DEVELOPMENT OF STEM ACTIVITIES FOR "MEASUREMENT OF FORCE AND THE FRICTION" UNIT

Ferhat Ozan[1], Şafak Uluçınar Sağır[2]

Abstract

STEM has been integrated into science curriculum with recent changes. However, teachers are in need of resources to effectively apply STEM in their classrooms. This study aimed to prepare STEM activities and to find out the students' opinions about these activities. Case methodology was used. First, 5 activities were developed by the researchers and they were implemented in the classroom over a 4-week period. Then, the students were asked to prepare an activity related to the unit standards to be implemented in class. Semi-structured interview technique was used to obtain the students' views about STEM activities. The students had fun and took an active role during the STEM activities. However, the students had difficulty in adjusting the time during the implementation process. The students wanted similar activities to be implemented in other topics in science lessons. Based on the findings, we suggest that more STEM activities are developed.

Keywords: STEM, activity development, student activities, measurement of force, friction.

KUVVETİN ÖLÇÜLMESİ VE SÜRTÜNME ÜNİTESİNE YÖNELİK FeTeMM ETKİNLİKLERİ GELİŞTİRİLMESİ

ÖZ

Fen bilimleri öğretim programlarındaki değişikliklerle FeTeMM, öğretim programına entegre edilmiştir. Öğretmenlerin sınıflarında FeTeMM'i uygulamaları konusunda rehber materyal ve etkinliklerin eksikliğinden söz edilebilir. Bu çalışmada amaç fen öğretiminde kullanılacak FeTeMM etkinlikleri hazırlamak ve bu etkinliklerin öğrenciler tarafından değerlendirilmesini sağlamaktır. Çalışmada örnek olay yöntemi kullanılmıştır. Öncelikle araştırmacılar tarafından ünite kazanımlarına uygun olarak 5 adet etkinlik geliştirilmiş ve bu etkinlikler sınıfta uygulanmıştır. Etkinliklerin uygulaması 4 hafta sürmüş ve uygulama bittikten sonra öğrencilerden istedikleri kazanıma yönelik birer etkinlik hazırlamaları istenmiştir. Hazırlanan öğrenci etkinlikleri de sınıfta uygulanmıştır. Uygulamaların tamamlanmasının ardından, öğrencilerin FeTeMM etkinliklerine yönelik görüşleri yarı yapılandırılmış mülakat tekniği kullanılarak alınmıştır. Araştırmada öğrencilerin FeTeMM etkinlikleri ile yapılan öğretim esnasında eğlendikleri, aktif olarak etkinliklerde rol aldıkları görülmüştür. Ancak öğrencilerin etkinliklerin uygulaması sırasında zamanı ayarlama konusunda sıkıntı yaşadıkları tespit edilmiştir. Öğrenciler etkinliklerin bütün fen konularında uygulanmasını istediklerini belirtmişlerdir. Araştırma sonunda FeTeMM etkinliklerinin hazırlanması ve uygulanmasına yönelik önerilerde bulunulmuştur.

Anahtar Kelimeler: FeTeMM, etkinlik geliştirme, öğrenci etkinlikleri, kuvvetin ölçülmesi, sürtünme.

Article Information:
Submitted: 01.01.2019
Accepted: 04.07.2019
Online Published: 04.29.2019

[1] Teacher, Uluköy Şehit Komiser Mustafa Düzgün Middle School, ferhatozanferhatozan@gmail.com, ORCID: https://orcid.org/0000-0001-7648-1371
[2] Prof. Dr., Amasya University, Faculty of Education, Department of Elementary Education, safak.ulucinar@amasya.edu.tr, ORCID: https://orcid.org/0000-0003-3383-5330

INTRODUCTION

Science education has long been of great importance in the development of countries. Especially in the second half of the 20th century and at the beginning of the 21st century, the importance given to science education in the world and the authors' country (Turkey) has increased. Today, the tremendous speed in the development of science and technology has made it necessary to review the science education given to students. This has brought about the introduction of science education going beyond teaching concepts, and associating it with practice, implementation of an interdisciplinary approach and the reflection of this perspective on the learning standards. The Science, Technology, Engineering, and Mathematics [STEM] approach, which has been featured in science education in recent years, has been integrated into the 2017 science curriculum of Turkey (Ural Keleş, 2018). In Turkey, this approach is used in the form of STEM education (Corlu, 2014), which is an acronym of the disciplines of Science, Technology, Engineering, and Mathematics.

Many different definitions have been made for STEM. Some of these are as follows: According to Dugger (2010) STEM education presents the disciplines that are contained in a way that is intertwined in everyday life, not independently in separate courses thus, allowing students to perceive the world as a whole. Corlu, Capraro, and Capraro (2014) describe STEM education as the students and teachers' construction of knowledge, skills and ideas by using multiple STEM fields in cooperation. Vasquez, Sneider, and Comer (2013) describe STEM education as an interdisciplinary learning and teaching approach that removes traditional barriers between the disciplines of science, technology, engineering, and mathematics.

The skills required to lead the 21st century can be classified as 21st century skills (Griffin, McGaw, & Care, 2012). These skills can be considered as 13 skills under three main headings (Partnership for 21st Century Skills, 2013), although there is no definite definition and no specific content:

1. Learning and Innovation Skills: Creative thinking, critical thinking, problem solving, communication, and collaboration;
2. Information, Media and Technology Skills: Information literacy, information and communication technologies (ICT) literacy, and media literacy; and
3. Life and Career Skills: Flexibility and harmony, self-management, social skills, productivity, accountability, and leadership.

Today's leaders of the business world, politicians, and educators have almost agreed that students should have 21st century skills to succeed in life (Rotherham & Willingham, 2010). In addition to academic achievement, the skills gained in educational life can impact students' future business lives. The objective of STEM education is to help students gain these skills. Group work, laboratory research, and projects used in STEM education allows for an easier adaptation of necessary skills of the 21st century such as communication, social skills, non-routine problem solving, self-management and systematic thinking which leads to people who make better decisions on issues concerning their country's agenda (Bybee, 2010).

