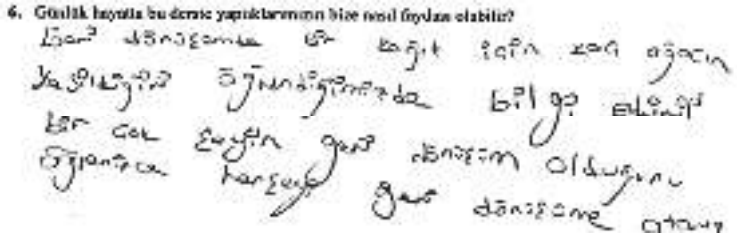

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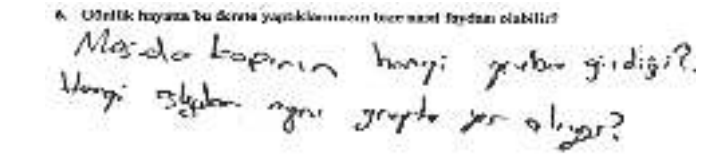
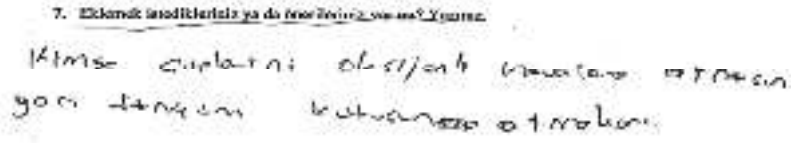


(d)

Figure 48. The participants' response to advantages of lecture in daily life.



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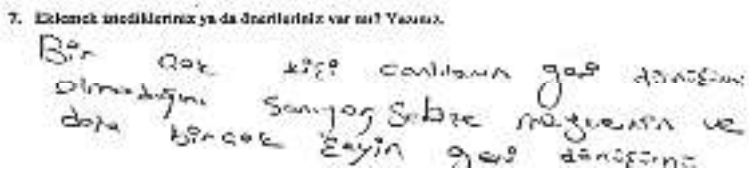

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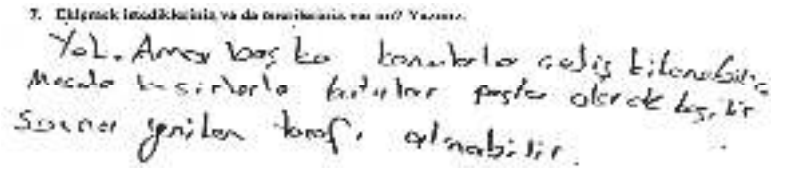
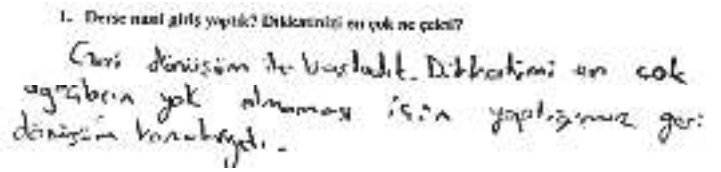
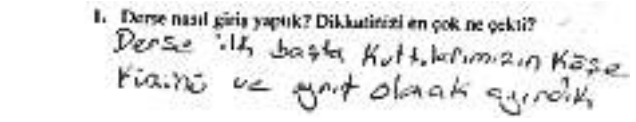


(c)

Figure 49. The participants' response to adding and suggestions.



(a)



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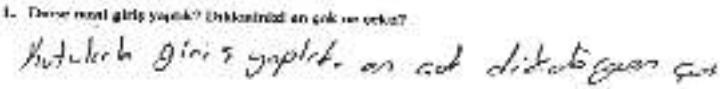

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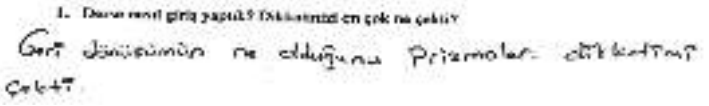


(d)

Figure 50. The participants' response to how class was started and what attracted their attention.

B. ACTIVITY SHEETS USED IN CLASSROOM

Çalışma Kağıdı 1.1

1. Heeyyy sen. Özel bir görev için seçildin. Bilmen gereken 1 ton kağıt için 17 ağaç kesildiği. Elindeki kutunun ağırlığı ortalama 200 gram/m^2 ve görevin bu 17 ağacı kesilmekten kurtarmak. Bunun için kaç tane kutu biriktirmelisin?

2. Sizce geri dönüşüm nedir?

3. Geri dönüşüme neden ihtiyaç duyulur?

4. Ambalaj atığı ne demektir? Örnek veriniz.

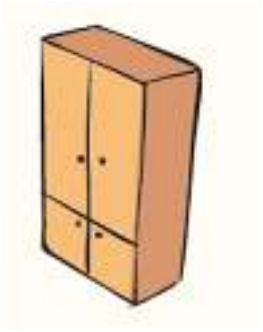
5. Hangi ürünler geri dönüştürülebilir?

Çalışma Kağıdı 1.2

6. Kutuları hangi özelliklerine göre sınıflandırdınız? Kaç grup oluştu?

7. Bu sınıfların özel isimleri olsa, sizce ne olurdu? Nasıl belirlediniz?

8. Aşağıdaki cisimler belirlediğiniz grupların hangileriyle benzerlik göstermektedir? Köşe, ayrıt ve yüzeylerini gösteriniz, sayılarını yazınız.



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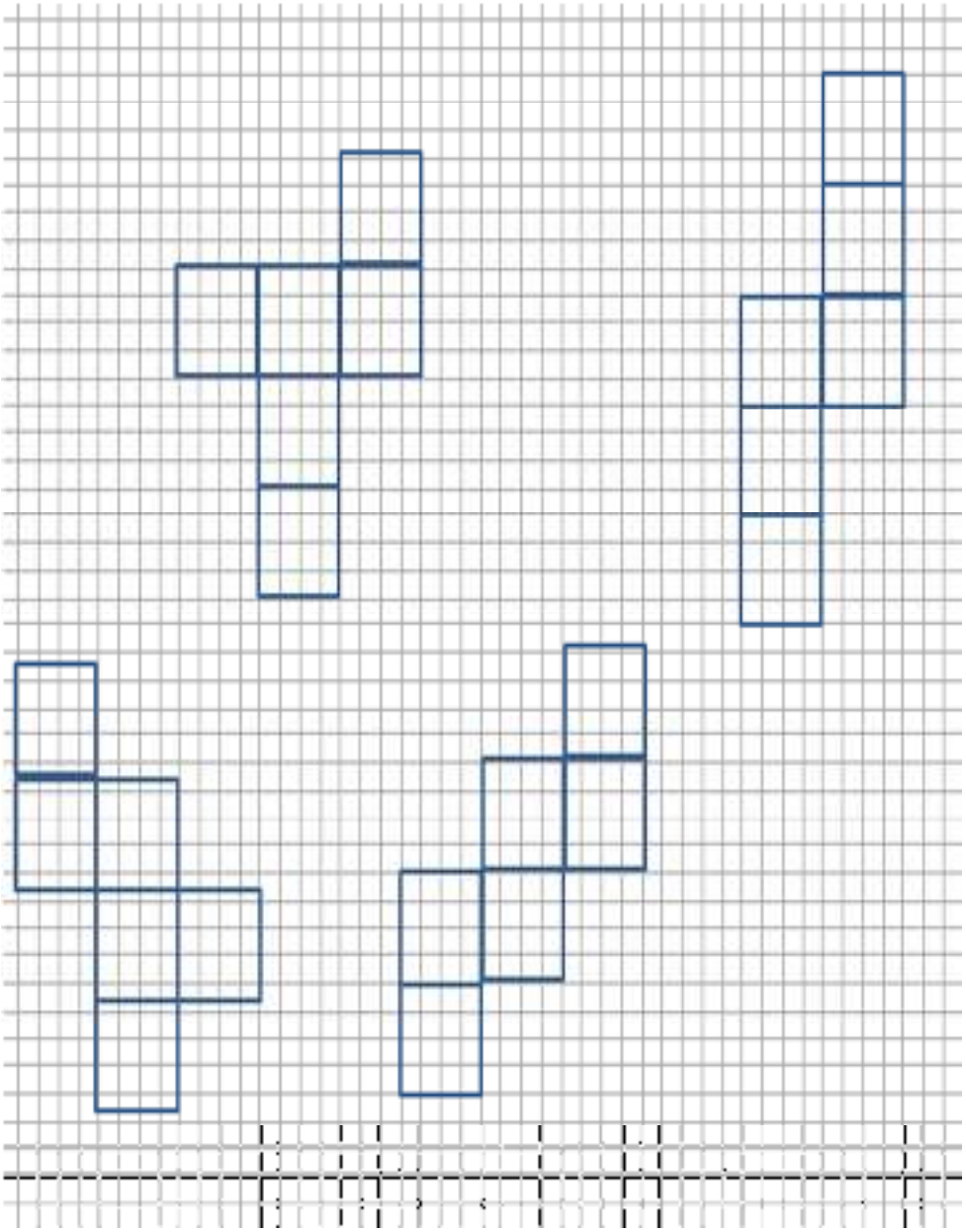
Çalışma Kağıdı 2.1

Grup 1

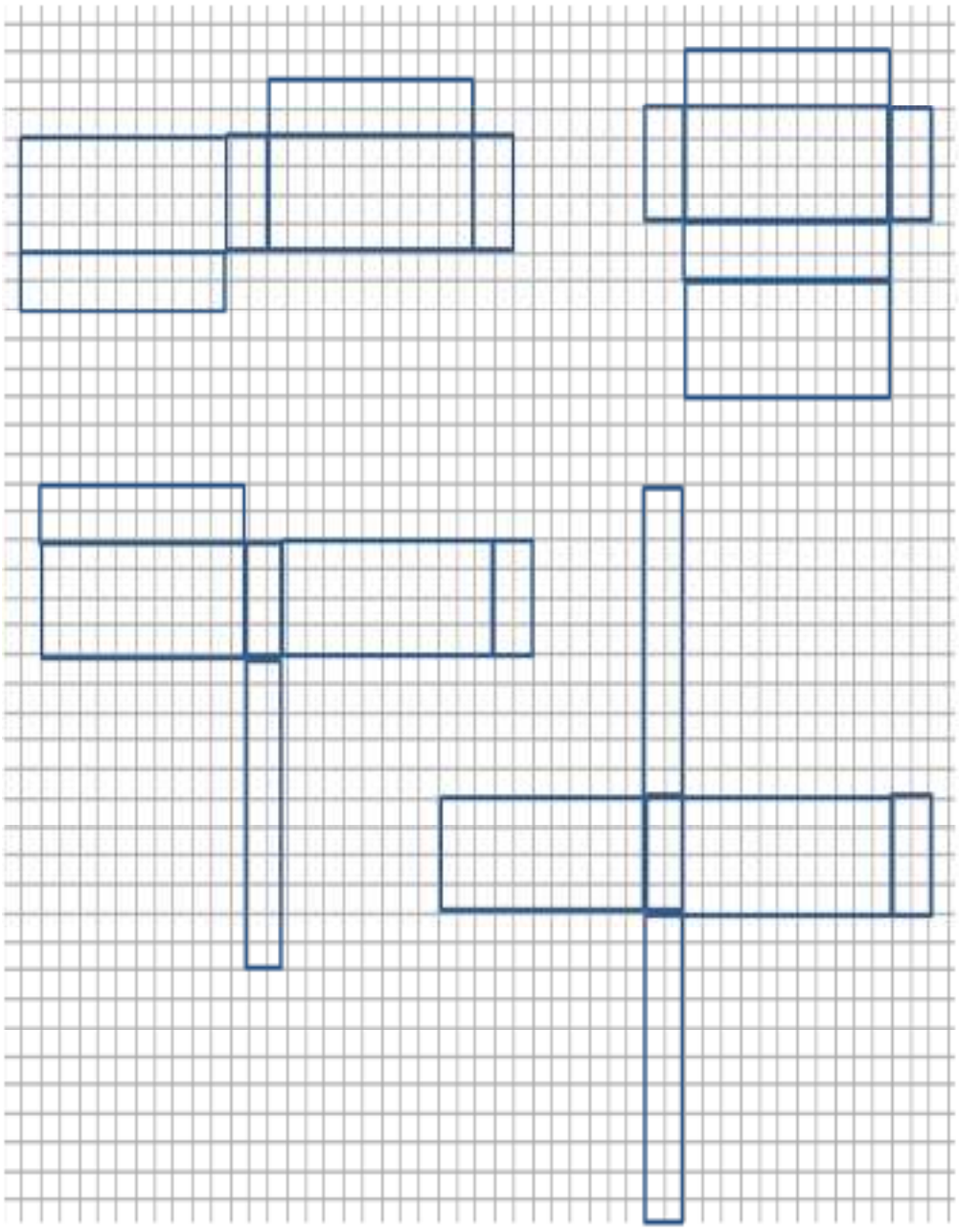
Elinizdeki kutuyu parçalara ayırınız ve aşağıda verilen açınımları bu parçalar aracılığıyla kendi kutunuzla oluşturunuz.



