

SCIENCE AND ENGINEERING IMPLEMENTATION: A CASE STUDY ON EDIBLE AND RENEWABLE CAR ACTIVITY

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ABSTRACT

The Edible and Renewable Car Contest activity that would allow students to experience objectives of secondary school science, mathematics, technology, and design courses was conducted in this study. An engineering design cycle was implemented. The research group consisted of five female and seven male students in the 7th grade. A case study was used as a qualitative research design. Semi-structured interviews and reflective open-ended questions were analyzed by descriptive analysis. The performances of the students were evaluated with Edible and Renewable Car Activity Rubric and Peer Assessment Rubric. Data analysis revealed that even though the students expressed the view that they had difficulty in team work and material supply, they expressed that the activity was fun, they had an idea about the similarities and differences between science and engineering practices, and also they enjoyed applying the design cycle.

Keywords: STEM education, science education, edible and renewable car contest.

FEN VE MÜHENDİSLİK UYGULAMASI: YENİLEBİLİR VE YENİLENEBİLİR ARABA YARIŐMASI ETKİNLİĐİ ÜZERİNE BİR DURUM ÇALIŐMASI

ÖZ

Arařtırmada öđrencilerin ortaokul fen bilimleri, matematik, teknoloji ve tasarım dersi kazanımlarını birlikte deneyimlemelerine olanak sađlayan Yenilebilir ve Yenilenebilir Araba Yarışması etkinliđi uygulanmıřtır. Çalıřmada bir fen, teknoloji, mühendislik ve matematik uygulaması olarak mühendislik tasarım döngüsü kullanılmıřtır. Arařtırmanın çalıřma grubu bir devlet ortaokulunda 7. sınıfta öđrenimlerini sürdüren beř kız yedi erkek öđrenciden oluřmuřtur. Sınıf dıřı etkinlik olarak beř günde her gün iki ders saati olmak üzere toplam on saat olarak gerçekteřtirilen bu çalıřmada, nitel desenlerden durum çalıřması kullanılmıřtır. Arařtırmada, yarı yapılandırılmıř görüřmeler ve yansıtıcı açık uçlu sorular ile elde edilen veriler betimsel analiz yöntemi ile çözümlenmiřtir. Öđrencilerin performansları Yenilebilir ve Yenilenebilir Araba Yarışması Dereceli Puanlama Anahtarı ve Akran Deđerlendirme Dereceli Puanlama Anahtarı ile ölçülmüřtür. Arařtırma sonucunda öđrenciler malzeme temini ve takım çalıřmasındaki güçlükleri belirtmeler de, etkinliđin eđlenceli olduđunu, bilim ve mühendislik uygulamaları arasındaki benzerlik ve farklılıklara iliřkin fikir edindiklerini, mühendislik tasarım döngüsünü uygulamaktan hořlandıklarını ifade etmiřlerdir.

Anahtar kelimeler: STEM eđitimi, FeTeMM, fen eđitimi, yenilebilir ve yenilenebilir araba yarışması.

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INTRODUCTION

Science, technology, engineering, and mathematics [STEM] education appropriate an integrative and interdisciplinary inquiry by overlapping boundaries within the four disciplines (Capraro, Capraro, & Morgan, 2013; Gonzalez & Kuenzi, 2012; Wang, Moore, Roehning, & Park, 2011). In the United States of America [USA], a framework for science education developed by National Research Council (2012) defined eight common categories for scientific and engineering practices in the first dimension. Although the practices for science and engineering are similar and complementary in many categories, engineering design has a basic difference in terms of purpose and product. Similarly, recently revised science curriculum in Turkey has placed science and engineering skills in addition to scientific process and life skills to obtain the outcomes expected from students who can converge science with the other disciplines and manage the process of applying theory and skills to practice and product (Ministry of National Education [MoNE], 2017).

In this study, an activity named Edible Car Contest that has been organized by Illinois Valley Community College at the USA to celebrate National Engineering Week since 2006 (Perez, Gibson, Opsal, & Lynch, 2011) was adapted to Turkish. The accessible open source activity and classroom worksheets were redesigned based on the opinions of a Turkish linguist, a science educator, a science teacher, a mathematics teacher, and a technology design teacher. The science and engineering activity was applied based on the five steps engineering design cycle (Ask-Imagine-Plan-Create-Improve) (Cunningham, 2009) by integrating mathematics and technology practices with classroom worksheets. Also, the activity was renamed as Edible and Renewable Car Contest.

The Edible Car Contest in the USA has been conducted in many categories such as best design, fastest, and most colorful etc. with provided prizes to match the contest purpose and classes from kindergarten to college level. Similarly, in our country, in recent years the edible car contest has been practiced in schools as a STEM activity. For example, the study of

Aslan-Tutak, Akaygün, and Tezseçen (2017) provided pre-service teachers with experiences of integrating science, mathematics, engineering, and technology knowledge by engaging in the edible car contest with constrained resources. But, there is no study that explored students' views and experiences directly throughout the process of similar activity.