STEM education should ensure that students develop an understanding about how machines, tools, or systems are functioning and improve their use of technology. In addition, STEM education should give students more engineering knowledge in their pre-university education. Engineering is directly related to problem solving and creativity, which is important for every country. When the literature is examined, STEM applications are expected to leave its mark for both the education and various business areas in the coming years. In this context, it is necessary to increase the examples of and improve the effectiveness of these applications which have been newly integrated into teaching programs in Turkey as well.

Aim

The aim of this study is to develop STEM activities for the fifth grade science unit "Measurement of Force and Friction" in middle school and to examine student opinions on the activities.

METHOD

The case methodology method was used in this research. The case methodology method is an approach to design and implement teaching activities to help ensure that theories are implemented by solving real-life problems in the classroom environment (Stensmo, 1999). This method can be used to teach students a concept or a skill for the purpose of application. It can also be used to solve a real problem that is encountered in everyday life.

Sample

In this study, 10 fifth grade students who were studying at a public school in a district of Amasya province, Turkey volunteered to participate. Although the sample classroom was composed of 11 students, one student could not participate in some of the activities including the last activity designed by the students. The official permissions were obtained for the study.

Data Collection Tools

In this study, a semi-structured interview method was used to obtain the students' views on STEM activities. This method is advantageous for the technical questions to be prepared in advance and to provide the ease of obtaining comparable information (Yıldırım & Şimşek, 2013). Furthermore, the semi-structured interview technique provides an advantage if the answer is not sufficiently descriptive, because it gives the opportunity to deepen the answer (Çepni, 2007). In this study, a semi-structured interview form consisting of eight open-ended questions was prepared. After the questions were prepared, they were examined by two science teachers and two subject area specialists and the necessary revisions were made.

ACTIVITY IMPLEMENTATION

The research started with the examination of the Science Course Curriculum. The fifth grade "Measurement of Force and Friction" unit was determined to be used for the study. The following actions were carried out to provide the students with skills for STEM applications:

- Students were given information on STEM applications.
- Students were homogeneously distributed into four groups. Thus, it was aimed that the groups be heterogeneous within themselves, and equal within the class.
- A pilot study was carried out with the students.
- The fifth grade "Measurement of Force and Friction" unit was taught by the researchers with previously prepared STEM activities.
- Finally, students were asked to prepare their own unique activities for STEM applications. Activities prepared by the students are provided in Appendix 1 and 2.

Development of the Activities

This section provides a set of activities developed by the researchers. Table 1includes the content standards which are considered while developing the activities. Each activity is presented with the associated standard.

Table 1. Activities Developed According to the "Measurement of Force and Friction" Standards

Activity Name	Content Standard
Let's Measure the Force	F. 5.3.1.1. Measures the magnitude of the Force with a dynamometer and expresses its unit as Newton. F. 5.3.1.2. Designs a dynamometer model using simple tools.
Direction or Orientation?	F. 5.3.1.3. Describes the concepts of direction and orientation.
Newton's Cradle	F. 5.3.1.4. Forces classified as "forces requiring contact" and "contact-free forces".
Who is Faster?	F. 5.3.2.1. Gives examples of friction forces from daily life. F. 5.3.2.2. Explores the effect of friction forces on action in various environments.
Fatih's Ships	F. 5.3.2.3. Produces new ideas for increasing or decreasing friction in everyday life.

Once the content standards were determined and the activities decided upon, we moved on to the development stage of the activities. In the development of the activities, the design cycle provided by the 2005 Science and Technology Curriculum (Ministry of National Education, 2005), the engineering design process (Wendell et al., 2010), and the STEM integration phases (Yıldırım & Selvi, 2016) were taken into consideration. Two of the activities prepared are given below.

Activity 1: Measure the Force

Introduction. In the implementation of this activity, the concept of force is firstly introduced to the students. For this, a video depicting Newton's life and how he discovered the force of gravity is shown.

Discussion and discovery. Following the video, students discuss what features of the nature of science are observed by Newton throughout his life. Then by asking, "What would have happened in the world without gravity?" the students are helped to grasp the characteristics of force and the nature of some scientific features.

Elaboration. The students are taught the units of force and how to measure it. Dynamometers are made by utilizing the flexibility of metals. They consist of two nested pipes. The inner tube is hung in the bow and is evenly divided into equal segments. An object is attached to the hook at the end of the inner tube. The weight of the object is equal to how much gravity is observed on the object. The greater the strength of the object, the more the hook is stretched. The values measured in the dynamometer are shown in Newton units (N).

Newton is the unit of force and its symbol is "N." The term comes from the name of the British scientist Isaac Newton due to his contributions to physics. The force that gravity applies to an apple with a mass of approximately 102 g is 1N. After measuring the working principle of the dynamometer used to measure force, students are asked to make their own dynamometers with various materials.

Design. At this stage, students are asked to consider themselves as scientists and use a variety of materials to make a dynamometer: Imagine that you are a scientist and a tool to measure force has not been discovered yet. You should develop a tool to measure force. Newton will be used as the unit of this tool.

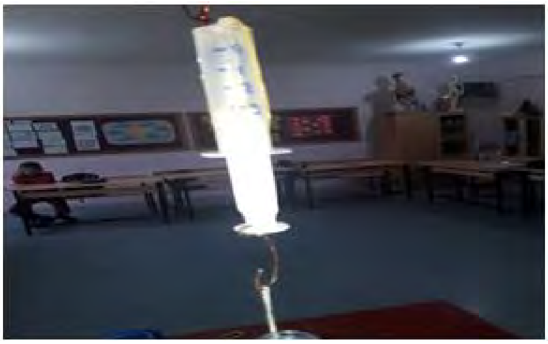
How the activity is connected to the STEM disciplines are summarized below.
1. The Science Aspect: Regarding this aspect, the concept of force is taught, its unit of measurement is explained, and how it is measured is elaborated. The working principle of a dynamometer is grasped.
2. The Technology Aspect: The materials to be used in the construction of a dynamometer are determined. How to obtain materials is determined and the cost of the materials is calculated by considering the most economical way to complete the product. In this activity a plastic injector and rubber bands are used.
3. The Mathematics Aspect: The indicator on the dynamometer is divided into intervals and calculations are made in order to get consistent measurements by the dynamometer.
4. The Engineering Aspect: The design of the dynamometer at this stage is completed and the necessary implementations are performed.