Çalışma Kağıdı 2.1

Grup 2

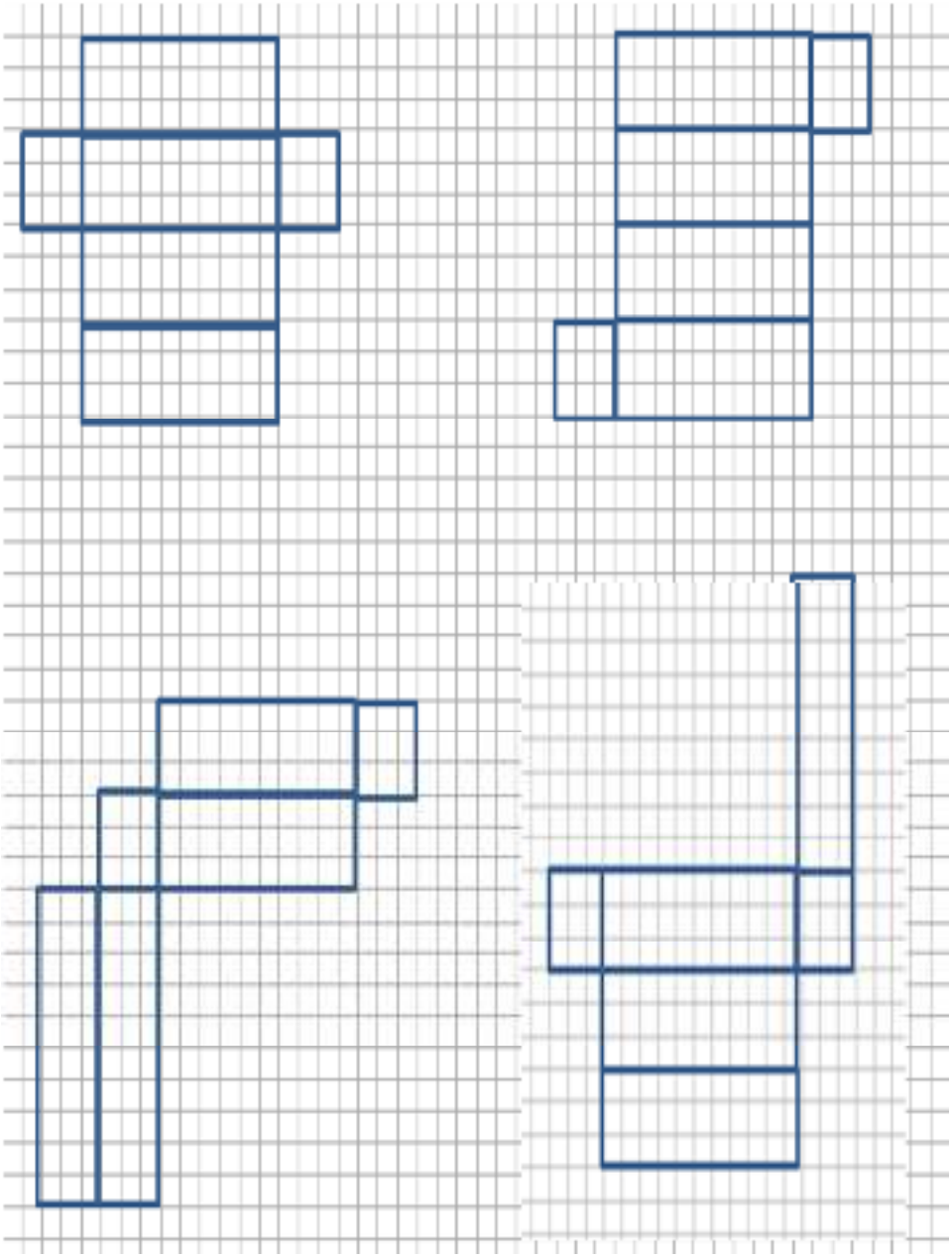
Elinizdeki kutuyu parçalara ayırınız ve aşağıda verilen açınımları bu parçalar aracılığıyla kendi kutunuzla oluşturunuz.



Çalışma Kağıdı 2.1

Grup 3

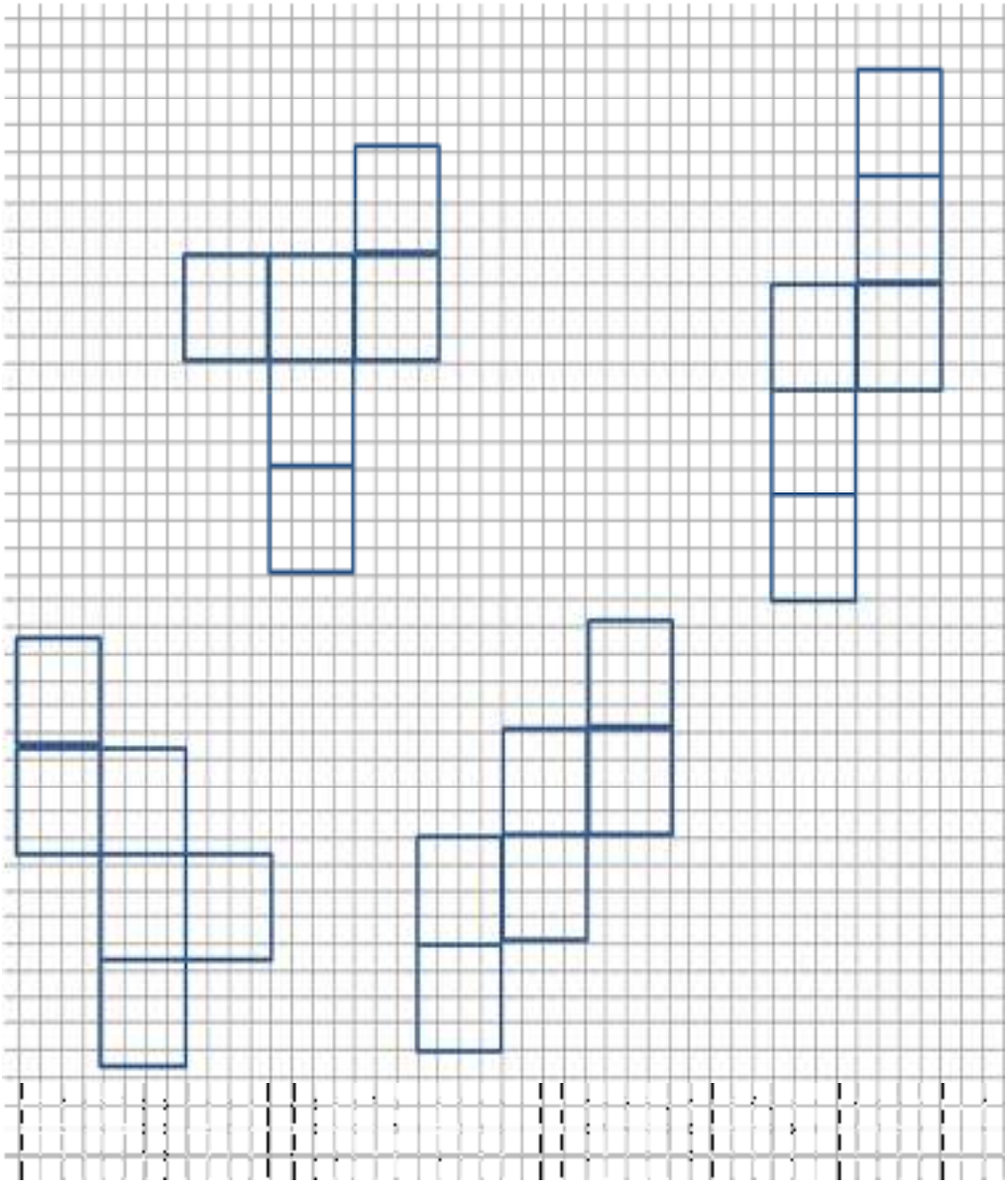
Elinizdeki kutuyu parçalara ayırınız ve aşağıda verilen açınımları bu parçalar aracılığıyla kendi kutunuzla oluşturunuz.



Çalışma Kağıdı 2.1

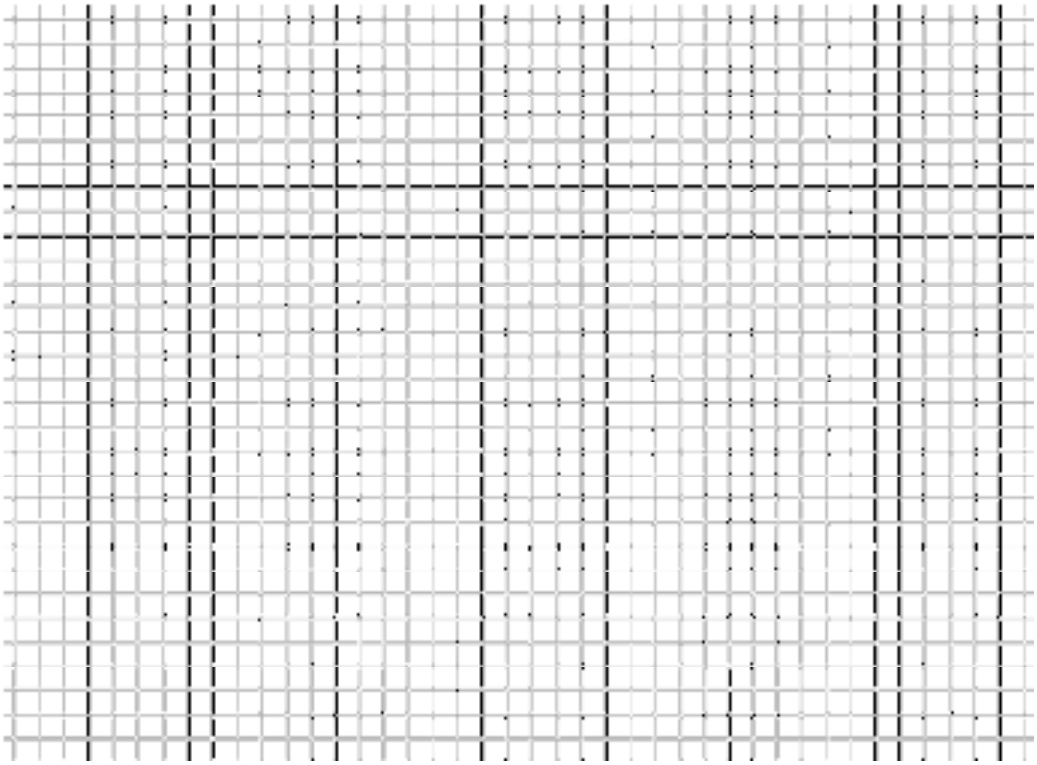
Grup 4

Elinizdeki kutuyu parçalara ayırınız ve aşağıda verilen açınımları bu parçalar aracılığıyla kendi kutunuzla oluşturunuz.