In this study, students were expected to relate science topics of nutrients and their properties, force, motion, and energy; mathematics topics of data analysis, triangles and angles, polygons, ratio, and proportion; technology and design topics of product, planning, develop model and prototype, and evaluation with each other. The learning outcomes of elementary and middle school science teaching program for the 3, 4, 5, 6, 7, and 8th grades (MoNE 2013a), middle school mathematics teaching program for the 5, 6, 7, and 8th grades (MoNE, 2013b), and middle school technology and design teaching program for the 7 and 8th grades (MoNE, 2016) were considered to develop the activity. The topics and outcomes related with the activity are given in the Appendix 1.

In the activity of Edible and Renewable Car Contest, students are expected to behave like an engineer. While students are experiencing all roles specific to STEM fields, they can see the role of related scientific area. Students carry out their projects by overlapping scientific knowledge and engineering design cycle with the pre-defined rules (Perez et al., 2011). The students were expected to;

- understand similarities and differences between science and engineering,
- apply engineering design cycle in the projects,
- work in communication and collaboration with the other team members in the project,
- develop interdisciplinary work and skills by integrating STEM disciplines,
- and develop skills of problem solving, creativity, computational thinking, responsibility, and using information technologies.

Within this framework, the current study with the Edible and Renewable Car Contest activity aimed to provide students with an opportunity to experience the practical applications of science, technology, engineering, and mathematics in order to understand how their experiences impact their learning, to find out their opinions about the activity, and to identify problems emerged from the practice. The research questions oriented the study were as follows:

1. How does participating in the science and engineering practice of the Edible and Renewable Car Competition affect students' learning experiences?
2. What are the opinions of students on the science and engineering practice of the Edible and Renewable Car Competition?

In this research, a case study was used as a qualitative research design. Creswell (2014) defines case study as "the researcher explores in depth a program, event, activity, process, or one or more individuals" (p.13). According to Merriam (2013), the bounded context is the most important characteristic of a case study. In the case studies a variety of data collection methods are utilized (Yıldırım & Şimşek, 2016).

Semi-structured interviews, reflective open-ended questions, a rubric to evaluate the performances of the students and peer assessment were utilized as data collection tools. The obtained data were analyzed by means of descriptive analysis. Yıldırım and Şimşek (2016) mentioned a four-step analysis process of descriptive analysis approach in which the data obtained are summarized and interpreted according to the previously determined themes, and then systematically and clearly described. According to these steps for this study; a theoretical framework for descriptive analysis was established, data were processed as regard to the defined themes, and findings were obtained and interpreted.

ACTIVITY IMPLEMENTATION

The research group consisted of twelve students: five female and seven male students

in the 7th grade continuing their study in a public school in Antalya. The students were divided into four groups. Before the study, the written permission of the student parents was obtained and the students participated voluntarily to work. The study was conducted as an out of classroom activity for two hours in five days, and the total study period was ten hours. The names of the teachers and students are pseudonyms in order to keep the identities of the participants confidential. In order to ensure the homogeneity of the groups, before the class application, the study group consisting of twelve students was divided into four groups according to their academic success level and the names of the students in the groups were announced one day before.

Day 1 / 2 Class Sessions

Students were allowed to sit around a table where they can work together in groups. The activity started with a worksheet about descriptions of objectives, key concepts, rules, application procedures, evaluation criteria, and explanations about the activity by teacher (Appendix 2 and Appendix 3). The work to be done during the activity and the steps of implementation were examined by all groups with the guidance of the teacher. In other parts of the activity, similar and different features of science and engineering practices were emphasized (Appendix 4).

Day 2 / 2 Class Sessions

The instruction for the work to be done (Appendix 2) and the engineering design cycle (Appendix 3) were examined together with the students. It was discussed what to do at each stage. After this phase, the key concepts in Appendix 2 were searched online by each group. In this study, computers in the computer laboratory were used to reach online resources.

Key concepts consist of concepts that students learned in previous years or in the same school year. The search of these concepts was planned to remind students of their previous learning and to correct their misunderstandings. Photograph 1 shows the students who are searching concepts.



Photograph 1. Online Research of Key Concepts by the Students

The teacher emphasized the importance of team work and achieving reliable knowledge by discussing the information that students got about the concepts within all group members. Afterwards, students were asked to give examples and the correct and wrong examples were evaluated by the other students.

While students were researching online, it was expected that they make an inference that carbohydrates, fats, proteins, and vitamins may coexist in different nutrient contents, but water and minerals are found in all nutrients. The teacher supported this process with guiding questions. In this study, the teacher asked the students "Which nutrients contain carbohydrates, proteins, fats, and vitamins?" "Which nutrients contain water and minerals?" Students stated that more than one food group can be found in the food content while water and minerals are usually found in all foods by discussing the obtained information in the group. Later on, students defined constant velocity movement, revealing their ideas about how they can calculate velocity of vehicles that they create in the activity. At this stage, the questions asked by the teacher are expected to help students to develop their ideas. In order to calculate velocity, the students discussed which variables should be used and how the velocity can be calculated. In this study, the teacher asked each group to explain how to calculate the velocity. Group 1 students answered:

S1: We measure with a chronometer.

S2: We divide the distance by the time to find the velocity.

S3: Distance divided by the time.

Teacher: What is velocity unit?

S1: Kilometers?

S3: Centimeters divided by seconds

Teacher: Can there be other units?

S3: Kilometers per second, meters per minute.