Implementation. Images illustrating this stage are presented in Photographs 1 and 2. The implementation phase is as follows:
- All ideas about the design are noted.
- The imagined design is drawn.
- The necessary materials are determined and supplied.
- The design is materialized and tested.

Photograph 1. Students' Work During the Design Phase

Photograph 2. The Students are Scaling the Dynamometer

A key feature of STEM activities is the diversity of products that are constructed at the end of the activities. According to the integration of the technology field, students create different products by experimenting with different materials. As a result of the integration of the engineering field, they try different designs. Within the scope of this study, both in Activity 1 and Activity 2, which will be explained below, the groups exhibited diversity in their products by using different materials. A product created at the end of activity 1 is given in Photograph 3.



Photograph 3. A Sample Product from Activity 1

Activity 2: Who is Faster?

Introduction. The aim of this activity is to understand what friction force is, how it affects movement, and how and where it can appear in everyday life. To do this, the following envelope game is completed.

Envelope game. Before the teacher enters the classroom, she/he prepares an envelope for each student containing an image showing friction force. After entering the classroom, the teacher randomly distributes these envelopes to the students and asks them to explain what is in the visual. Figure 1 provides examples of the visuals used.

Figure 1. Pictures Used in the Envelope Game

Discussion and discovery. At this stage, students interpret the visuals from their envelopes, inference what kind of force is in the visual, and what its strength is. These inferences and comments are debated in a group discussion between the students.

Elaboration. Following the debate and discovery phase, the teacher makes further explanations if students have misunderstanding regarding friction force and/or any missing knowledge on the topic. Students also share their conceptions about the topic.

Design. At this stage, students are asked to think like a scientist and use various materials to design a system that shows the effect of friction force on motion in various environments. How the activity is connected to the STEM disciplines are summarized below.

1. The Science Aspect: Regarding the science aspect, the students are reminded how friction force varies depending on the environment and how it changes. Examples of where these situations can occur are explained.
2. The Technology Aspect: The materials to be used in the construction of environments affecting friction are determined. How to obtain the materials is determined and the cost of the materials is calculated by considering the most economical way to complete the product.
3. The Mathematics Aspect: The dimensions of the model are determined and the necessary calculations are made for the materials to be used.
4. The Engineering Aspect: The design of the model is completed and the necessary applications are performed to test whether the model is working or not. Revisions are made when necessary.

Implementation. Images illustrating this stage are presented in Photographs 4 and 5. The implementation phase is as follows:

- All ideas about the design are noted.
- The imagined design is drawn.
- The necessary materials are determined and supplied.
- The design is built and tested.
- A product created at the end of activity 2 is given in Photograph 6.

Photograph 4. Students are Designing Together Within Their Groups

Photograph 5. The Groups are Experimenting Their Products

Photograph 6. A Sample Product from Activity 2

Student Activities

In this section, the activities prepared by the students are presented. In the study, the fifth grade students were asked to prepare their own original STEM designs after completing the activities developed by the researchers in order to help them gain the learning goals involved in the science course plan. Students used the format of the activities prepared by the researchers in creating their designs. Below are some examples of the activities that students developed.

The activity developed by group 1. The activity that the students in group 1 developed for their designs is given in Figure 2. The activity paper prepared by the group is given in Appendix 2. The images from the implementation stage are given in Photographs 7 and 8.

Subject: The Effects of Force

Equipment: Cardboard box, plastic sheet, sewing machine bobbin, wooden tongue press, pet bottle caps, some nylon rope, pipette, skewer, various weights, model knife, ruler, pencil, and scissors.

STEM Dimensions

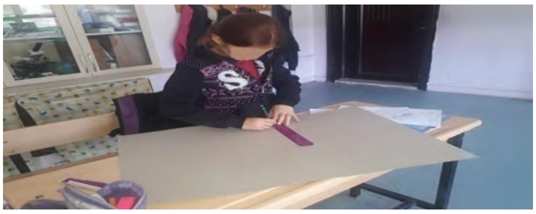
The Science Aspect: An effect that moves a stationary object, changes the direction or speed of the moving object, or stops the moving object is called force. We will benefit from this effect on this project.

The Mathematics Aspect: We cut the size of the model carton by 17x30 cm and set our cylindrical boards to be 0.4 cm. We cut our rope 130 cm long.

The Engineering Aspect: In this part, the students explained each of the design phases, and what they drew at each stage.

The Technology Aspect: The students explained how and where they obtained the materials. They added the cost of these materials, if they obtained any material which had a cost (we bought the caps from unused water bottles, we bought the cardboard from the grocery store for 2 tl etc.).

Figure 2. The Activity Developed by Group 1



Photograph 7. Design Stage of the Activity Developed by Group 1 Students

Photograph 8. Implementation Stage of the Activity Developed by Group 1 Students

The activity developed by group 2. The activity that the students in group 2 developed for their designs is given in Figure 3. The activity paper prepared by the group is given in Appendix 2. The images from the implementation stage are given in Photographs 9 and 10.

Subject: Increasing Friction

Materials: One small and two large grocery bags, a plastic box, some rope, a ruler, scissors, and a pencil.

STEM Dimensions

The Science Aspect: The force that rubs against an object that slows it down is called friction. Vehicles such as parachutes or sails increase friction. Friction has positive and negative effects in daily life.

The Mathematics Aspect: After cutting the bag to 30 cm, we cut our ropes to 15 cm. We left a 3 cm fastening margin on the ropes. We made holes in the plastic box positioned 4 cm between the ropes.

The Engineering Aspect: In this section the students drew a parachute design. They showed the measurements of this drawing in the mathematical section.

The Technology Aspect: In this section the students specified how the materials they use in the design are supplied and the cost of these materials, if any.

Figure 3. The Activity Developed by Group 2

Photograph 9. Design Stage of the Activity Developed by Group 2 Students

Photograph 10. Implementation Stage of the Activity Developed by Group 2 Students

FINDINGS

At the end of the study, the students' opinions on STEM activities were taken. As a result of the analyses, the students' positive opinions on STEM activities are summarized in Figure 4 and their negative opinions are summarized in Figure 5.