Çalışma Kağıdı 2.2

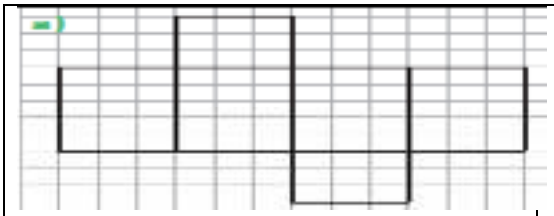
1. Elinizdeki diğer kutuyu açınız ve bu açınımı aşağıdaki kareli kağıda çiziniz.

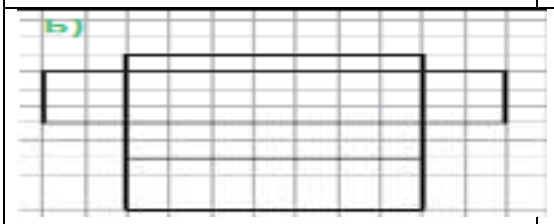


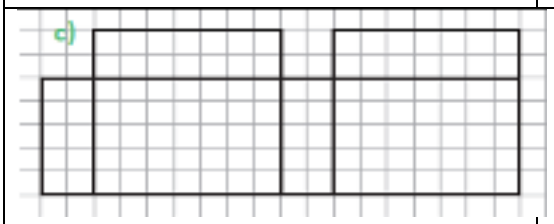
2. Çizmiş olduğunuz açınım, kutular aracılığıyla açınımı oluşturduklarınızdan hangisine benzemektedir? Neden?

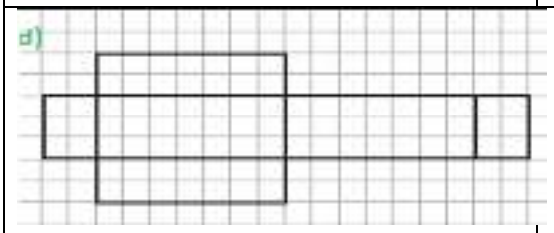
Çalışma Kağıdı 3

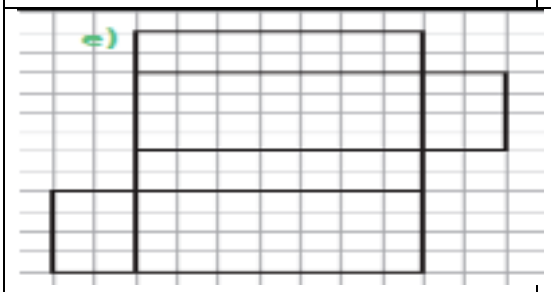
1. Aşağıda verilen açınımların prizma oluşturup oluşturmadıklarını nedenleriyle açıklayınız.











Çalışma Kağıdı 4

1. Derse nasıl giriş yaptık? Dikkatinizi en çok ne çekti?

2. Günlük hayatla konumuzun nasıl bir bağlantısı vardı?

3. Kutuları nasıl ayırdık?

4. Günlük hayatta kullandığımız hangi kutuları getirdik?

5. Bu kutuları ayırırken neye dikkat ettik? Neden kutuları ayırmak önemli?

6. Günlük hayatta bu derste yaptıklarımızın bize nasıl faydası olabilir?

7. Eklemek istedikleriniz ya da önerileriniz var mı? Yazınız.

C. INTERVIEW QUESTIONS WITH TURKISH LANGUAGE

GÖRÜŞME SORULARI (Participant 3-P3/ Interviewer- I)

1. I: Prizmayı nasıl tanımlarsınız?

P3: Önce gruplara ayırdık. Yüzeyleri dikdörtgen olanlar, tamamı kare olanlar, dikdörtgen ve kare olanlar.

I: Köşe, ayrıt, yüzey sayısı? (kitap üzerinden saydı)

P3: 8 köşe, 12 ayrıt-kenar, 6 yüzey

I: Ayrıt mıydı, kenar mı?

P3: İkisini de kullanıyorduk ama çoğunlukla ayrıt

2. I: Prizmaları nasıl sınıflandırırsınız?

I: İsimlerini verirken tüm yüzeylerine mi, bazı yüzeylerine göre miydi?

P3: Alt ve üst yüzeyine göre

I: Özel adı var mıydı bu yüzeylerin? (taban cevabı gelmedi)

P3: Kareyse kare prizma, dikdörtgense dikdörtgenler prizması, hepsi kareyse küp.

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P3: İnsanlar doğayı kirletip, zarar veriyor. Olmasa bu daha çok olur

I: Biz neyin dönüşümü yaptık?

P3: Kutuların, kağıdın

I: Özel adı var mıydı?

P3: Kutu

I: Geneline ne diyorduk?

P3: … ambalaj

4. Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

(bu soru atlanmış)

5. I: Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden?

(soru anlaşılmadığı için tekrar aşağıdaki haliyle soruldu)

I: Açınıma bakarak sınıflandırabilir miydik?

P3: Hayır yapamazdık

I: Neden?

P3: Bizim küptü, çizerek kare hale getirdik. Diğer türlü dikdörtgen diyebilirdik.

I: Kutuya mı bakmamız mı gerekti, açınımına mı bu durumda?

P3: İkisine de odaklanmalıyız bence.

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P3: Pil, cam, yağ, plastik

Geri dönüşüme uygun olduğu için.

I: Her şey olur mu sadece belli ürünler mi?

P3: Belli ürünler

I: Hangileri?

P3: Kumaş, boya, tahta

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir?

P3: Hoşuma gitti.

I: Başka konularda yapılabilir mi?

P3: Toplama işlemleri ya da kesirlerde

I: Yine kutularla mı?

P3: Olabilir ya da başka atık ürünler. Şişeleri boyarız parçalara ayırdıktan sonra.

I: Bir şeyler değişti mi günlük yaşantında?

P3: Daha duyarlıyım.

I: Ne değişti, neler yapıyorsun, her zaman yapabiliyor musun?

P3: Bazen yapıyorum.

I: Örnek?

P3: Geri dönüşüm için kutular yeterli olmadığı için kağıt/ kartonu görülecek yerlere koyuyorum. Pilleri sınıfa getirip atık kutusuna atıyorum. Şişeleri okula getiriyorum. (Plastik şişeler olabilir buradaki).

8. I: Küpün açınımında kesilen kutu parçalarının üstüne çizim yaptınız, neden?

I: Elinizdeki kutu dikdörtgenler prizması mıydı küp müydü?

P3: İkisine de benziyordu.

I: Neden böldünüz?

P3: Parçalar farklı uzunluktaydı, üzerine çizmesek dikdörtgen olacaktı.

GÖRÜŞME SORULARI (P7)

1. I: Prizmayı nasıl tanımlarsınız?

P7: 6 yüzü, 8 kenarı

I: Kenar mı?

P7: 4 köşe

I: Kitaptan sayabilirsin.

P7: 6 yüzey, 8 köşesi, 12 ayrıtı olan cisim

2. I: Prizmaları nasıl sınıflandırırsınız?

P7: Tek kareler, dikdörtgenler, kare dikdörtgenler

I: Özel isimleri var mıydı?

P7: Kare prizma, küp, dikdörtgenler prizma

I: İsimlendirirken neye dikkat ettik?

P7: Yüzeylerine

I: Hepsine mi, özel bir yer var mıydı?

P7: (tabanları gösterdi)

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P7: Bir şeyi tekrar kullanmak, birçok ağaç kesiliyor.

4. I: Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

P7: Ayrıtlarını görmek için

I: Geri dönüşümle ilgili mi?

P7: Evet.

I: Mesela?

P7: Konuyu işledikten sonra herkes geri dönüşüme gönderdi.

I: Yer açısından ilgisi var mı?

P7: Olabilir.

5. I: Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden?

P7: Hangi kenarların farklı olduğunu açınca da aynı şekilde gördük

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P7: Yemekler. Tekrar tekrar kullanmak için

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir?

P7: Hoşuma gitti, daha az kağıt harcıyorum

8. I: Küpün açınımında kesilen kutu parçalarının üstüne çizim yaptınız, neden?

P7: Hepsini bozup bozup yapmak yerine hepimiz ayrı ayrı oluşturduk.

I: Çizimdeki kareleri saydınız mı? Küp olduğuna nasıl karar verdiniz?

P7: Kalemle ölçtük.

I: Peki kutunuz dikdörtgenler prizmasıydı, elinizdeki açınımda dikdörtgenler prizmasına ait olsaydı yine çizecek miydiniz?

P7: Evet.

GÖRÜŞME SORULARI (P2)

1. I: Prizmayı nasıl tanımlarsınız?

P2: Bilmem.

I: Kutular desem? Köşesi, kenarı, ayrıtı, yüzeyi var mıydı? Nerelere diyorduk?

P2: 6 yüzey, 12 ayrıt, 8 köşesi vardı. (kitap üzerinde doğru göstererek)

2. I: Prizmaları nasıl sınıflandırırsınız?

P2: Köşe, ayrıt ve kenarlarına göre

I: Yüzey etkisi var mıydı?

P2: Vardı dikdörtgen ve kare olarak dikkate aldık

I: 2. Sınıflandırmayı neye göre yaptık?

P2: Bazı arkadaşlarımız yanlış yere koymuştu.

I: Nasıl karar verdik?

P2: Tahmin ettik, karışla da ölçtük

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P2: Kitapları geri dönüşüme vermiştik geçen seneler, başkaları kullansın diye. Ağaç kesilmesin.

4. I: Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

P2: Kaç parçası var diye. Bir de kapatınca hangi şekil çıkıyor diye

5. I: Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden?

P2: Farklı gruplama olurdu, açınım şekline göre yapardım

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P2: Ambalaj atıkları, piller, camlar, tahtalar. Ağaçlar için

I: Camın ağaçla ilgisi var mı?

P2: O zaman camı fazla kullanmamak için

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir?

P2: Hoşuma gitti

I: Günlük yaşamında değişiklik oldu mu?

P2: Hayır

I: Başka konuları ilişkilendirebilir miyiz?

P2: Fen, İngilizce

I: Matematik'te?

P2: ….

GÖRÜŞME SORULARI (P13)

1. I: Prizmayı nasıl tanımlarsınız?

P13: …..

I: Kitap bir prizma mı?

P13: Evet

I: Buna göre nasıl tanımlarsın?

P13: 6 yüzey, 12 ayrıt, 8 köşesi var olan şeyler

I: Ayrıt nereye diyorduk?