Students shared their views on the concept of energy by defining the work in the physical sense with their group mates. Students were asked by the teacher to give real life examples for the conversion of potential energy to kinetic energy, and the conversion of kinetic energy to potential energy. Students explained the effect of friction force to make it faster. They shared their views on how potential and kinetic energy transformations can be carried out in an effective way. During the activity, when the teacher asked the Group 2 students "What can you do to make the vehicle go farther?" the following dialogue occurred:

S5: Friction can be reduced.

S6: We can reduce the weight.

Teacher: If you reduce the weight, why is your vehicle going to go further?

S5: I think it's better to be heavy. Full jar versus empty jar, then the full jar goes farther.

S6: But if it is heavy, the friction force will be greater. Then it goes further.

Teacher: Does the friction force being greater make the vehicle go farther?

S5: Decreases.

S6: My idea changed.

The teacher stated that the scientific inquiry is controlled by dependent-independent variables and that our ideas may change during this process. In order to enable students to participate in the scientific inquiry process, the teacher asked the question "If you increase weight, you say that the friction force increases. What do you think about the potential energy that the car will have if its weight increases?" By asking this question, the teacher directed the students to discuss in the group about which type of energy that potential energy transforms into when this vehicle starts to move.

After this step, the group was asked by the teacher "What is technology?" Groups shared the information that they obtained online with each other. All groups defined technology as electronic devices such as machines and computers. The teacher explained that technology does not only cover tools such as computers and smartphones; all the tools that are developed by human, and all the information related to them is technology.

Day 3 / 2 Class Sessions

The descriptions of the group members' roles were determined by each group (Appendix 5). While the groups were working in accordance with the engineering design cycle (Ask-Imagine-Plan-Create-Improve), how scientific knowledge (nutrients and properties, velocity, work, energy, friction force) was needed for the "Edible and Renewable Car Contest" activity as an engineering application was discussed.

In the study, the students determined the criteria in line with the scenario in Appendix 2 and brainstormed ideas. The first phase of the engineering design cycle "Ask" was completed in a cyclical fashion by all groups. Group 1 students clearly expressed their ideas during the second phase of "Imagine" as follows:

S1: The wheels should be made from round biscuits.

S4: I think it should be made by egg plant.

S2: We can wrap the wheel with another material.

S3: The body must be made of bread.

After the group members explained their views about materials that they selected for the parts of vehicle, they discussed the reasons within the group and expressed as the following:

Body: Sandwich bread for light weight.

Wheel: Biscuit for the wheels to be strong.

Axles: Carrot can be shaped or a sesame stick.

Wheels: Marshmallow for fastening.

The teacher directed the students to re-examine the criteria (cost, durability, energy) by stating that all criteria should be taken into account in relation to the materials they selected. The materials to be used for the vehicle were determined by the groups, the logo was designed and the vehicle prototype was drawn using the design template given in Appendix 6. Students who took on the role of an engineer should have an idea about engineers using their creativity during logo design and prototype drawing, and expect to find possible defects in the vehicle by using the prototype drawn. In the prototype drawing, which nutrient were used for which part of the vehicle were indicated in the drawing. The groups shared

tasks for bringing the determined foods for the next lesson.

Day 4 / 2 Class Sessions

The materials to be used by the students in the vehicle design were weighed after the pieces were separated for use in vehicle design (Photograph 2) and the data were recorded in grams. The cost of the vehicle worksheet (Appendix 7) and the nutrient value worksheet (Appendix 8) were filled out by the students. Calorie values obtained from online sources were taken into account while calculating information on nutritional values. A spreadsheet program was used to make calculations. The students determined the materials to be used for the vehicle design with the highest energy and most economical ones according to the findings obtained from their calculations.



Photograph 2. Weighting the Foods Used by the Students in Vehicle Design

A discussion was initiated about why the energy of foods that make up the vehicle is wanted as high and the cost as low. Students were expected to assess which types of nutrients have higher energy levels and to appreciate about the positive or negative aspects of low vehicle cost.

According to the engineering design cycle, vehicle prototypes were created and their performances were tested (Photograph 3). At the same time, it was discussed how the effects of energy transformations and friction forces affected the velocity of the vehicle, and what changes can be made in their design to increase velocity. To improve the performance of the vehicle, the engineering design cycle was reapplied and the final shape of the vehicle was established.



Photograph 3. Testing Vehicle Performance

Velocity of the vehicles released from the platform was calculated. For this purpose, a volunteer student from each group determined the landing time from the platform with a chronometer. Discussions were held on how to eliminate errors resulting from measurement process and the role of science, technology, engineering, and mathematics. At this stage, the teacher asked the following questions to emphasize the similarities in the use of data both in science and engineering.

- *Why did three people measure?*
- *What value should we use?*
- *How do you calculate the average value?*
- *Do scientists and engineers use more than one data collection tool?*
- *How did you use science, mathematics, engineering, and technology to create and measure vehicle design?*

In the current study, the above questions were asked and a debate was started about why three people measured. The students expressed their opinions about the calculation of the average value. It was emphasized by the teacher that both scientists and engineers use mathematics in their work. After the discussion, the velocity was calculated by each student separately for each group and the results obtained were compared. Students were expected to answer the following questions asked by the teacher and express their opinions.