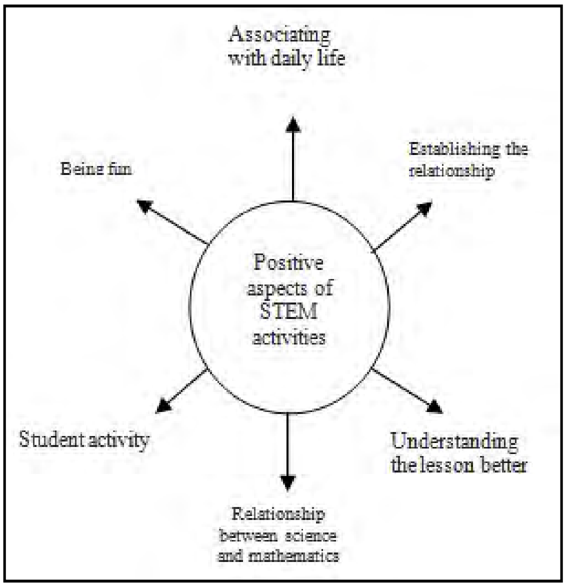


Figure 4. Positive Aspects of Activities Based on Student Reviews

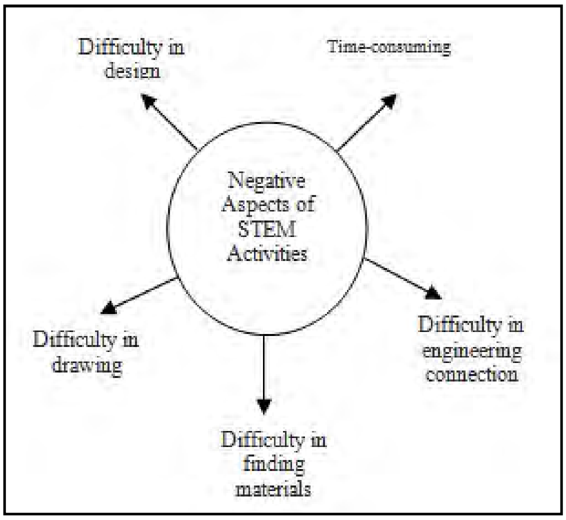


Figure 5. Negative Aspects of Activities Based on Student Reviews

The findings summarized in Figures 4 and 5 are detailed below. These findings are exemplified by the views of some students. The findings are presented by coding the students as S1, S2, etc.

Students stated that some of the situations they encounter in their daily life are related to the science course. Some students pointed out which scientific basis these situations are based on, while others chose to give the scientific foundation with an example without using the scientific terminology. For instance, S10 said "Some of our activities and projects are in our lives. For example, the positive and negative aspects of friction."

It was found that all students had a desire to continue the activities in other subjects. Related to this finding S3 said "These activities are more useful and fun for us. I would like to continue these activities on other topics, because I can understand the lesson better with these activities." Another student, S4 spoke as follows to express the opinion that there should be more STEM activities: "We were not experimenting so much in the lessons before. I understand and enjoy these activities more easily, so I want the activities to continue in other topics."

Students stated that mathematics, engineering, and technology dimensions are used as well as the aspect of science in the activities completed, however many students have placed more emphasis on the aspect of mathematics. This situation is thought to be due to the absence of the concepts of engineering and technology dimensions that students have not encountered before. An example that illustrates this finding is S7's following opinions: "We might use what we learned in these activities in other lessons as well. For example, we took measurements in the activities we completed in science lessons, which means science and mathematics go together." Similarly, S8 said "In these activities we measure, we draw, and we design, so it is related to other subjects."

Students have expressed difficulties in some areas, despite having fun in the activities. Especially, finding the materials and time management are highlighted among the difficulties that have been experienced. For instance, S1 said "We could not finish our activities early sometimes. There were some activities that took a long time. Nevertheless, we very much enjoyed some of the activities with our friends." Another student, S9 said "We had difficulty in finding the materials and it was difficult to finish some of the activities before the bell rang."

CONCLUSIONS and SUGGESTIONS

After the pilot study, it was observed that the students were not competent in designing, measuring, and using mathematical operations during the activity. At the same time, only one of the groups was able to complete the pilot activity.

During the implementation of the activities developed by the researchers, it was observed that the students faced a lot of difficulties at first. With the progress of the subject matter and the continued implementation of the activities, the students became more active in the lessons and they wanted less help. It was stated by some group members that some of their friends were more responsible than they were in prior lessons. The environment in which students work has an impact on their motivational beliefs and participation in the activities (Fortus & Vedder-Weiss, 2014). As some students are more interested in science and engineering, their involvement and leadership may be more in STEM activities.

It was seen that the students tried to prepare their own activities in accordance with the original activities prepared by the researchers. Science, mathematics, engineering, and technology are the four dimensions in the activities. The science aspect of the activities gave students theoretical information about the subject and the activity they prepared. The students expressed scientific information with their own sentences and made little mistakes in some concepts. Regarding the mathematical dimension, the students considered and noted measurements during the design of the activities, but these measurements were not exactly followed during the implementation. It is thought that this might be due to the students' handicraft abilities not being adequate and that the problems arising during the activity caused students not return to the activity framework while attempting to resolve them. Regarding the engineering aspect, it was observed that the students drew the design of the product that will be constructed, and the measurements were written on the design. In the engineering discipline, students develop critical and creative thinking skills in the design process (Lawanto et al., 2013). With regards to the technology aspect, students considered the materials to be used, and some students also paid attention to the cost. These results corroborate the findings by Gökbayrak and Karışan (2017) who examined the sixth grade students' views on STEM. In their study, it was reported that the relationship between the science, technology, mathematics, and engineering dimensions were explained by the students along with the reasons.

The materials required for the construction of the product designed by students in the activity were available from nearby and the materials could generally be considered as domestic waste (bottle cap, grocery bag, ice-cream stick, cardboard box, etc.) is another point that stands out. In the literature, a survey study reached a similar conclusion. It stands out that simple and low-cost materials were used in the activities that students prepared for the study (Ünlü & Dere, 2018).