P13: Şuraya, (kitap üzerinde doğru gösterdi). Kenar da diyebiliriz.

2. I: Prizmaları nasıl sınıflandırırsınız?

P13: Kare – dikdörtgenler, Dikdörtgenler, Küp

I: Neyi dikkate aldık sınıflandırırken?

P13: Yüzey, köşe ayrıtına baktık.

I: Sayılarda fark var mı diğer prizmalarla?

P13: Sayılarında fark yok

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P13: Kullandığımız pil bitti, geri dönüşüme attık. Dönüşüp geldi. Çevreyi kirletmesin, zarar vermesin.

I: Kağıt, ambalaj atığı için neden dönüşüm yaptık?

P13: Ağaçların kesilmemesi için.

4. I: Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

P13: Onları sınıflandırmak için, açınımlarını incelemek için

I: Kutuları naklederken ne gibi faydası olabilir, geri dönüşüm için gönderirken?

P13: Kutuyu açınca daha kolay giderler

I: Yer açısından avantajlı mı?

P13: Küçük küçük oluyorlar, daha az yere çok kutu oluyor

5. I: Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden?

P13: Olmadı

I: Peki, açınım verilip kutuların hangi gruba ait olduğunu bulabilir miydik?

P13: Hayır, bulamazdık

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P13: Yağ, pil, ambalaj, kalem (yok değil),

I: Cam olabilir mi?

P13: Olur

I: Plastik?

P13: Olur

I: Plastik kaç yılda doğada çözünüyordu (TÜBİTAK'tan hatırla)

P13: 1000 milyon yıl

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir? Hoşuna gitti mi bu şekilde?

P13: Evet, gitti.

I: Peki hayatında ne değişti, daha dikkatli davranıyor musun mesela ayrıştırıyor musun?

P13: Yeni şeyler öğrendik. Ayırıyorum, çöpe atmıyorum

I: Çevreni uyarıyor musun?

P13: Evet

8. I: Prizmanın açınımında, kutunun farklı parçalarını kullandınız, neden? Kutunun açınımında parçaları değiştirdiniz neden?

P13: Kağıttakine göre yaptık, orada da küçük parçalar kullanılmıştı.

I: Çizim mi yanılttı sizi?

P13: Evet, kağıtta da öyleydi, ona göre yaptık

I: Sonra niye değiştirdiniz?

P13: Kutu kapanmadı, boşluklar kaldı.

GÖRÜŞME SORULARI (P15)

1. I: Prizmayı nasıl tanımlarsınız?

P15: Kenarları değişik.

I: Nasıl?

P15: Daha büyük.

2. I: Prizmaları nasıl sınıflandırırsınız?

P15: Dikdörtgen prizma, kare prizma, dikdörtgen- kare prizma

I: Özel anlamı var mı sana bu sınıflandırmanın

P15: Geri dönüşüme katkı sağlamak için.

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P15: Çöpleri, plastik camı dönüştürürüz. Ağaçlar kesilmesin, çevre kirlenmesin.

4. I: Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

P15: Ağırlıkları bulalım

I: Geri dönüşümle ilgisi?

P15: Üstüne ayrıştırmak istediğin ürünler için isimleri yazarsın

5. Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden? (sorulmamış)

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P15: Cam, plastik. Çöpe atmak yerine dönüşüm kutusuna atmalıyız, israf olmasın diye.

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir?

P15: Sevdim.

8. I: Geri dönüşümle ilgili verdiğin örnekler farklıydı, hatta geri dönüşüm kutularını çizdin. Daha önceki okulunda buna yönelik çalışmalar var mıydı, özel bir ilgi mi?

P15: Çalışma vardı. Okulda, Çevko kutuları vardı, ona göre ayrı atılıyordu. Çok sevdiğim için ilgiliyim.

GÖRÜŞME SORULARI (P16)

1. I: Prizmayı nasıl tanımlarsınız?

P16: Yüzey, ayrıt, kenar, dik açılı

2. I: Prizmaları nasıl sınıflandırırsınız?

P16: Açılarına, ayrıtlarına, köşelerine göre

I: Başka?

P16: Yüzeylerine göre. Kare olanlar, dikdörtgen- kare, dikdörtgen şeklinde.

I: Özel isimleri?

P16: Küp, kare prizma, geometrik cisimler, dikdörtgenler prizması.

I: Sınıflandırırken tüm yüzeylerine mi baktık belli yüzeylerine mi?

P16: Alt ve üst yüzeylerine baktık bir de kenarlarına.

I: Küp için özel durum var mıydı?

P16: Tamamı kare olanlardı.

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P16: Bizim yaşantımız. Bizi yaşatmak için gerekli

4. I: Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

P16: Öğrenmemiz için, daha küçük parçalara ayırarak daha iyi gördük

I: Yer açısından avantajlı mı?

P16: Evet. Kutu kapalıyken daha fazla yer kaplıyor, diğer türlü daha çok şeyi üst üste koyabiliriz.

5. I: Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden?

I: Mesela, ayrı ayrı verilseydi aynı gruplama olur muydu?

P16: Açınımın hangisine ait olduğunu kutuyu kapatmadan yapamazdık

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P16: Cam, kağıt, plastik, hayvanlar

P16: Geri dönüştürmezsek ağaçlar kesiliyor, oksijenimiz bitiyor, ozon tabakası zarar görüyor.

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir?

P16: Olumlu etkisi oldu. Geri dönüşüm için ayrıştırıyorum, çöpün olduğu yerlerde zor oluyor. Meyve suyu kutumu attım bu sabah. Canlıların geri dönüşümünü internetten araştırdım, daha iyi bilgim oldu

8. I: Prizmanın açınımında, kutunun farklı parçalarını kullandınız, neden? Kutunun açınımında parçaları değiştirdiniz neden?

P16: Kutuların boyu aynı değildi. Küçük ve büyük parçaları vardı. Karıştırdık bilemedik. Sonra kutu kapanmayınca değiştirdik.

I: Çizim mi yanılttı, kutunun çok parçası oluşu mu?

P16: Çok parçası oluşu.

GÖRÜŞME SORULARI (P12)

1. I: Prizmayı nasıl tanımlarsınız?

P12: Üçgen, prizma gibi şeylerin konisi, aynı şeyden diğer tarafında da oluşu

I: Ayrıtı, kenarı, köşesi var mı bunların?

P12: 12 tane kenarı, 8 tane köşesi, 6 tane ayrıtı var

I: Ayrıt mı yüzey mi?

P12: Ayrıt

I: Yüzey sayısı?

P12: 6

2. I: Prizmaları nasıl sınıflandırırsınız?

P12: Sınıflandırma?

I: 1. Grup, 2. grup diye ayırmıştık derste?

P12: Hepsi dikdörtgen olanlar, yarı kare yarı dikdörtgen olanlar, hepsi kare olanlar

3. I: Sizce geri dönüşüm nedir? Neden ihtiyaç duyulur?

P12: Eski şeyi geri dönüşüme atıyoruz, yeni gibi geliyor

I: Çevre ile ilgili olarak?

P12: Kağıtları koruyabiliriz.

4. I: Kullandığımız kutuları neden açmaya ihtiyaç duyduk?

P12: Öğrenmek için.

I: Geri dönüşümle ilgisi olabilir mi?

P12: Olabilir.

I: Ne gibi?

P12: Açacağız.

5. I: Prizma açınımlarının farklı olması sınıflandırma yaparken etkiye neden oldu mu? Neden?

P12: Etkisi var. Açınımlar farklı olabilir. Açınımları verilseydi farklı bir gruba gönderebilirdik.

6. I: Kağıt dışında farklı ürünleri geri dönüşüm amaçlı kullanabilir miyiz? Neden?

P12: Bilgisayar, kola şişesi

7. I: Matematik ve sürdürülebilirlik eğitimlerinin birleştirilmesinin size etkisi nedir? Başka konularda yapılabilir mi?

P12: Sevdim, olabilir

I: Günlük yaşamına etkisi oldu mu?

P12: Çevreme söylemiyorum ama daha dikkatliyim

8. I: Çalışma kağıtlarında kutuları özel olarak isimlendirseydiniz, bunların adı ne olurdu sorusuna prizma, küp şeklinde cevap veren tek kişisin. Bunları daha önce duydun mu yoksa tahmin mi ettin?

P12: Daha önce her yerde duydum.

D. PARENTS' CONSENT FORMS & INFORMATION FORMS

Veli Onay Formu

Sevgili Anne/Baba

Bu çalışma Orta Doğu Teknik Üniversitesi yüksek lisans öğrencisi Ece KANDİLLİ tarafından yürütülmektedir.

Bu çalışmanın amacı nedir? Bu çalışmanın amacı, matematik ve sürdürülebilirlik eğitiminin 5. sınıf öğrencilerinin prizmalar konusunda birleştirilmesinin, öğrencilerin sürdürülebilirlik algısının değişimine ve prizmalar konusunun anlaşılmasına yönelik etkisinin incelenmesidir.

Çocuğunuzun katılımcı olarak ne yapmasını istiyoruz?: Bu amaç doğrultusunda, çocuğunuzdan derse katılımını isteyeceğiz ve cevaplarını/davranışlarını görüntü kaydı biçiminde toplayacağız. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü olarak katılımıyla ilgili rızası mutlaka alınacak.

Çocuğunuzdan alınan bilgiler ne amaçla ve nasıl kullanılacak?: Çocuğunuzdan alacağımız cevaplar tamamen gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Elde edilecek bilgiler sadece bilimsel amaçla (yayın, konferans sunumu, vb.) kullanılacak, çocuğunuzun ya da sizin ismi ve kimlik bilgileriniz, hiçbir şekilde kimseyle paylaşılmayacaktır.

Çocuğunuz ya da siz çalışmayı yarıda kesmek isterseniz ne yapmalısınız?: Katılım sırasında sorulan sorulardan ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğun rahatsız olduğunu öngörürse, çalışmaya sorular tamamlanmadan ve derhal son verilecektir.

Bu çalışmayla ilgili daha fazla bilgi almak isterseniz: Çalışmaya katılımınızın sonrasında, bu çalışmayla ilgili sorularınız yazılı biçimde cevaplandırılacaktır. Çalışma hakkında daha fazla bilgi almak için İlköğretim

Fen ve Matematik Eğitimi bölümü yüksek lisans öğrencisi Ece KANDİLLİ ile (e-posta: ece.kandilli@metu.edu.tr) ile iletişim kurabilirsiniz. Bu çalışmaya katılımınız için şimdiden teşekkür ederiz.

Yukarıdaki bilgileri okudum ve çocuğumun bu çalışmada yer almasını onaylıyorum (Lütfen alttaki iki seçenekten birini işaretleyiniz.

Evet onaylıyorum___ ***Hayır, onaylamıyorum___***

Annenin adı-soyadı: _____ Bugünün

Tarihi:_____

Çocuğun adı soyadı ve doğum tarihi:_____

(Formu doldurup imzaladıktan sonra araştırmacıya ulaştırınız).

Araştırma Sonrası Bilgilendirme Formu

Öncelikle araştırmamıza katıldığınız için teşekkür ederiz.

Katıldığınız araştırmanın amacı matematik ve sürdürülebilirlik eğitiminin 5. sınıf öğrencilerinin prizmalar konusunda birleştirilmesinin, öğrencilerin sürdürülebilirlik algısının değişimine ve prizmalar konusunun anlaşılmasına yönelik etkisinin incelenmesidir.