- *What caused the car to move down?*
- *What can you say about the energy that the vehicle has at the top of the platform?*
- *How does the energy of the car vary when it is moving?*
- *How can the vehicle move faster?*
- *If the platform surface was different in type (e.g. fabric, carpet, glass), would there be any change in velocity of the vehicle? Why?*

- *How can you make your design more efficient as an engineer?*

Calculation of the wheel diameters, distance taken by the wheel (Appendix 9) and the calculation of the velocity of the vehicle were recorded and calculated by a spreadsheet program. In addition, the properties of the angles on the platform and their values were determined and noted on the worksheets by the students.

Day 5 / 2 Class Sessions

A three-member jury consisting of science, mathematics, and technology and design teachers was formed for the competition. The jury evaluated the groups by using the Edible and Renewable Car Contest Rubric (Appendix 11). The groups exhibited the vehicles they designed (Photograph 4) for jury's examination and to answer the questions by the jury.



Photograph 4. Vehicle Designs of the Groups

The groups that came together for the competition were asked to make a final control. In order to calculate the velocity of the vehicles, the students were assigned for making the measurements and the competition started. Students released the vehicles from the platform with the command of the teacher. Three students were responsible for recording the data of the landing time from the top of the platform and the velocity of vehicles were calculated (Photograph 5). The activity ended with students responding to reflective open-ended questions about the competition (Appendix 10).



Photograph 5. Edible and Renewable Car Competition

Results and Evaluation of the Activity

As a result of evaluating the data obtained from the researcher's field notes and observations, the findings were reached as follows. When the students were investigating the key concepts, Group 1 students were actively working in cooperation, S12, a Group 3 member, was studying alone, and the other students in the same group were working together. Group 2 students were divided into two subgroups. By sharing the task, these two subgroups explored the concepts. They recorded the obtained data in their notebooks.

It was observed that Group 1 students worked more harmonious in the team during the drawing of the vehicle design. Group 2 and Group 3 students were found to have difficulty in drawing the vehicle design. For example, a Group 2 student described this process as:

S5: You want something very difficult from us.

Teacher: What would happen if you do not do this design?

S5: The vehicle becomes indiscriminate.

Regarding the vehicle design, the findings were evaluated according to the criteria of the Edible and Renewable Car Competition rubric shown in Appendix 11, based on the criteria given in Appendix 2. The criteria that were used in this rubric according to the four-point performance level are given below.

- Vehicle design
- Vehicle performance
- Team name - logo and vehicle relationship
- Draft design
- Work plan and design process
- Reflection

- Team work
- Cost
- The amount of food energy

According to this evaluation result; it was found that all the vehicles designed by all groups were made of edible foods and that they looked like cars (passenger cars, trucks, vans, minibuses, etc.), with at least two axles and at least three wheels. All of the vehicles met the design requirements.

According to the performance criterion, the vehicles must descend without falling from a 120cm ramp in length. However, it was seen that the vehicles designed by Group 2 and Group 3 were not able to meet this criterion. Therefore, the performance criterion was met only by the vehicle designed by Group 1. When analyzed in terms of team name-logo relationship, it was determined that the groups used names from TV series or cartoons such as Group 1 called 4 + 1, Group 2 called Camikaze, and Group 3 called Flash. According to the team name - logo relation; it can be said that Group 1's name was irrelevant or weak, Group 2's name was at the basic level, and Group 3's name had a strong relationship.

Although proportional errors were made in draft drawings, it was seen that all the drawings met the majority of requirements for vehicle design. When the group members' role descriptions and design processes were evaluated; It was observed that the role descriptions were completed by Group 1, but the tasks that needed to be done in collaboration was given to only one person, and the design process was not described. It was determined that role descriptions of Group 2 members and the tasks were defined for purchasing more materials rather than the tasks that were required for the design process. Group 3 seemed to define tasks better than other groups do and make clear role descriptions, but they did not express the design process clearly. After the activity, the reflective open-ended questions (Appendix 10) that were answered by all students in the groups were evaluated. The findings are presented in Table 1, Table 2, and Table 3.

Table 1. Reflection of Group 1

Themes	Students			
	S1	S2	S3	S4
Difficulties	Material supply	Material supply	Material supply	Material supply
Coping with Challenges	Team work	Material change	Material change	Material change
Calculating Velocity	Calculates	Calculates	Calculates	Calculates
Developing Performance	No change	New materials	New materials	New materials
Favourable Sections	All	Brain storming	All	Construction stage
Unfavourable Sections	Not any	Design	Measuring	Measuring and writing
Team Work	Worked in cooperation	Worked in cooperation	Worked in cooperation	Worked in cooperation
Proposals	Not use food for everthing	To go shopping together	Reduce the number of group members	Making the body better

When the Table 1 was examined, the following findings were identified. All the students in Group 1 had difficulties in supplying materials but they overcame these difficulties by changing materials (75%). All of the group members were able to calculate the velocity, adjusted the performance of the vehicle by using new material (75%), and indicated good performance so there is no need to change (25%). The students expressed the whole activity (50%), brainstorming (25%), and constructing phase (25%) as favorite parts of the activity. As unfavorite part of the activity, the students wrote the design process (25%), measurement (50%), writing (25%), and nothing to unlove (25%). Teamwork was successfully accomplished by all students. Students' suggestions for the activity included using non edible materials (25%), going to shopping together (25%), and reducing the number of group members (25%).