Students did not have much difficulty in the process of preparing and reporting activities, but they were not able to manage their time during the implementation and they had trouble finding the appropriate materials. For this reason, the groups differed in their time to complete the implementation of the activities. Siew, Amir, and Chong (2015) achieved a similar conclusion in a study and suggested that STEM activities be done outside of class to remedy this problem. Similarly, Brown and Crippen (2016) stated that the activity plans should be prepared in accordance with the students' sensitivities and their daily lives.

It is seen that out of the science, mathematics, technology, and engineering dimensions, the students associated the mathematical dimension the most with the science dimension, and made the most detailed preparation for mathematical measurements. In addition, they focused more on the engineering dimension during the implementation phase and the maximum duration was spent at this phase. Another remarkable point was that different from the researchers' activities, the students did not plan a motivation section while designing their activities. The researcher activities had a motivation section at the beginning of the lessons.

When the students' responses to the interview questions were examined, the opinions of the students indicated that the students enjoyed the STEM activities and connected different disciplines to each other. Additionally, the activities promoted students' active participation and created a positive learning environment. It is noteworthy that there are research studies that found similar results in the related literature. Gülen and Yaman (2018) developed STEM activities using argumentation based science learning approach for the "Transmission of Electricity" topic. They found that the students enjoyed participating in the activities and had a better understanding of the topics. Similarly, the students in Aydın-Günbatar's (2018) study found the STEM activity interesting and expressed that it helped to improve their scientific research skills. Schnittka (2009) indicated that STEM activities developed conceptual understanding in the teaching of physics subjects. In the study of Gökbayrak and Karışan (2017) students stated that they wanted to have science courses with STEM activities, and the students found the lessons instructive, entertaining, and motivating. In his study with prospective teachers, Pekbay (2017) stated that STEM activities were found to be efficient, educational, and entertaining. Vennix, den Brok, and Taconis (2018) found an increase in attitudes and motivations towards STEM of students attending STEM training programs.

Hill (2019) emphasized that the focus in STEM education should be on community and social skills, presentation and communication skills, management, interpersonal skills, entrepreneurial skills, cultural knowledge and awareness, including language and art but also emphasized that STEM skills are needed for modern citizenship. Based on the student opinions and observations in the classroom, it can be said that the students' social skills such as communication, teamwork, and entrepreneurship might have developed.

In this study, the stages of development and implementation of STEM activities, and the development of similar activities by the students were examined. Students' opinions were also taken after the activities were prepared and applied. The results showed that the students found these activities to be entertaining and instructional. With this result, STEM activities can also be proposed in other units and in courses that will be connected to science.

Although the activities were carried out by the students with interest, some activities had a shortage of time. For this reason, activities can be designed in a way that the activities are completed in the time specified for the activity.

Teaching based on STEM activities can be proposed to be run in heterogeneous groups of students who will find it easy to adapt to each other. In this way, the development of social skills can be supported.

Different STEM training modules, course booklets, and their effects on different variables can be investigated to guide teachers' applications. Finally, professional development programs on STEM education might be designed for inservice teachers.

REFERENCES

Aydın-Günbatar, S. (2018). Designing a process to prevent apple's browning: A STEM activity. *Journal of Inquiry Based Activities, 8*(2), 99-110. Retrieved from http://www.ated.info.tr/index.php/ated/issue/view/16

Brown, J. C., & Crippen, K. J. (2016). Designing for culturally responsive science education through professional development. *International Journal of Science Education, 38*(3), 470-492.

Bybee, R. W. (2010). What is STEM education? *Science*, *329*(5995), 996-996.

Çepni, S. (2007). *Araştırma ve proje çalışmalarına giriş [Introduction to research and project work]* (Genişletilmiş 3. Baskı). Trabzon: Celepler Matbaacılık.

Çorlu, M. S. (2014). FeTeMM eğitimi makale çağrı mektubu [Call for Manuscripts on STEM Education]. *Turkish Journal of Education, 3*(1), 4-10.

Çorlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM Education: Implications for educating our teachers for the age of innovation. *Educatian and Science, 39*(171), 74-85.

Dugger, W. E. (2010*). Evolution of STEM in the United States.* Paper presented at the 6th Biennial International Conference on Technology Education Research, Queensland, Australia.

Fortus, D., & Vedder-Weiss, D. (2014). Measuring students' continuing motivation for science learning. *Journal of Research in Science Teaching, 51*(4), 497-522.

Gökbayrak, S., & Karışan, D. (2017). Altıncı sınıf öğrencilerinin FeTeMM temelli etkinlikler hakkındaki görüşlerinin incelenmesi [Exploration of sixth grade students' views on STEMM based activities]. *Alan Eğitimi Araştırmaları Dergisi, 3*(1), 25-40.

Griffin, P., Care, E., & McGaw, B. (2012). The changing role of education and schools. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 1-15). Dordrecht, Germany: Springer.

Gülen, S., & Yaman, S. (2018). Altıncı sınıf öğrencilerinin FeTeMM tabanlı ATBÖ yaklaşımı etkinlikleri hakkındaki görüşleri [The opinions of sixth grade students about ABSL approach activities based on STEM]. *OPUS Uluslararası Toplum Araştırmaları Dergisi*, *8*(15), 1293-1322.

Hill, C. T. (2019). STEM is not enough: Education for success in the post-scientific society. *Journal of Science Education and Technology*, 28, 69–73.

Lawanto, O., Butler, D., Cartier, S. C., Santoso, H. B., Goodridge, W., Lawanto, K. N., & Clark, D. (2013). Pattern of task interpretation and self-regulated learning strategies of high school students and college freshmen during an engineering design project. *Journal of Stem Education, 14*(4), 15-27.

Ministry of National Education. (2005). *Fen ve teknoloji öğretim programı [Science and technology curriculum].* Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Partnership for 21st Century Skills (2009). *Curriculum and instruction: A 21st century skills implementation guide.* Tucson, AZ: Author.

Pekbay, C. (2017). *Fen teknoloji mühendislik ve matematik etkinliklerinin ortaokul öğrencileri üzerindeki etkileri [Effects of* *science technology engineering and mathematics activities on middle school students*] (Unpublished dissertation). Hacettepe Üniversitesi, Ankara.

Rotherham, A. J., & Willingham, D. T. (2010). "21st-Century" skills. *American Educator*, *17*, 17-20.