Bu amaçla, sizden ilk olarak derse etkin katılımınız beklenmiştir. Ders akışı sırasında sergilemiş olduğunuz davranışlar, sorduğunuz sorular ve verdiğiniz cevaplar kapsamında ise en son aşama olarak görüşme yapılmıştır. Katılımcılara araştırmada yanıltıcı bilgiler verilmemiştir.

Bu sırada, öğrenci algılarında sürdürülebilirlik açısından farklılık oluşup oluşmadığı ve öğrencilerin prizmalar konusunda anlama ve bilgilerinin neler olduğu incelenecektir. Analizlerin sonuçlarında, matematik ve sürdürülebilirlik eğitiminin birleştirilmesinin öğrenci algıları ve konuyu anlamaları üzerinde istatistiksel olarak anlamlı ve olumlu bir etkiye sahip olduğunu ortaya koyması beklenmektedir.

Eğer araştırmayla ilgili sorularınız varsa araştırmacıya sorabilir veya ece.kandilli@metu.edu.tr adresinden Ece KANDİLLİ' ye ulaşabilirsiniz.

E. TURKISH SUMMARY/ TÜRKÇE ÖZETİ

5. SINIFLARDA PRİZMA ÖĞRETİMİNİN SÜRDÜRÜLEBİLİR KALKINMA İÇİN EĞİTİM İLE DESTEKLENMESİ ÜZERİNE BİR ARAŞTIRMA

GİRİŞ

Matematik, soyut gösterimleri, kavram ve becerileri içererek, sistematik öğrenmenin meydana geldiği hiyerarşik bir yapıdan oluşur (Sarwadi & Shahrill, 2014). Matematik müfredatı içerisindeki önemli konulardan biri geometridir (Marchis, 2012). Ayrıca, geometrinin kendine ait bir dili olmakla birlikte (Clements, 2003), geometri özel semboller, terminoloji ve anlamlı ilişkiler içerir (Gökkurt vd., 2015). Ulusal Matematik Öğretmenleri Konseyi'ne (NCTM, 2000) göre, geometri bireylere gerçek hayattaki durumları anlama, problemleri çözme ve farklı matematik konularını kavrama açısından avantaj sağlar. Ayrıca, geometri bireylere dünyayı anlama, çevreyi yorumlama ve çevre hakkında bilgiye sahip olmanın yanında matematik ve fen bilimleri gibi disiplinler arası ortamlar oluşturma fırsatı sunmaktadır (Clements, 2003; Fidan ve Türnüklü, 2010; NCTM, 1989; 2000). Bireylerin çevreyi yorumlayabilmesi için görsel bilgiye ihtiyaç duyulur. Sağlanan bilgiyle bireyler hem görselleştirme becerilerini hem de çözüm yolu üretme yeteneklerini geliştirirler (Jones, 2002).

UNECE stratejisine (2009) göre, Sürdürülebilir Kalkınma Eğitimi, SKE, bireyleri sürdürülebilir kalkınma konusunda bilgi ve becerilerle donatmayı, aynı zamanda bireyler için doğayla uyumlu, sağlıklı ve üretken yaşam biçimleri geliştirirken, bireylerin sosyal değerler, cinsiyet eşitliği ve kültürel çeşitlilik konularındaki kaygılarını azaltmayı amaçlamaktadır (Hopkins ve McKeown,

2002). SKE, eğitim ve halk bilincinin koordinasyonuyla daha sürdürülebilir toplumlar ve sürdürülebilir bir gelecek inşa edilmesine dair öneride bulunur (Wals, 2012). Bu nedenle, SKE'nin geleceği için ortak bir vizyon geliştirmek, insanları eğitmeye önem vermek, yenilikleri teşvik etmek, SKE liderliği geliştirmek, stratejik planlar geliştirmek, eylem planları oluşturmak veya bireyleri eğitmek gerekir (Hopkins & Mckeown, 2002).

Bireylerin günlük yaşamda kullandığı ya da karşılaştığı birçok ürünün ve paketleme için kullanılan ambalajların da prizma örneğini oluşturması çalışmanın başlangıç noktasını oluşturmuştur. Aynı zamanda, paketleme için kullanılan ambalajlar, kullanım sonrası atığa dönüşmektedir. Bu durumda, ambalaj atıkları, geri dönüşüm amacıyla kullanılamayacağı için sürdürülemez tüketimin temel nedeni olmaktadır. Geometriyi temsil eden prizmalar konusu ile SKE'yi temsil eden geri dönüşüm ve ambalaj atıkları kavramlarının, farklı disiplinler olmasına rağmen işbirliği içinde olmaları bağlamında, öğrencilerin prizmaları sınıflandırmaları ve prizma açınımlarını çizmeleriyle ilgili algılarının tespit edilmesi ile geri dönüşüm ve ambalaj atıklarıyla ilgili farkındalık kazanmaları beklenmektedir.

Teorik Çerçeve

Geometri, matematik ve diğer disiplinler arasında bir köprü olarak rol almaktadır (NCTM, 1989; 2000). Bu nedenle, geometri bilim ve matematiğin ortak noktası olarak kabul edilir (Clements & Sarama, 2011). Clements ve Battista' ya (1992) göre, geometri fiziksel çevreyi anlama ve yorumlama için bireylere fırsat sunar. Ayrıca, geometri eğitiminde öğrenciler sadece geometrik kavramları değil, aynı zamanda bu kavramların arkasındaki matematiği de anlarlar (NCTM, 2000). Bu nedenle, matematiğin öğretilmesinde ve öğrenilmesinde geometri önemli bir role sahiptir. Geometri, öğrencilerin şekil ve uzay kavramlarını desteklediği için (Güven & Kosa, 2008), öğrencilerin uzamsal yeteneklerini ve muhakeme becerilerini geliştirebilir (French, 2004). Uzamsal yetenek, üst düzey düşünme, akıl yürütme ve yaratıcı süreçler için temel kabul

edilirken (Sorby, 2007), uzamsal yetenek, bilgisayar grafikleri, mühendislik, fen bilimleri, teknoloji ve matematik, yer bilimleri veya mimarlık gibi birçok alanda önem taşımaktadır (Titus & Horsman, 2009). Ayrıca, Battista (1992) görselleştirme yeteneğinin öneminden bahsederken, öğrencilerin geometri öğrenmesiyle uzamsal görselleştirme yeteneklerinin ilişkili olduğu bilinmektedir. (Karaman ve Toğrol, 2009).

Çevre sorunlarının çözümünün önemi arttıkça, geri dönüşüm hükümetler açısından önem kazanmaktadır McCarty ve Shrum'a (1994). Bu durumda, hükümetler geri dönüşümle ilgili bazı programlar uyguladığında, vatandaşların bu programlara katılımı da desteklenmektedir. Bunun için, bireylere çevre bilinci sağlamak için bireylerin tutumlarını ve sonrasında da davranışlarını değiştirmeleri sağlanmalıdır (Ebreo vd., 1999; McCarty & Shrum, 1994; Arbuthnott, 2009). Daha önceki araştırmalara göre (Henion, 1976; Balderjahn, 1988; Schwepker & Cornwell, 1991), sorumlu tüketicilerin çevreye duyarlı olumlu tutumları vardır. Bu nedenle, kaynakların çıkarılmasında ve tüketilmesinde sürdürülebilir olmayan yöntemlerin yerine sürdürülebilir yöntemler seçilmelidir (Svanstrom vd., 2008). Bu durumda, eğitim sürdürülebilirlik açısından önemli bir role sahiptir (Hopkings & McKeown, 2002). Bunun için SKE, geleneklerle dengelenerek, doğal kaynaklara saygı duyarak ve sorunlara ortak çözümler bulmak için iletişimi artıran bir eğitim vizyonu sunar (Zenelaj, 2013). Dolayısıyla, sürdürülebilir kalkınma kavramı, öğrencilerin sadece kendileri için değil gelecek nesiller için de sorumluluk almasında önemli rol oynamaktadır (de Haan, 2006). Bu nedenle, ne eğitim ne de sürdürülebilir kalkınma birbirinden ayrı olarak düşünülemez (Hagglund & Samuelsson, 2009).

Araştırma soruları

Bu çalışma, 5. sınıflardaki prizma öğretiminin sürdürülebilir kalkınma için eğitim ile desteklenmesi üzerine bir araştırmadır. Çalışma kapsamında aşağıdaki sorular araştırma sorularını oluşturmaktadır.

1) 5. sınıf öğrencileri geri dönüşüm ve ambalaj atıkları açısından SKE'nin anlamı hakkında ne düşünüyor?

2) 5. sınıf öğrencilerinin sınıflandırma ve prizma açınımlarıyla ilgili düşünme stratejileri nelerdir?

3) 5. sınıf prizmaları öğretiminin SKE ile desteklenmesi hakkında ne düşünüyor?

ALANYAZIN TARAMASI

Prizma, bireylerin çevrelerini açıklamak için günlük yaşamlarında karşılaştıkları en yaygın kavramlardan biridir (Baki, 2006). Bununla birlikte, NCTM' in (2000) Geometri Standartları'na göre, ilköğretim sınıflarında, iki boyutlu şekiller kapsamlı olarak çalışılırken, üç boyutlu şekiller için durum böyle değildir. Prizmalarla yapılan çalışmalarda ise, prizmaların sınıflandırılması (Roth & Thom, 2009), tanımlanması (Koester, 2003; Marchis, 2012), öğrencilerin üç boyutlu düşünme becerilerinin geliştirilmesi (Pittalis vd., 2010; Sack, 2013; Fujita vd., 2017), üç boyutlu cisimlerle ilgili muhakeme becerilerinin geliştirilmesi (Hallowell vd., 2015) ve temsil becerilerinin geliştirilmesi (Pittalis & Christou, 2013) amaçlanmıştır. Türkiye'de üç boyutlu cisimlerle yapılan bazı çalışmalarda ise drama eğitiminden yararlanıldığı (Özsoy, 2003; Günhan & Özen, 2010), dinamik yazılım programlarının kullanıldığı (Gürbüz & Gülburnu, 2013; Şimşek, & Yücekaya, 2014, Uğur vd., 2016), origami aktivitelerinden (Şimşek, 2012) ve somut materyal olarak kukladan yararlanıldığı (Yılmazer & Keklikçi, 2014), ayrıca prizma öğretiminin Orff Yaklaşımı ile desteklendiği (Aktaş, Erdoğan-Kaya, 2017) görülmüştür.

Alshuwaikhat ve Abubakar'a (2008) göre, doğal kaynaklara dikkat etmek ve toplumların refahını sağlamak için doğal kaynakların sürdürülebilir kullanımlarını teşvik etmek önemlidir. Bu durumda, çevresel kaynakların sürdürülebilirliğini sağlamak sürdürülebilir kalkınmanın desteklenmesinde önemli bir role sahiptir. Glavic ve Lukman (2007) ise sürdürülebilir kalkınma için farklı boyutları içeren ilkelerden bahsetmektedir. Bu ilkelerden biri, tehlikeli

malzemeleri, enerji ve kaynak kullanımını azaltarak çevresel performansı artıran geri dönüşümdür (Ebreo, 1999).