The findings obtained from Table 2 indicated that all of the students in Group 2 had difficulties in supplying materials, these difficulties were overcome by material change; the velocity was calculated by two students (50%); they could improve the performance of the vehicle by using new material (75%). They expressed the whole activity (50%), constructing phase (25%), and having fun (25%) as favorite parts of the activity. As unfavorite parts of the activity, they wrote emerging problems (25%), losing out (25%), lack of material (25%), and nothing to unlove (25%). Team work was described by all

students as incompatible. Two students suggested nothing for the activity (50%), the other students' suggestions involved removing prototype drawing (25%) and changing group members (25%).

Table 2. Reflection of Group 2

Themes	Students			
	S5	S6	S7	S8
Difficulties	Material supply	Material supply	Material supply	Material supply
Coping with Challenges	Material change	Material change	Material change	Material change
Calculating Velocity	Calculate	Calculate	Uncalculate	Uncalculate
Developing Performance	-	New material	New material	New material
Favourable Sections	All	Construction	Having fun	All
Unfavourable Sections	Not any	Problem	Lose out	Lack of material
Team Work	Inharmonious	Inharmonious	Inharmonious	Inharmonious
Proposals	Not any	Removing the prototype drawing	Not any	Change the group

Table 3. Reflection of Group 3

Themes	Students			
	S9	S10	S11	S12
Difficulties	Group work	Material supply	Material supply	Material supply
Coping with Challenges	Voting	Material change	Material change	Material change
Calculating Velocity	Calculate	Calculate	Calculate	Calculate
Developing Performance	New material	New material	Redesing	Redesign
Favourable Sections	Design	All	Strategy-science, fun, intelligence	Realizing ideas
Unfavourable Sections	Inharmonious	Not any	Not any	Inharmonious
Team Work	Inharmonious	Inharmonious	Inharmonious	Inharmonious
Proposals	Groupmates	Material supply	Material supply	Material supply

The analysis of Table 3 indicated that Group 3 students had difficulty in material supply (75%) and group adaptation (25%) but they overcame these difficulties by making material changes (75%) and voting within the group (25%). All the students in the group could calculate the velocity, and all of them could improve the performance of the vehicle by using new materials. As favorite parts of the activity students listed the whole activity (50%), entertainment, and strategy and science (25%) while they expressed discomfort within the group (50%) and noting unfavorable aspects (50%) as unfavorable parts. Team work was described by all students as inharmonious

and they suggested that materials should be supplied for the activity (75%) and the groupmates should be changed (25%).

The findings obtained from semi-structured interviews conducted with one student from each group revealed students' opinions about the activity (Appendix 13). S1, a Group 1 member, expressed "axles" and "wheels do not turn" as the most difficult part; "being happy in succeeding" and "learning to make a table in excel" as the most popular part; "lack of material" as the least popular part of the activity. He described the team work as "harmonized" and described the science course by saying "research is done" and "calculations are related to mathematics." His suggestions for the activity were "creating the groups by ourselves because some of the students do not work in the group" and "buying the materials together" because of the fact that some students did not bring the materials. He said that they used the engineering design cycle and this cycle "repeated again and again to provide control." He stated similarities between scientists and engineers in regards to making observations: "Engineers make observations, too, but scientists have a more scientific point of view."

Group 2 member S5 stated that "The most difficult part was the team work the activity for me. I personally can not handle the team work that I can say it from the beginning." He stated that they had "fun" during the activity and "designed the car well" but they experienced "material shortage." He stated that the activity was linked to "science lessons", "group work is taught", but "the student distribution to the groups must be fair." The student explained the views about the engineers and scientists as "Engineers work in a design cycle and we were in big trouble when this cycle was not used." and "While scientists do things based on knowledge and investigate the world, engineers do things like cars and telephone, and both are using the technology in their work."

During the semi-structured interview with Group 3 member S12, he expressed "the axle part of the vehicle required for turning the tires" and "ask" phase while applying the engineering design cycle as the most difficult parts, but he liked this "difficulty", he also liked

"the construction of the car" while he disliked "lack of materials." He stated that "the activity is not so much different from science course but engineering design is different and both science and engineering are based on mathematical operations." He stated that they did not sufficiently follow the cycle during the activity, they started their vehicle design without doing some parts of the "ask" section, so "the result was bad because we did not follow the cycle." The student expressed that "science is experimental; engineering is more visual and, engineers use imagination" and scientists are trying to reach a conclusion by "arguing."

According to the analysis of the interviews with S1 in Group 1, S5 in Group 2, and S12 in Group 3, it can be concluded that engineering design cycle provided control and if the design cycle was not used, the groups could experience great troubles. When the group processes are taken into consideration, it can be said that the success achieved by the students in the activity is related to the fact that the engineering design is applied effectively and they had trouble when they did not use the design cycle appropriately.

With the Peer Assessment Rubric (Appendix 12), students evaluated each group member by a four-point performance level. Peer assessment averages are shown in Table 4 for each group. The findings obtained from the Peer Assessment Rubric and the Edible and Renewable Car Competition Rubric were parallel. In other words, the group that actively participated in the activity, had high performance of the task, worked towards the team goals, and made cooperation, designed their vehicle more successfully.