Schnittka, C. G. (2009). *Engineering design activities and conceptual change in middle school science* (Unpublished dissertation). University of Virginia, USA.

Siew, N. M., Amir, N., & Chong, C. L. (2015). The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science. *Springer Plus, 4*(8), 1-20.

Stensmo, C. (1999, August). *Case methodology in teacher education compared to 'traditional' academic teaching: A field experiment*. Paper presented at the 8th European Conference for Research on learning and Instruction (EARLI), Goteborg, Sweden.

Ural Keleş, P. (2018). 2017 Fen bilimleri dersi öğretim programı hakkında beşinci sınıf fen bilimleri öğretmenlerinin görüşleri [Opinions of fifth grade science teachers about the 2017 science curriculum]. *Eğitimde Nitel Araştırmalar Dergisi – Journal of Qualitative Research in Education, 6*(3), 121-142. doi:10.14689/issn.2148-2624.1.6c3s6m

Ünlü, Z. K., & Dere, Z. (2018). Okul öncesi öğretmen adaylarının hazırladıkları FeTeMM etkinliklerinin değerlendirilmesi [Evaluation of STEM activities prepared by prospective preschool teachers]. *Ahi Evran Universitesi Kırşehir Eğitim Fakültesi Dergisi, 19*(2), 1502-1512.

Vasquez, J., Sneider, C., & Comer, M. (2013). *STEM lesson essentials: Integrating science, technology, engineering, and mathematics.* Portsmouth, NH: Heinemann.

Vennix, J., den Brok, P., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? *International Journal of Science Education,* 40(11), 1-21.

Wendell, K. B., Connolly, K. G., Wright, C. G., Jarvin, L., Rogers, C., Barnett, M., & Marulcu, I. (2010*). Incorporating engineering design into elementary school science curricula*. Paper presented at American Society for Engineering Education Annual Conference & Exposition, Louisville, KY.

Yıldırım, A., & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri [Qualitative research methods in social sciences]* (7. Baskı). Ankara: Seçkin Yayıncılık.

Yıldırım, B., & Selvi, M. (Eylül 2016). *STEM entegresyonu ve uygulamalı örnek ders planı [STEM integration and practical sample lesson plan].* Paper presented at the 12th National Science and Mathematics Education Congress, Trabzon, Turkey.

Citation Information

Ozan, F., & Uluçınar Sağır, Ş. (2019). Development of STEM activities for "measurement of force and the friction" unit. *Journal of Inquiry Based Activities, 9*(1), 52-66. Retrieved from http://www.ated.info.tr/index.php/ated/issue/view/18

Appendix 1

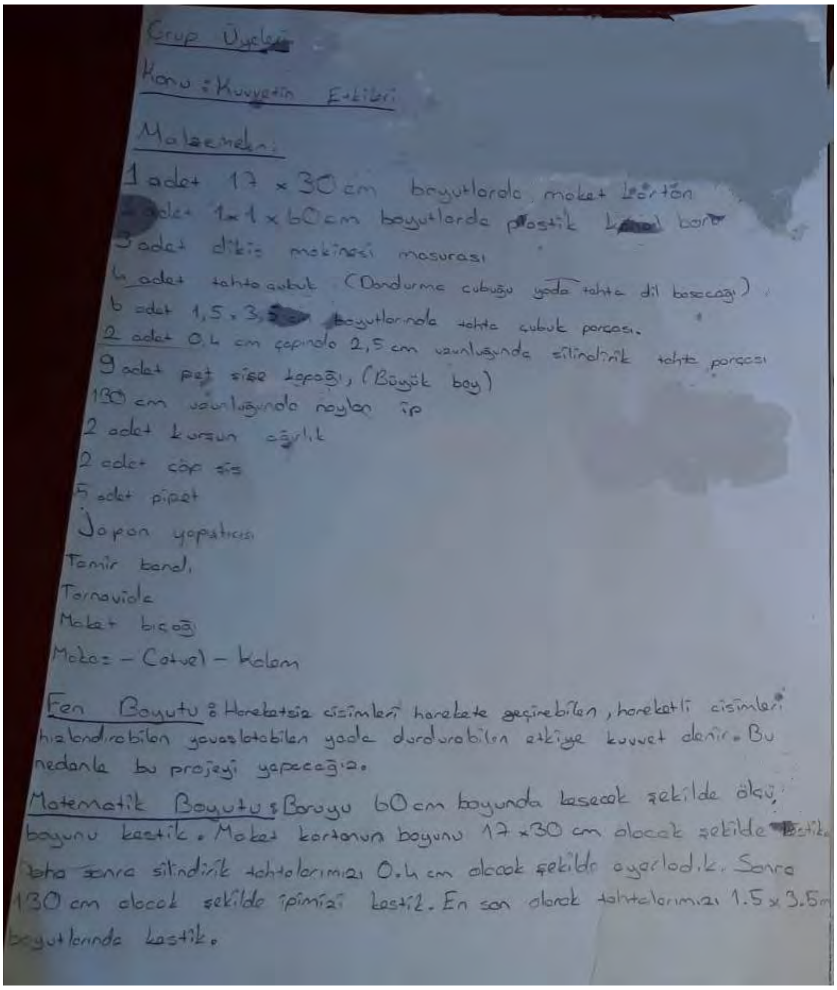
Student Activities Prepared According to Groups

Group	Subject	Standard
1	Effects of force	F.5.3.1.1. Measures the magnitude of the force with dynamometer and denotes the unit in Newton.
2	Increasing friction	F.5.3.2.3. Produces new ideas to increase or decrease friction in everyday life.
3	Increasing friction	F.5.3.2.3. Produces new ideas to increase or decrease friction in everyday life.
4	Increasing friction	F.5.3.2.3. Produces new ideas to increase or decrease friction in everyday life.