SKE, bireyler için sürdürülebilir gelecek sağlamayı hedeflediği için (Hann vd., 2010; Wals 2012) okul öncesi eğitimi, ilköğretim, ortaöğretim, yükseköğretim, yetişkin veya mesleki eğitim gibi tüm eğitim ve öğretim düzeyleri - ve örgün, yaygın veya yaygın olmayan öğrenme ortamları- SKE içerir (Hann vd., 2010; Bessant vd., 2015). Bu nedenle, eğitimdeki bu çalışmaların sayısı farklı ülkelerde günden güne artarken, müfredatta değişiklikler yapılmakta ve bu değişikliklerin etkisiyle verimli bir ortam oluşması beklenmektedir (Agut vd., 2014; Cutter-Mackenzie & Edwards, 2013; Gresch & Bögeholz, 2013; Kitamura & Hoshii, 2014; Milutinoviç & Nikoliç, 2014). Ayrıca, yapılan değişikliklerden verim elde edilebilmesi ve bu değişikliklerin etkili olabilmesi için, eğitimcilerin SKE'de öğrencileri desteklemesi de önemli bir yere sahiptir (Sauve, 1996; Sund, 2015). Türkiye'de, SKE ile ilgili çalışmalar genellikle okul öncesi eğitimi alan öğrencileri içermektedir. Bu durum, Toran'ın yaptığı çalışmada (2017), 2010 ve 2016 yılları arasında okul öncesi eğitimi içeren 17 çalışma olduğu şeklinde belirtilmiştir. Ayrıca, okul öncesi eğitimi için çeşitli çalışmalar ve öğretim yöntemleri sağlanmışken (Gülay, 2011) aileler, bireylerin çevresel farkındalığını artırmak ve SKE'nin önemini benimsetmek için önemli role sahiptir (Erkal vd., 2011). SKE, okul öncesi eğitimde dünya genelinde ön plana çıksa da sürdürülebilir kalkınmayı sağlayabilmek ve katı atık oluşumunun azaltılması için kampüslerde de çeşitli çalışmalar yapılmaktadır. Katı atık yönetimi programları aracılığıyla geri dönüşüm sağlanmaya çalışılmaktadır (de Vega vd., 2008; Elfithri vd., 2012; Smyth, 2010).

Özetle, hem prizma öğretimi hem de SKE farklı sınıf seviyelerinde farklı açılardan incelenmektedir. Farklı disiplinlerle etkileşimleri olmakta ve birbirlerine katkıda bulunmaktadırlar. Ancak, literatürde prizma öğretiminin SKE ile desteklenmesi konusunda boşluk bulunmaktadır. Sonuç olarak, öğrencilerin prizmaları sınıflandırma ve prizma açınımlarıyla ilgili algılarının tespit edilmesi,

aynı zamanda öğrencilere geri dönüşüm ve ambalaj atıkları konusunda farkındalık kazandırılması beklenerek, beşinci sınıflarda prizma öğretiminin SKE ile desteklenmesinin literatüre katkı sağlayacağı düşünülmektedir. Bir başka açıdan ise farklı disiplinlerin birbirlerini desteklemesine de katkıda bulunması beklenmektedir.

YÖNTEM

Çalışma Deseni

Beşinci sınıflarda prizma öğretiminin SKE ile desteklenmesinde, öğrencilerin geri dönüşüm ve ambalaj atıkları açısından SKE'nin anlamı hakkında ne düşündüklerini, sınıflandırma ile prizma açınımları için düşünme stratejilerini ve öğrencilerin prizmaları öğretiminin SKE ile desteklenmesi hakkında düşündüklerini incelemek için durum çalışması kullanılmıştır. Creswell (2009) durum çalışmalarının önemini doğal ortamların yakından ve derinlemesine analizini içermesiyle açıklar. Durum çalışmalarında, ilgili durumu doğrudan ve gözlem yoluyla, ilk elden ve derinlemesine anlamak için durum çalışmasına açık ve ayrıntılı bir içerik sağlamak gereklidir (Denscombe, 2003). Durum çalışması nedeniyle, veri toplama süreci planlama ve uygulama şeklinde başlıklara ayrılarak içerik detaylandırılmaya çalışılmıştır.

Katılımcılar

Bu çalışma durum çalışması olduğundan örneklem, çalışmanın ihtiyaçları doğrultusunda belirlenmiş, görüşme yapılacak katılımcılar için amaçlı örnekleme yöntemi kullanılmıştır. Çalışmaya, 5. sınıftan 18 öğrenci (9 erkek, 9 kız öğrenci) katılmıştır. Çalışmadaki amaçlı örnekleme yönteminde öğrencilerin farklı cevaplarına dayanarak, çalışma sonucunda görüşme için 7 öğrenci seçilmiştir.

Veri Toplama Süreci

Çalışmada, ders içeriği ve etkinlik sayfaları, müfredat ve ders kitabına göre hazırlanmıştır. Matematik ile Çevre Eğitimi derslerinin öğretim programlarındaki ilgili kazanımlardan a. öğrenciler dikdörtgen prizmayı tanır ve temel elemanlarını belirler; b. dikdörtgen prizma açınımlarını çizer ve farklı açınımların dikdörtgen prizma ile ilişkili olup olmadığına karar verir; c. geri dönüşüm ve geri kazanım kavramlarını açıklar ve geri dönüştürülebilir malzemelerin yeniden kullanımının sağlanmasına katkıda bulunur, kullanılmıştır. Bunun için çalışmanın uygulama süresi 5 ders saati olarak planlanmış ancak çalışma uygulama sırasında 8 ders saati sürmüştür. Uygulama sırasında, hem prizmaları hem de ambalaj atıklarını örneklendiren karton kutular, sınıfa katılımcılar tarafından getirilmiş ve katılımcılardan ilk ders saatinde bu kutuların neden toplandığını düşünmeleri istenmiştir. Öğrenciler kutuları toplama amaçlarının geometriyle ilgili olduğunu belirtmişlerdir. Bunun üzerine, öğrencilerin sınıfta geri dönüşüm amaçlı pilleri topladığı bilindiğinden, pilleri toplama amaçlarıyla kutuları toplama amaçları arasında ilişki olup olmadığı sorulmuştur. Verilen cevaplarla birlikte, öğrenciler geri dönüşüm, geri kazanım, yeniden kullanım ve ambalaj atığı hakkında bildiklerini paylaşmışlardır. Ambalaj atıklarının geri dönüşümüyle ilgili bir video izlenmiş ve bunun üzerine öğrenciler geri dönüşümün tanımı, geri dönüşümün gerekliliği, atık örnekleri ve ambalaj atıklarının tanımıyla ilgili düşüncelerini paylaşmışlardır.

Sonraki etkinliklerde, öğrenciler prizmaları sınıflamaya çalışarak, prizma çeşitlerinin benzerlik ve farklılıklarını bulmaya çalışmışlardır. Etkinliklerin devamında, katılımcılar prizmaları tanımlamaya çalışmışlardır. Ayrıca, prizma açınımlarını oluşturmak, açınımlarını çizmek ve çizdikleri açınım ile prizma türünü eşleştirmek için çaba harcamışlardır. Bu sırada, karton kutuların parçalarına ayrılması bir yandan katılımcılara avantaj sağlarken, diğer yandan açınım oluşturma ve çizim aşamasında zorlanmalarına da neden olmuştur. Bu sırada, katılımcılardan prizma açınımlarıyla cisimlerin yer kaplamasını prizma

öğretiminin SKE ile desteklenmesi açısından değerlendirmeleri beklenmiştir. Prizmalarla ilgili son etkinlik olarak katılımcılar verilen farklı açınımların prizma oluşturup oluşturmadığını nedenleriyle açıklamışlardır. Son etkinlik saatinde ise katılımcılar hem uygulama sırasında gördükleri kavramları yeniden değerlendirmişler hem de bu tür uygulamaların günlük yaşama etkisini açıklamaya çalışmışlardır. Her etkinlik sonrası çalışma kağıtlarını kullanan katılımcılar, etkinlikler sırasında ve sonrasında oluşturulan tartışma ortamında kendilerini ifade etme fırsatı yakalamışlardır. Çalışma sonunda, etkinlikler sırasındaki farklı cevapları ve yaklaşımları nedeniyle seçilen yedi öğrenciyle görüşme yapılmıştır.

Veri Toplama Araçları

Belgeleme bu çalışmadaki veri toplama araçlarından biridir (Yin, 1994; Bowen, 2009). Bu çalışmada veri toplamak için prizma öğretimindeki 5. sınıf kazanımları ve geri dönüşümle ambalaj atığı kavramlarını içeren etkinlik sayfaları kullanılmıştır.

Diğer bir veri toplama aracı olarak gözlemden yararlanılmıştır. Böylece, araştırmacının ve katılımcıların davranış ve söylemlerinin aynı anda doğrudan gözlemlenerek yorumlanması sağlanmıştır. Ayrıca, çalışma, çalışmanın araştırmacısı ders öğretmeni olduğundan, gözlem notlarındaki detayları görmek için kamera ile kaydedilmiştir.

Bu çalışmanın son veri toplama aracı ise görüşmedir. Frankel ve Wallen'e (2006) göre bir araştırmacı için gözlemlerinden kaynaklanan gösterimlerin doğruluğunu kontrol etmek ayrı bir öneme sahiptir. Bu çalışmada farklı cevapları ve yaklaşımları nedeniyle seçilen yedi öğrenciyle prizmalar, geri dönüşüm ve ambalaj atıkları hakkında görüşülmüştür. Toplam görüşme süresi yaklaşık 75 dakikadır.

Veri Analizi

İlgili araştırma sorularını incelemek için nitel araştırma yöntemlerinden içerik analizi yöntemi kullanılmıştır (Creswell, 2007; 2013; Flick, 2013; Stemler 2001). Krippendorf (1989; 2004), nitel içerik analizinde çıkarımda bulunmak için sözel, resimsel, sembolik ve iletişim verilerini içermesinin önemini belirtmiştir. Bu nedenle, bu çalışmada, prizma öğretiminin sürdürülebilir kalkınma için eğitim ile desteklenmesinde belgeleme, gözlem ve görüşmeden yararlanılmıştır. Böylece, içerik analizi yöntemleri yardımıyla bu üç veri kaynağı karşılaştırılmıştır.

İçerik analizi için açık kodlama kullanılmıştır. Bir kod, bir sözcüğü, kısa bir ifadeyi veya verileri tanımlayabilmek için bir cümleyi ifade eder (Saldana, 2015). Açık kodlamada, büyük miktarda veri daha az içerik kategorisine dönüştürülür (Weber, 1990) ve materyallerin okunmasında notlar ve başlıklar oluşturulur (Hsieh ve Shannon, 2005; Elo ve Kyngas, 2008). Bu çalışmada, içerik analizinin yapılabilmesi için öğrencilerin belgeleri, kayıtları, gözlem notları ve görüşme yazılarından yararlanılmıştır.

SONUÇLAR

Sürdürülebilir Kalkınma Eğitimi Açısından Sonuçlar

Mevcut çalışmada, SKE kağıdın geri dönüşümü ve ambalaj atıkları üzerinden değerlendirilmiştir. Başka bir deyişle, çalışma sonucunda katılımcıların geri dönüşümü ve ambalaj atıklarıyla ilgili farkındalık kazanmaları amaçlanarak öğrencilerin geri dönüşüm ve ambalaj atıkları açısından SKE'nin anlamı hakkında düşündüklerini paylaşmaları beklenmiştir.

Katılımcılara ilk olarak, geri dönüşümün ne olduğu sorulmuştur. Katılımcıların büyük çoğunluğu geri dönüşümü *hayat* olarak tanımlarken, bir kısmı geri dönüşümü *yeniden kullanma, eskiyi yeniye dönüştürme* olarak tanımlamıştır. Ayrıca geri dönüşüm, katılımcılar tarafından *doğanın, ağaçların ya da çevrenin korunması* şeklinde de algılanmıştır. Bu aşamada, katılımcıların bir

kısmı *pilin ve kağıdın geri dönüşüm sürecinden* de bahsetmiştir. Katılımcıların bu süreç için özel alanlara ihtiyaç duyulduğunu belirtmesi dikkat çekicidir.