Table 4. Findings of Peer Review Rubric

Groups	Criteria			
	Participation	Task Performance	Working Towards the Team Goals	Cooperation
Group 1	4,00	4,00	4,00	4,00
Group 2	3,16	3,42	3,58	3,50
Group 3	3,08	2,58	2,92	2,58

CONCLUSIONS and SUGGESTIONS

Edible and Renewable Car Contest can be applied from kindergarten to higher education, as well as a fun activity that involves multiple subject areas of different disciplines at low cost. When the applications in the USA are examined, it is widely used in many schools as a competition and as a STEM activity. The activity can be organized with different materials from the simplest measuring instruments to high-tech sensors and measuring instruments. In addition to being able to be designed in many different ways, the activity offers group work, problem solving, using the engineering design cycle, applying knowledge about STEM disciplines, and revealing creative ideas. In this context, it can be applied easily in educational environments or in different forms of non-school settings. Although the activity is easy to implement and economical, it is necessary for the practitioner to plan and carry out the activity very well and use appropriate interventions at every stage.

It has been determined that incompatibilities among group members negatively affect group success in the activity. The most important reason that the students did not have the skills required for group work seems to be they had never participated in such activities before. In fact, students who participated in the study were from different classes, and then working together for the first time may also have caused the incompatibility in group work. For this reason, it is very important for the students to acquire these skills from early grades.

If the activity is implemented in a more crowded classroom, the classroom environment should be adapted to group work. It is necessary that students are informed about the process to be applied and the rules are clearly defined by the teacher in order to accomplish the purpose of the project. The practitioner should work in collaboration with the teachers from other disciplines in order to solve the problems that may arise.

Groups should be observed about following the engineering design cycle. They should not pass one stage of the design cycle before completing the previous stage. There might be a poster of the engineering design cycle in the classroom to guide the students.

In order to eliminate the difficulties related to the supply of materials, it is possible that the group members can be encouraged to go to the shopping together and choose the materials together. Another solution might be that students design their vehicles by selecting from the materials that are brought to the class by the teacher, although this might limit the creativity of the students.

Based on the findings of the study, it can be concluded that the participating students realized how scientists and engineers work and they had an idea about similar and different aspects of science and engineering. As a suggestion for future implementations, students might be required to write their opinions about the similarities and differences between science and engineering or they might fill a worksheet prepared by the teacher during the implication process.

REFERENCES

- Aslan-Tutak, F., Akaygun, S., & Tezsezen, S. (2017). İşbirlikli FeTeMM (fen, teknoloji, mühendislik, matematik) eğitimi uygulaması: Kimya ve matematik öğretmen adaylarının FeTeMM farkındalıklarının incelenmesi [Collaboratively learning to teach STEM: Change in participating pre-service teachers' awareness of STEM]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 32(4), 794-816. doi: 10.16986/HUJE.2017027115
- Capraro, R. M., Capraro, M. M., & Morgan, J. R. (Eds.). (2013). *STEM project-based learning: An integrated science, technology, engineering, and mathematics (STEM) approach*. Rotterdam, The Netherlands: Sense Publishers.
- Creswell, J. W. (2014). *Nitel, nicel araştırma deseni ve karma yöntem yaklaşımları [Research design: Qualitative, quantitative, and mixed methods approaches]* (S. B. Demir, Çev. Ed. [Trans. Ed.]). Ankara: Eğitim Kitap.
- Cunningham, C. M. (2009). Engineering is elementary. *The Bridge*, 30(3), 11-17.
- European Commission. (2004). *Europe needs more scientists!* Brussels, Belgium: Author.

- Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer*. Washington, DC: Congressional Research Service.
- Merriam, S. B. (2013). *Nitel araştırma: Desen ve uygulama için bir rehber [Qualitative research: A guide to design and implementation]* (S. Turan, Çev. Ed. [Trans. Ed.]). Ankara: Nobel Yayın Dağıtım.
- Ministry of National Education. (2013a). *İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Foundational education institutions (3, 4, 5, 6, 7, and 8th grades) science curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.
- Ministry of National Education. (2013b). *Ortaokul matematik dersi öğretim programı (5, 6, 7 ve 8. sınıflar) [Middle school (5, 6, 7, and 8th grades) mathematics curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.
- Ministry of National Education. (2016). *Ortaokul teknoloji ve tasarım dersi (7 ve 8. sınıflar) öğretim programı [Middle school (7 and 8th grades) technology and design curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.
- Ministry of National Education. (2017). *Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar) [Elementary and middle school (3, 4, 5, 6, 7, and 8th grades) science curriculum]*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.
- National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press. Retrieved from <https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts>
- Perez, D., Gibson, J., Opsal, S. C., & Lynch, R. M. (2011). *Organizing an edible car contest: A how to handbook*. Oglesby, Illinois: Illinois Valley Community College. Retrieved from <http://www2.ivcc.edu/mimic/nsf/Resources%20for%20Teachers/Manual-2011.pdf>
- Yıldırım, A., & Şimşek, H. (2016). *Sosyal bilimlerde nitel araştırma yöntemleri [Qualitative research methods in social sciences]* (Extended 10th Ed.). Ankara: Seçkin Yayıncılık.
- Wang, H. H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research*, 1(2), 1-13.