Appendix 2

Activity Plans Written by Students

Group 1's Activity Plan



Grup Üyeleri

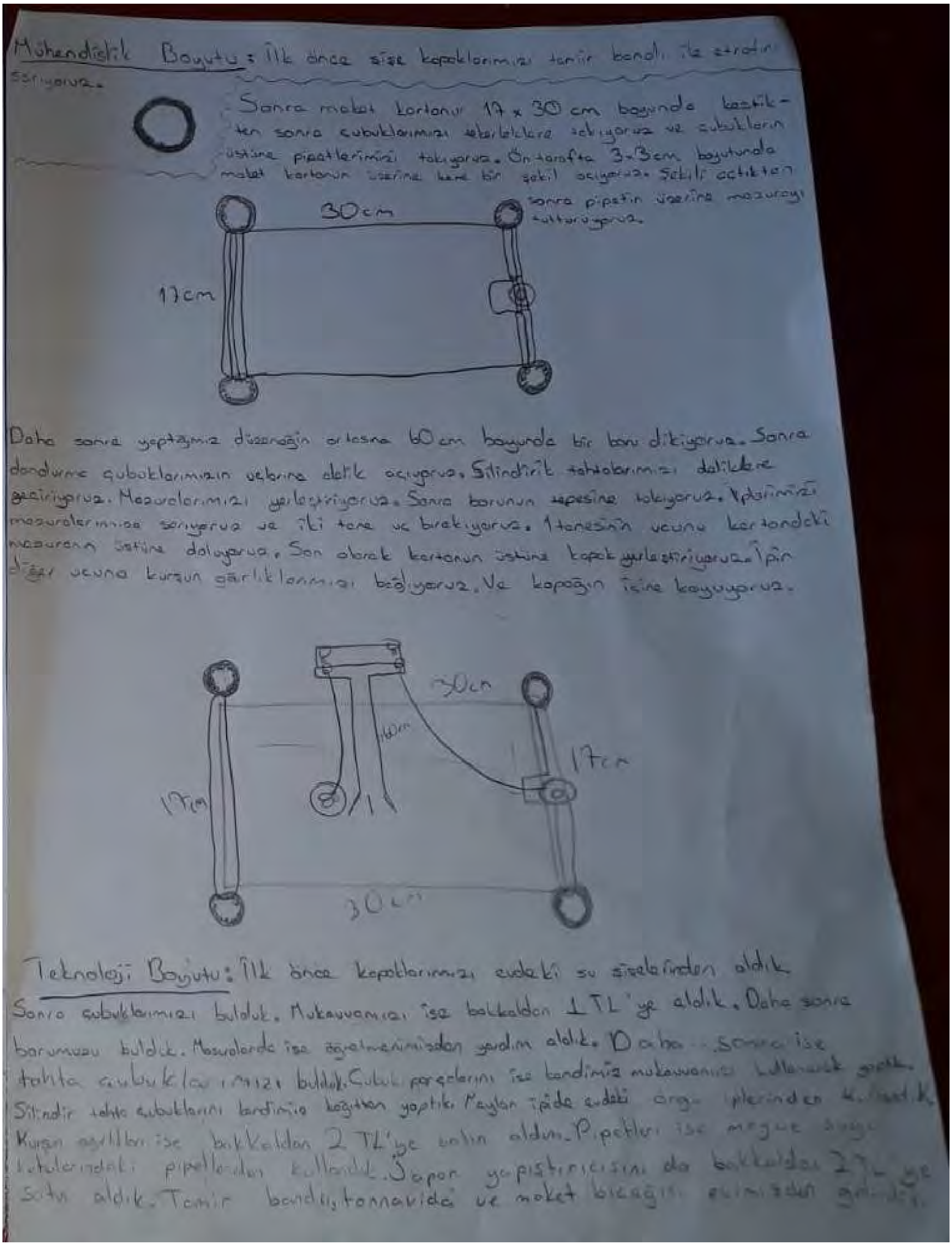
Konu: Kuvvetin Etkileri

Malzemeler:

1 adet 17 x 30 cm boyutlarda maket karton
[illegible] adet 1x1 x 60 cm boyutlarda plastik [illegible] boru
3 adet dikiş makinesi masurası
4 adet tahta çubuk (Dondurma çubuğu yada tahta dil basacağı)
6 adet 1,5 x 3,[illegible] boyutlarında tahta çubuk parçası.
2 adet 0,4 cm çapında 2,5 cm uzunluğunda silindirik tahta parçası
9 adet pet şişe kapağı, (Büyük boy)
130 cm uzunluğunda naylon ip
2 adet kurşun ağırlık
2 adet çöp şiş
5 adet pipet
Japon yapıştırıcı
Tamir bandı
Tornavida
Maket bıçağı
Makas – Cetvel – Kalem

Fen Boyutu: Hareketsiz cisimleri harekete geçirebilen, hareketli cisimleri hızlandırabilen yavaşlatabilen yada durdurabilen etkiye kuvvet denir. Bu nedenle bu projeyi yapacağız.

Matematik Boyutu: Boruyu 60 cm boyunda kesecek şekilde ölçü, boyunu kestik. Maket kartonun boyunu 17 x 30 cm olacak şekilde kestik. Daha sonra silindirik tahtalarımızı 0.4 cm olacak şekilde ayarladık. Sonra 130 cm olacak şekilde ipimizi kestik. En son olarak tahtalarımızı 1.5 x 3.5 m boyutlarında kestik.



Mühendislik Boyutu: İlk önce şişe kapaklarımızı tamir bandı ile etrafını sarıyoruz.

Sonra maket kartonu 17 x 30 cm boyunda kestikten sonra çubuklarımızı tekerleklere takıyoruz ve çubukların üstüne pipetlerimizi takıyoruz. Ön tarafta 3 x 3 cm boyutunda maket kartonun üzerine kare bir şekil açıyoruz. Şekili açtıktan sonra pipetin üzerine masurayı tutturuyoruz.

30cm

17cm

Daha sonra yaptığımız düzeneğin ortasına 60 cm boyunda bir boru dikiyoruz. Sonra dondurma çubuklarımızın uçlarına delik açıyoruz. Silindirik tahtalarımızı deliklere geçiriyoruz. Masuralarımızı yerleştiriyoruz. Sonra borunun tepesine takıyoruz. İplerimizi masuralarımıza sarıyoruz ve iki tane uç bırakıyoruz. 1 tanesinin ucunu kartondaki masuranın üstüne doluyoruz. Son olarak kartonun üstüne kapak yerleştiriyoruz. İpin diğer ucuna kurşun ağırlıklarımızı bağlıyoruz. Ve kapağın içine koyuyoruz.