İkinci aşamada katılımcılardan geri dönüşümün gerekli olup olmadığı ve geri dönüşüme neden ihtiyaç duyulduğunu açıklamaları istenmiştir. Katılımcıların tamamı geri dönüşümü *gerekli* görmektedir. Katılımcıların büyük çoğunluğu geri dönüşüme *çevreyi ve ağaçları korumak için* ihtiyaç duyulduğunu söylerken, bir kısmı *yaşamın devamlılığı ve daha sağlıklı, güvenli bir yaşam için* gerekli olduğundan bahsetmiştir. Ayrıca, geri dönüşümün *ozon tabakasının korunması, oksijenin devamlılığı ve atıkların artmaması için* önemli olduğunu belirten katılımcılar da vardır.

Üçüncü aşamada katılımcılardan geri dönüştürülebilen atıklara örnek vermeleri istenmiştir. Geri dönüşebilen atıklardan olan *kağıt*, katılımcıların tamamı tarafından örnek olarak verilirken; *pil, plastik, cam, şişe ve yağ* örnek olarak gösterilen diğer atıklardandır. Ayrıca, katılımcıların çok azı s*ebze, meyve, taş ve eski kıyafetleri* örnek olarak vermiştir. Bu örnekleri verme nedeni olarak, katılımcıların geri dönüşümü, yeniden kullanma olarak algıladıklarından bahsedilebilir.

Bir sonraki adımda, katılımcılar ambalaj atığının ne olduğunu tanımlamaya ve ambalaj atıklarına örnek vermeye çalışmışlardır. Katılımcıların çok azı her ikisine de cevap verirken, bazıları sadece örnek vermiş, bazıları ise sadece tanımlamaya çalışmıştır. Bu nedenle ambalaj atığı, katılımcılar tarafından *içindekini koruma amacı taşıyan ve artık işlevini yitirmiş olan madde* olarak tanımlanmıştır. Katılımcılar tarafından verilen örnekleri ise *oyuncak paketleri, karton kutular, çikolata paketleri, balon paketleri ve pillerin dış yüzeyini kaplayan madde* oluşturmaktadır. Bu aşamada, katılımcıların bulunduğu yaş grubu bu örneklerin verilmesine neden olabilir.

Katılımcılar, SKE açısından değerlendirildiğinde, birçoğunun SKE'yi günlük yaşamla ilişkilendirdiği, disiplinler arası geçişlerden yararlandığı ve geri

dönüşüm, ambalaj atığı tanımlamalarını kelimelerin kendilerinde oluşturduğu çağrışım üzerinden yaptıkları görülmüştür.

Prizmaların Öğretilmesi Açısından Sonuçlar

Bu bölümde, katılımcıların cevapları beşinci sınıf matematik dersi seviyesindeki prizmalar konusunu içererek, prizmaları sınıflandırmaları, tanımlamaları ve prizma açınımları açısından analiz edilmiştir. Prizmalar öğretimi sırasında katılımcılar dikdörtgenler prizması, kare prizma ve küplerden yararlanmıştır.

İlk aşamada, katılımcılardan prizmaları sınıflandırmaları istenmiştir. Sınıflandırma öncesinde, katılımcılar prizmaların yüzey şekillerinin hangi şekillerden oluştuğunu bulmuşlardır. Burada, katılımcılar ayrıt uzunluklarını ölçmüşler ve ölçme işlemi sırasında kalem, kalem kutusu, karış ya da el parmaklarından yararlanmışlardır. Katılımcıların, ayrıt uzunluklarının eşit oluşuna veya farklı oluşuna göre yüzey şekillerini kare ve dikdörtgen olarak belirttikleri görülmüştür. Bu şekilde, katılımcıların informal ölçme yaptığı ve tahmin yeteneğinden yararlandıkları söylenebilir. Sınıflandırma sırasında, katılımcılar birden fazla sınıflandırma yapmışlardır. İlk olarak, katılımcılar tüm yüzey şekilleri kare olan prizmaları *sadece kareden oluşanlar*; yüzey şekilleri dikdörtgen olan prizmaları *sadece dikdörtgenlerden oluşanlar*; yüzey şekillerinde hem kare hem de dikdörtgen olanları ise *hem kare hem dikdörtgenden oluşanlar* şeklinde isimlendirerek gruplandırmışlardır. Bu sırada, katılımcılara eğer bu grupların özel isimleri olsaydı ne olurdu diye sorulmuştur. Verilen cevaplar arasında *uzun-kısa kutular, yarı kare- yarı dikdörtgen kutular, dikey-yatay kutular, tüm kareler- tüm dikdörtgenler* yer alırken, çok az sayıda katılımcının *küp ve prizma* cevabını verdiği görülmüştür. Bu cevapları veren katılımcılara neden bu şekilde isimlendirdikleri sorulduğunda, daha önce duyduklarını söylemişlerdir. İlk sınıflandırma sonrası, prizmaların formal tanımları yapılmıştır. İkinci sınıflandırma için, prizmaların köşe, ayrıt ve yüzey sayılarına bakılmıştır. Katılımcıların büyük çoğunluğu, *köşe sayısını 8, ayrıt sayısını 12 ve yüzey sayısını*

6 olarak belirtmiştir. Katılımcıların az bir kısmı ise bu sayıları farklı bulduklarını, bu duruma neden olarak ise bazı yerleri *iki kez saydıklarını ya da bazı yerleri saymadıklarını ve prizma olarak kullanılan ambalaj atıklarından kaynaklanan sorunlar* olduğunu belirtmişlerdir. Katılımcıların tüm prizmalar için aynı sayıya ulaşmasıyla, katılımcılar *sınıflandırmada köşe, ayrıt ve yüzey sayısının etkili olmadığını* belirtmiştir. Son sınıflandırmayı, katılımcılar prizmaların tabanlarına göre yapmışlar ve prizma tabanına karar verebilmek için formal tanımdan yararlanmışlardır. Ayrıca, ayrıt uzunluklarına karar verebilmek için tahmin yeteneklerini yeniden kullandıkları ve prizmaları buna göre sınıflandırdıkları görülmüştür. Katılımcıların neredeyse tamamı, prizmasını doğru gruba yerleştirmeyi başarmıştır. Ancak, görüşme sırasında, katılımcılara tekrar sorulan prizmalar nasıl sınıflandırılır sorusuna, katılımcıların çalışma sırasında yapmış olduğu üç sınıflandırmayı da dahil ederek cevap verdikleri, ardından verdikleri cevaba göre sorulan sorularla ve verilen ipuçlarıyla doğru cevaba ulaştıkları görülmüştür. Ayrıca, görüşme sırasında katılımcıların bir kısmı, *prizma açınımının prizmaların sınıflandırılmasında etkili olacağını* söylerken, sadece bir tane katılımcı *prizma açınımının sınıflandırmayı etkilemeyeceğini* söylemiştir.

Bu kısmın ikinci aşamasında, görüşme yapılan katılımcılardan prizmaları tanımlamaları istenmiştir. Bu aşamada, tüm katılımcıların tanım yaparken zorluk yaşadığı ve beklenen tanımı yapamadıkları gözlemlenmiştir. Ancak, katılımcılardan birçoğunun, prizma tanımı için köşe, yüzey ve ayrıt sayılarını kullanmaya çalışmaları dikkat çekmiştir. Ayrıca, bazı katılımcıların ayrıt kavramı yerine kenar kavramını kullandığı tespit edilmiştir. Katılımcıların tanım yapamaması ve tanım yapmak için köşe, yüzey ve ayrıt sayılarını kullanmaya çalışırken bunları yanlış hatırlamaları üzerine, katılımcılardan kitabın prizma olup olmadığını cevaplamaları, köşe, yüzey ve ayrıtlarını göstererek saymaları istenmiştir. Bu soru üzerine, katılımcılar *kitabın bir prizma örneği olduğunu* belirtmiş ve kitabın köşe, yüzey ve ayrıtlarının yerlerini göstererek, sayılarını *8 köşe, 6 yüzey ve 12 ayrıt* olacak şekilde saymışlardır. Görüşmeler sırasında fark

edilen bir nokta ise, katılımcıların somut materyal üzerinde kendilerini daha rahat ifade etmeleridir.

Bu bölümün üçüncü aşamasını prizma açınımları oluşturmuştur. Katılımcılar, sadece prizma açınımlarını oluştururken dörderli ve beşerli gruplar halinde çalışmışlardır. Tüm grupların başarılı bir şekilde prizma açınımlarını oluşturduğu gözlemlenmiştir. Grupların birinde ise prizma açınımlarını oluştururken materyal kaynaklı bir sorun yaşandığı gözlemlense de, katılımcılar deneme yanılma yoluyla doğru parçaları kullandıkları gözlemlenmiştir. Prizma açınımlarının çizilmesiyle ilgili bölümde, katılımcıların büyük bir çoğunluğunun prizma açınımını altı yüzeyli çizdiği, iki katılımcının ise yedi ve sekiz yüzeyli çizim yaptığı ortaya çıkmıştır. Ancak, katılımcıların büyük bir kısmı, prizma açınımını altı yüzeyli çizmesine rağmen çizimlerde ya yüzeylerin birbiriyle örtüştüğü ya da ayrıt uzunluklarının uygun olmadığı ve ayrıtların örtüşmediği sonucuna ulaşılmıştır. Sadece 3 katılımcı, doğru bir şekilde prizma açınımını çizmiştir. Katılımcılardan çizdikleri prizma açınımlarıyla prizma çeşitlerini (küp, dikdörtgenler prizması ve kare prizma) eşleştirmeleri istediğinde ise 5 katılımcının çizimi/ çizmeye çalıştığı açınım ile seçtiği prizma çeşidi eşleşmiştir. Prizma açınımlarıyla ilgili olan üçüncü bölümde ise katılımcılardan verilen şekillerden hangilerinin prizma açınımlarına ait olup olmadığını nedeniyle birlikte açıklamaları istenmiştir. Genel olarak bakıldığında ise sorulan beş şekilden tamamına doğru cevap veren katılımcı sayısı yarıdan az olmasına rağmen, sonuçlar her şekil için ayrı değerlendirildiğinde katılımcıların yarıdan fazlası doğru bir açıklamayla şekillerin prizma açınımına ait olup olmadığını belirlemiştir. Burada, katılımcıların prizma açınımlarının çizimi sırasında yaptıklarının aksine, ayrıt uzunluklarının eşitliğini, yüzeylerin yeri ve üst üste binen ayrıtlar ile üst üste binen yüzeyleri dikkate aldıkları görülmüştür.

Prizma Öğretiminin Sürdürebilir Kalkınma için Eğitim ile Desteklenmesinin Avantajları Açısından Sonuçlar

Prizma öğretiminin SKE ile desteklenmesini, kutuların hem ambalaj atığı olarak geri dönüştürülebilir olması hem de prizma örneklerinden olması sağlamıştır. Bu aşamada, katılımcılardan, kutunun açık ve kapalı durumunu yüzey kaplama açısından karşılaştırmaları istenmiştir. Daha kolay karşılaştırma yapabilmeleri için katılımcılara bu kutuları bir kamyon ile taşıyacakları ve kutuları hangi durumda (açık veya kapalı) taşımanın, çevre açısından daha avantajlı olduğu ve bu avantajların neler olabileceği sorulmuştur. Katılımcılar kutuları *açık bir şekilde taşımanın avantajlı olduğunu*, bu şekilde *daha az yere daha çok kutu yerleştirebileceklerini* belirtmişlerdir. Bu kısımda, katılımcılar az yer kaplamaya odaklanırken, katılımcıların çok az kısmı prizma ve geri dönüşümle bu durumu ilişkilenmiştir. Ancak, katılımcılardan bazılarının prizma açınımıyla yüzey kaplama arasında ilişki olmadığına vurgu yaptıkları görülmüştür.