Citation Information

- Doğan, H., Savran Gencer, A., & Bilen, K. (2017). Science and engineering implementation: A case study on edible and renewable car activity. *Journal of Inquiry Based Activities*, 7(2), 62-85. Retrieved from <http://www.ated.info.tr/index.php/ated/issue/view/14>

Appendix 1

The Learning Outcomes of Edible and Renewable Car Contest Activity

Edible and Edible Car Contest activity can be applied for the following learning outcomes: Middle school science curriculum 5th grade *nutrients and their properties*, 6th grade *force and motion / physical events*, 7th grade *force and energy / physical events* units; mathematics curriculum 5th grade *data analysis*, 6th grade *geometry and measurement and data analysis*, 7th grade *polygons, and ratio and proportion* topics; technology and design curriculum 7th grade *design and solution* units (MoNE, 2013a, pp.14-32; MoNE, 2013b, pp. 10-27; MoNE, 2016, p.22).

Science Lesson5th Grade

5.1.1. Foods and Features

- 5.1.1.1. Recognizes that nutrient content is essential for vital activities of living things.
- 5.1.1.2. Search and present information on which foods have the most vitamins.
- 5.1.1.3. Make an inference that water and minerals are present in all foods.

6th Grade

6.2.2. Constant Velocity Motion

- 6.2.2.1. Describe velocity and unit.

7th Grade

7.2.3. Force, Work, and Energy Relation

- 7.2.3.1. Understand and specify the unit of work that is done in the physical sense which proportional to the force applied and the way is taken.
- 7.2.3.2. Relate energy with the concept of work and classify energy as kinetic and potential energy.
- 7.2.4. Energy Conversions
- 7.2.4.1. Explain with examples how kinetic and potential energy types are transformed into each other and realize energy conservation.
- 7.2.4.2. Explain the effect of friction force on kinetic energy with examples.

Mathematics Lesson5th Grade

5.3. Data Analysis

- 5.3.1. Generate research questions, collect data, arrange, and display
- 5.3.2. Data analysis and interpretation

6th Grade

6.3.1. Angles

- 6.3.1.2. Explore the properties of adjacent, exact, and opposite; solve related problems.
- 6.4.2. Data analysis
- 6.4.2.1. Compute and interpret the arithmetic mean of a data set.

7th Grade

7.3.2. Polygons

- 7.3.2.1. Explain edge and angle properties of regular polygons.
- 7.3.2.2. Identify the diagonals of the polygons, their internal and external angles; calculate the total measure of inner and outer angles.
- 7.1.4. Ratio and Proportion
- 7.1.4.1. When the ratio is given out of two multipliers find the other one
- 7.1.4.7. Solve problems related to the right and inverse proportion.

Technology Design Lesson7th Grade

- 7.9.4.3. Visualize the design solution as a model or drawing.
- 7.9.4.4. Select the appropriate tools, equipment, and materials to create a model or prototype.
- 7.9.4.5. Create the model or prototype of the design.
- 7.9.5.1. Evaluate the design according to the determined criteria.
- 7.9.5.2. Evaluate suitability of end product (model or prototype) with peers.
- 7.9.5.3. Suggest ways improve product according to evaluation results.

Appendix 2

Instructions for the Edible and Renewable Car Contest Activity

Purpose and Criteria

Engineers use mathematics, science, and creativity to investigate and solve problems that improve everyone's life and invent new products. There are many different engineering types such as chemistry, electricity, computer, mechanics, construction, environment, and biomedical. Engineers design and develop things such as bridges, cars, fabrics, food, virtual reality, and amusement parks.

It is desired to design an environmentally friendly vehicle that can destroy itself over time by producing the fuel from its own constituents and can be a solution to the energy problem that humanity may encounter in the future. For this competition, you are asked to make an edible and renewable car as a machine engineer. This car should be low cost, high energy, strong and fast at the same time it should be constructed from the food materials (cooked / uncooked vegetables, fruits, sugar, pasta etc.). In order to receive an award, you need to follow the criteria and get the highest score from the evaluation rubric given in the Appendix 11.

Criteria for Edible and Renewable Cars

1. Vehicles must be made entirely of edible foods.
2. Vehicles should look like cars (passenger cars, trucks, vans, minibuses, etc.).
3. Vehicles must have at least two axles and at least three wheels that are edible to humans.
4. In order to qualify for the competition, the vehicle must descend from a ramp approximately 120 cm long without tipping over.
5. The name you designate for your group and the logo you designed should be in line with the vehicle.
6. Your outline drawing should include the outline of the vehicle and the materials you will use.
7. The cost should be low.
8. The amount of energy the vehicle-making food must be high.

Before you start to work, you need to research with your team about how a vehicle moves when it is left from a platform. The information on mechanical energy, potential energy, kinetic energy and their transformation, friction force and effects will help you. In addition, having a preliminary knowledge of the types of foods and the amounts of energy these foods have in relation to the 5th grade foods topic will make your job easier in the competition. For this reason, first search the key concepts below and share the findings with your group.