30cm

60cm

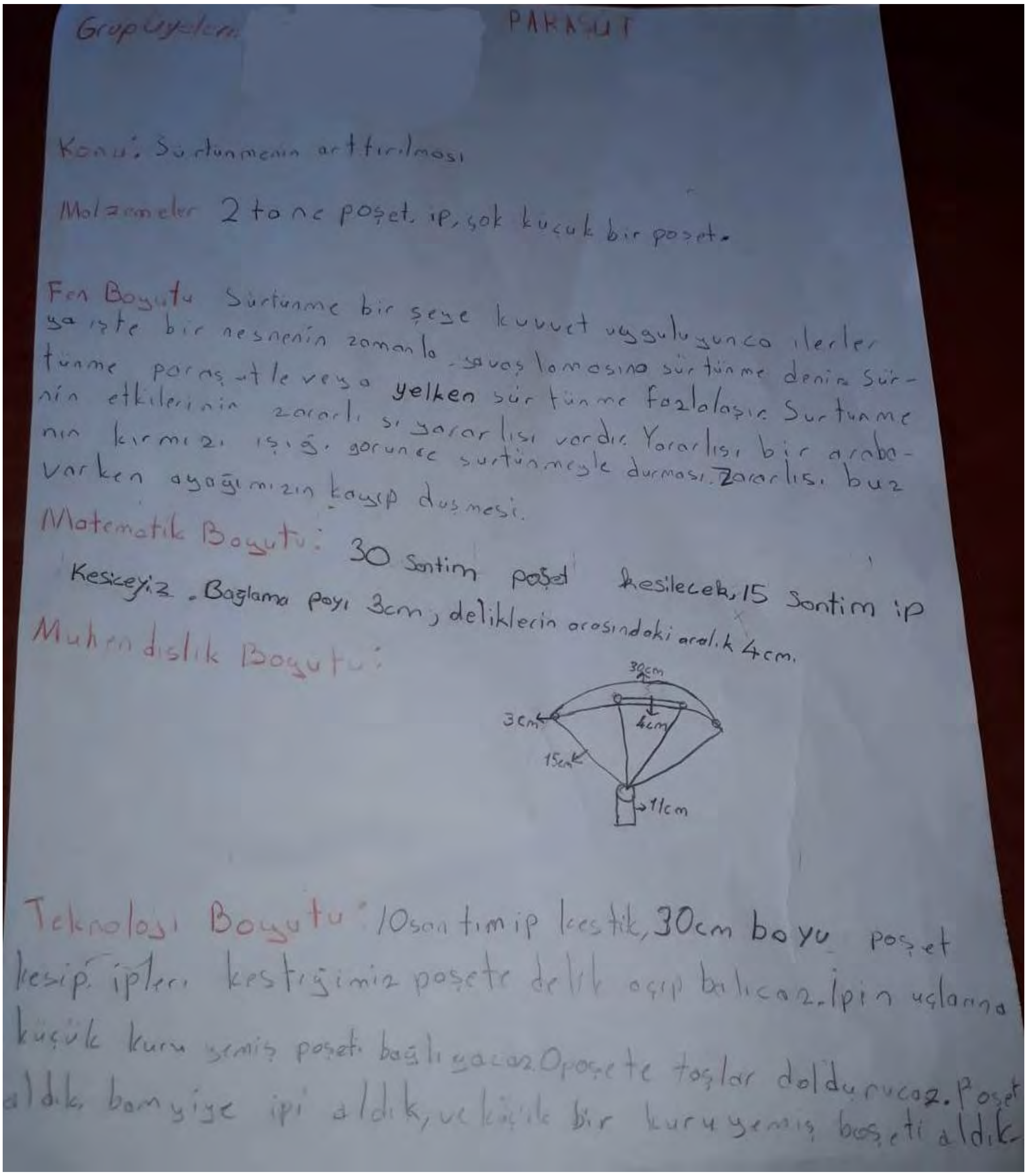
17cm

17cm

30cm

Teknoloji Boyutu: İlk önce kapaklarımızı evdeki su şişelerinden aldık. Sonra çubuklarımızı bulduk. Mukavvamızı ise bakkaldan 1 TL'ye aldık. Daha sonra borumuzu bulduk. Masuralarda ise öğretmenimizden yardım aldık. Daha sonra ise tahta çubuklarımızı bulduk. Çubuk parçalarını ise kendimiz mukavvamızı kullanarak yaptık. Silindir tahta çubuklarını kendimiz kağıttan yaptık. Naylon ipide evdeki örgü iplerinden kullandık. Kurşun ağırlıkları ise bakkaldan 2 TL'ye satın aldım. Pipetleri ise meyve suyu kutularındaki pipetlerden kullandık. Japon yapıştırıcısını da bakkaldan 2 TL'ye satın aldık. Tamir bandı, tornavida ve maket bıçağını evimizden getirdik.

Group 2's Activity Plan



Grup Üyeleri: PARAŞÜT

Konu: Sürtünmenin arttırılması

Malzemeler 2 tane poşet, ip, çok küçük bir poşet.

Fen Boyutu Sürtünme bir şeye kuvvet uygulayınca ilerler ya işte bir nesnenin zamanla yavaşlamasına sürtünme denir. Sürtünme paraşütle veya yelken sürtünme fazlalaşır. Sürtünmenin etkilerinin zararlısı yararlısı vardır. Yararlısı bir arabanın kırmızı ışığı görünce sürtünmeyle durması. Zararlısı buz varken ayağımızın kayıp düşmesi.

Matematik Boyutu: 30 Santim poşet kesilecek, 15 Santim ip Kesiceyiz. Bağlama payı 3cm, deliklerin arasındaki aralık 4cm.

Mühendislik Boyutu:

Teknoloji Boyutu: 10santim ip kestik, 30cm boyu poşet kesip ipleri kestiğimiz poşete delik açıp bağlıcaz. İpin uçlarına küçük kuru yemiş poşeti bağlıyacaz. O poşete taşlar dolduracaz. Poşet aldık, bamyiye ipi aldık, ve küçük bir kuruyemiş poşeti aldık.