İkinci aşamada, prizma öğretiminin SKE ile desteklenmesini katılımcılara günlük yaşamla ilgisi olup olmadığı sorulmuştur. Katılımcıların birçoğu bu çalışmayı sadece geri dönüşüm açısından değerlendirirken, amaçlarının doğayı korumak olduğunu belirtmişlerdir. Ayrıca, görüşmeler sırasında, katılımcılar çalışmanın yaşamlarında ne gibi değişikliklere neden olduğunu cevaplamışlardır. Görüşme yapılan yedi katılımcıdan bazıları, atıklarla çöpleri ayırarak geri dönüşüm için biriktirmeye çalıştığını, çevreye daha duyarlı hale geldiğini, bu konuda araştırma yaptığını, çevresindeki insanları bilinçlendirmeye çalıştığını belirtmiştir.

Üçüncü aşamada ise katılımcılar prizma öğretiminin SKE ile desteklendiğinde *ilgi çekici bir ortamda öğrenme sağladıklarını, daha kalıcı öğrendiklerini, daha eğlenceli öğrendiklerini belirtirken, bu işlemin farklı konular, örneğin kesirler, için de yapılabileceğini* söylemişlerdir.

TARTIŞMA ve ÖNERİLER

Prizma Öğretimi Hakkında

Bu çalışmada katılımcılar, prizmaları sınıflandırmaya, prizmaları tanımlamaya ve prizma açınımlarını oluşturmaya, prizma açınımlarını katlayıp açmaya ve onları çizerek anlamaya çalışmışlardır. Bunlar sırasında, ambalaj atıkları olan kutulardan somut materyal olarak yararlanmışlardır**.** Bu şekilde, Roth ve Thom (2009) tarafından yapılan çalışmada da olduğu gibi katılımcıların prizmaların sınıflandırılmasında somut materyaller kullanmaları, onların formal ve informal geometri bilgilerinde gelişmeye neden olması açısından benzerlik göstermiştir. Çalışma sırasında, katılımcıların ezbere dayalı öğrenmeleri yıkılmaya çalışılarak, anlamlı bir öğrenme ortamı oluşturulmuştur. Bunun nedeni olarak, katılımcıların materyal üzerinden somut öğrenme gerçekleştirmesi, sorulara deneme ve yanılma yöntemiyle cevap aramaları olabilir. Koester'in çalışmasında (2003) da benzer şekilde katılımcılar, ezbere dayalı olmadan prizmaların tanımlamaya çalışmışlardır. Katılımcılar, prizmayı tanımlarken *paralel tabanlar* ifadesini kullanmasalar da, prizmaların yüzey, köşe, ayrıt sayılarını bulmak ve prizma türlerini örneklemek için çaba harcamışlardır. Bu durumun nedeni, çalışma sırasında prizmanın formal tanımının verilmeden önce, prizmaların farklı gruplar halinde sınıflandırılması olabilir. Katılımcıların bu çalışma sırasında, uzamsal yeteneklerinde, görselleştirme yeteneklerinde veya üç boyutlu yapılar ve iki boyutlu şekillerin eşleştirilmesiyle ilgili kavramlarda gelişme olduğundan bahsedilebilir (Pittalis vd., 2010; Sack, 2013; Pittalis & Christou, 2013; Fujita vd., 2017; Hallowell vd., 2015). Ancak, uzamsal yeteneklerinde gelişme olduğunu söylemek için daha farklı çalışmalara ihtiyaç duyulacaktır. Bazı katılımcıların prizma açınımlarının oluşturulması ve çizilmesinde zorluk yaşamasına rağmen, bu gelişmeler prizma açınımlarının oluşturulmasında, çizilmesinde ve prizma açınımlarının katlanmasıyla prizma açınımlarının anlaşılmasında etkili olmuştur. Bu zorlukların nedeni, katılımcıların ayrıt uzunluklarındaki ve kareli kağıt üzerinde ayrıtlardaki birimlerin

uzunluklarında eşitliği düşünmemeleri olabilir. Bu zorluklara ek olarak, katılımcılar çizim sırasında yüzeylerin örtüşüp örtüşmeyeceğine dikkat etmemişlerdir. Bu zorlukların nedeni katılımcıların prizma açınımları konusundaki deneyim eksikliğinden kaynaklanabilir (Piaget & Inhelder, 1948) veya prizma açınımlarını hayal edememeleri olabilir (Cohen, 2003). Ayrıca, katılımcılar prizmalar sınıflandırılırken prizma açınımları verilseydi sınıflandırma farklı olurdu şeklinde fikir beyan ettiklerinde, bunun nedeni yine prizma açınımlarında karşılaştıkları durumla aynı olabilir.

Farklı disiplinlerden ya da zenginleştirilmiş etkinliklerden yararlanılarak prizma öğretiminin yapıldığı çalışmalarda (Özsoy, 2003; Günhan &Özen, 2010; Aktaş & Kaya, 2017) olduğu gibi, bu çalışmanın sonunda da katılımcıların yüksek motivasyon, yüksek ilgi ve yüksek katılım gösterdikleri, katılımcılar için anlamlı öğrenme ortamının oluştuğu veya katılımcıların deneme yanılma yoluna başvurdukları, bireysel çalışmalarda olduğu gibi grup çalışmalarında da sorumluluk aldıkları, işbirliğine önem verdikleri, kendilerini daha rahat ifade ettiklerinden bahsedilebilir. Ayrıca, katılımcılar hatalarını bulmada da akran öğrenme ortamından yararlanmışlardır.

Sürdürülebilir Kalkınma Eğitimi Hakkında

Çevrenin korunması ve geliştirilmesi, çevrenin sürdürülebilirliği açısından önemli bir role sahiptir (Kates vd., 2005). Mevcut çalışmada da, katılımcıların geri dönüşüm ve ambalaj atığı kavramları, SKE ile ilgili bakış açısı kazanmaları, bu anlamda duyarlı hale gelmeleri hedefler arasındaydı. Çalışmanın sonucunda ise katılımcıların geri dönüşüm ve ambalaj atığı kavramlarına yönelik farkındalıklarında bazı değişiklikler gözlemlenmiştir. Gerek sınıf içerisinde gerek okul içerisinde yapılan gözlemlerde katılımcıların aşırı tüketim ve tasarruf konularında duyarlı oldukları elde edilmiştir. Oluşan değişiklikler de Hann ve diğerleri (2010) tarafından daha sürdürülebilir bir gelecek için desteklenmiştir. Katılımcıların, SKE' ye örnekler vermek ve farklı sorular sormak amacıyla günlük yaşam deneyimlerinden ve deneme yanılma yönteminden yararlandıkları

görülmüştür. Dolayısıyla, yeni bir konu öğrenmek amacıyla ön bilgilerini kullanan katılımcıların anlamlı bir şekilde öğrendiği sonucuna varılabilir. Örneğin, kağıdın geri dönüşüm sürecini tartışırken katılımcılar, atık yağın, atık camın veya atık pillerin de geri dönüştürülebileceğini söylemiştir. Katılımcıların bahsettiği kuraklığın, ormansızlaşmanın, insan kaynaklı felaketlerin veya ozon tabakasındaki sorunların olumsuz etkileri ise McNaughton (2010) tarafından da yaptığı çalışmada belirtilmiştir. Ayrıca, Vega ve arkadaşları tarafından yapılan çalışma ile (2008), kağıt ve karton, plastik, gıda atıkları gibi organik atıklar, yaprak ve ot, ağaç dalları, metaller, cam, piller gibi tehlikeli atıklar ile katılımcıların dönüştürülebilen atık örneklerinden bazıları eşleşmektedir. Ambalaj atıkları Avrupa Parlamentosu ve Konsey Direktifi (94/62 / EC) tarafından atık tanımı, *kapsadığı herhangi bir ambalaj veya ambalaj malzemesi* olarak yapılmıştır. Bu çalışmada, katılımcıların yarısından azı için ambalaj atıklarının anlamlı bir tanımı olmadığı gözlemlenmiştir. Bununla birlikte, bunların yarısından fazlası örneklerin ne olduğunu bilmelerine rağmen, bu örnekleri eski/ kullanılmış malzemeler veya çöp gibi kavramlarla eşleştirmeye çalışmışlardır. Katılımcıların ambalaj atığını tanımlamada yaşadığı zorluğun nedeni, katılımcıların geri dönüşüm ve yeniden kullanım gibi kavramları aynı algılıyor olmasından kaynaklanabilir.

Öneriler

Çalışmanın sonuçları, prizma öğretiminde geometrinin soyut dünyadan çıkarak somut dünyayla ilişkilendirilebileceğini göstermektedir. Aynı zamanda, prizma örneği olan ambalaj atıklarının geri dönüşüm konusunda farkındalık kazandırma amaçlı kullanımı, prizma öğretiminin çevresel sorunların çözümüyle ilişkilendirilmesi sağlanmıştır. Her iki disiplin açısından, çağın gerekleri doğrultusunda hizmet edilmeye çalışılmıştır. Bu durumda, sonuçlar prizma öğretiminin SKE ile desteklenebileceğini ortaya koymaktadır. Ancak farklı çalışmalarda, iki disiplin farklı konularla, farklı sınıf seviyelerinde birbirini destekleyebilir ya da daha fazla sayıda disiplinin birbirini desteklemesi

sağlanabilir. Katılımcı sayısının artırıldığı, gözlem süresinin saat olarak uzatıldığı ya da yıllara yayıldığı çalışmalar da desteklenebilir. Ayrıca, öğretmen adaylarıyla benzer çalışma gerçekleştirilerek bu iki disiplini nasıl algıladıkları, çalışma sonunda oluşan/değişen farkındalıkları ile edindikleri tecrübeler hakkında, prizmaları sınıflandırmalarıyla, açınımları katladıklarıyla ya da açtıklarıyla ve prizma veya geri dönüşümü tanımlamalarıyla ilgili bilgi edinilebilir. Ayrıca katılımcıların, dünyayı üç boyutlu nesne nasıl algıladıkları, gerçek dünya sorunları hakkında ne düşündükleri ve gerçek dünya sorunlarını nasıl çözdükleri de sorgulanabilir. Bu durumda, disiplinlerin birbiriyle işbirliği katılımcıların algısına göre şekillendirilebilir.

F. PERMISSION FROM HUMAN SUBJECTS ETHICS COMMITTEE

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Sayın Doç.Dr. Didem AKYÜZ ;

Danışmanlığını yaptığınız yüksek lisans öğrencisi Ece KANDİLLİ 'nin ***"Matematik ve Sürüdülebilirlik Eğitiminin 5. Sınıf Öğrencilerinin Prizmalar Konusunda Birleştirilmesinin Etkisi"*** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2017-EGT-083** protokol numarası ile **08.05.2017 – 30.12.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

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A copy of the Decision of the Institute Administrative Committee will be delivered to the library together with the printed thesis.

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