Key Concepts

Energy conversation-Mecanical Energy-Potential Energy-Kinetic Energy- Energy Engineering-Friction Force-Speed-Nutrient-Carbohydrates-Fats-Proteins-Vitamins-Water and Minerals-Technology

Tools and Materials:

- | | |
|--|---|
| <ul style="list-style-type: none"> • Chronometer / Smart Phone • Protractor • Meter / ruler • Digital kitchen scale • Plastic blade • Types of food (in sufficient quantity) | <ul style="list-style-type: none"> • Platform (platforms where vehicles can compete) • Computer / laptop with Office Program (One for each group) • Any cell phone, tablet, notebook computer connected to the internet for research |
|--|---|

Evaluation of the Activity

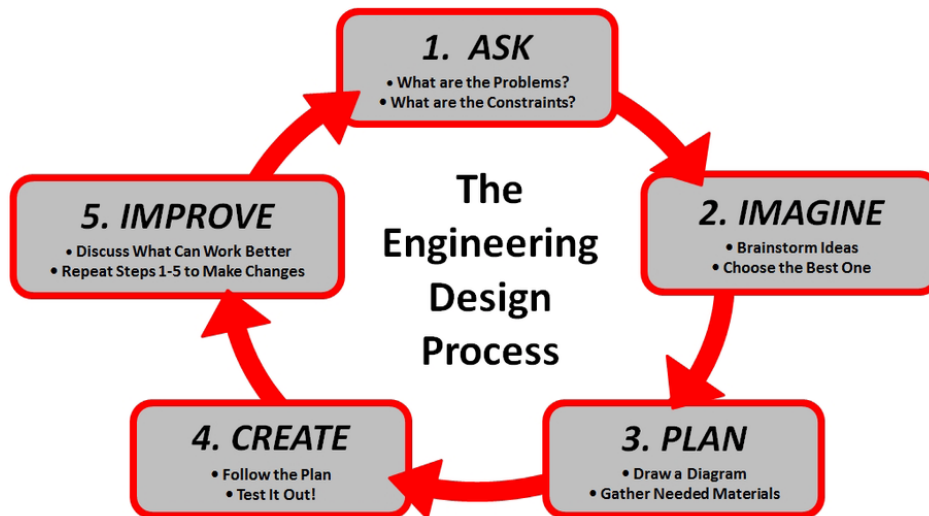
The following assessment tools will be used for evaluation. They will be distributed after work .

1. Rubric for your vehicles' design and performance (Appendix 11)
2. Rubric for peer review (Appendix 12)

Appendix 3

Edible and Renewable Car Contest Engineering Design Cycle

In the activity, we will apply the engineering design cycle to follow the engineering design processes mentioned below.



(Cunningham, 2009)

1. ASK

What kind of vehicle do you want to make for the "Edible and Renewable Car Contest"? What are the restrictions for this vehicle? How big should the car be? How can I do this tool robustly? What materials should I use?

2. IMAGINE

In this phase you will be doing a brainstorming as an engineer. When all ideas are shared, choose the best solution by setting out the positive and negative aspects of each.

3. PLAN

You have to transfer the best design ideas to the paper and then collect the necessary materials. What materials do you need to build your car?

4. CREATE

At this stage, you build your model according to the design drawing and then test whether it works or not. Record the data you obtain as a test result.

5. IMPROVE

Evaluate your solutions to see if you could solve the problem effectively. If the problem is not solved, look for other ways to improve your design and improve it.

Appendix 4

Distinguishing Practices in Science from Those in Engineering

1. Asking Questions and Defining Problems	
Science begins with a question about a phenomenon, such as “Why is the sky blue?” or “What causes cancer? Scientists seek to develop explanatory answers to such questions.	Engineering begins with a problem, need, or desire that suggests an engineering problem that needs to be solved. For example, how can we utilize solar energy to reduce the nation’s dependence on fossil? Engineers ask questions to define an engineering problem, determine criteria for a successful solution, and identify constraints.
2. Developing and Using Models	
Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models are made in order to test hypothetical explanations.	Engineering makes use of models and simulations to analyze existing systems so as to see where flaws might occur or to test possible solutions to a new problem.
3. Planning and Carrying Out Investigations	
A scientist is planning and carrying out a systematic investigation, which requires what are to be treated as the dependent and independent variables (control of variables).	Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs.
4. Analyzing and Interpreting Data	
Scientific investigations produce data that must be analyzed in order to derive meaning. Scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data.	Engineers analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria—that is, which design best solves the problem within the given constraints.
5. Using Mathematics and Computational Thinking	
In science, mathematics and computation are fundamental tools for representing physical variables and their relationships.	In engineering, mathematical and computational representations of established relationships and principles are an integral part of design.
6. Constructing Explanations and Designing Solutions	
The goal of science is the construction of theories that can provide explanatory accounts of features of the world. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence.	Engineering design, a systematic process for solving engineering problems, is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technological feasibility, cost, safety, esthetics, and compliance with legal requirements
7. Engaging in Argument from Evidence	
Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated.	In engineering, reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas.
8. Obtaining, Evaluating, and Communicating Information	
Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. Major practice of science is thus the communication of ideas.	Engineers cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models.

National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas (pp: 51-52-53). Washington, DC: The National Academies Press.

Appendix 5

Task Definitions / Job Chart (Example of Task Descriptions completed by Students)

KID
GRUP 3 = FLASH

İş Tanımları ve Tasarım Süreci

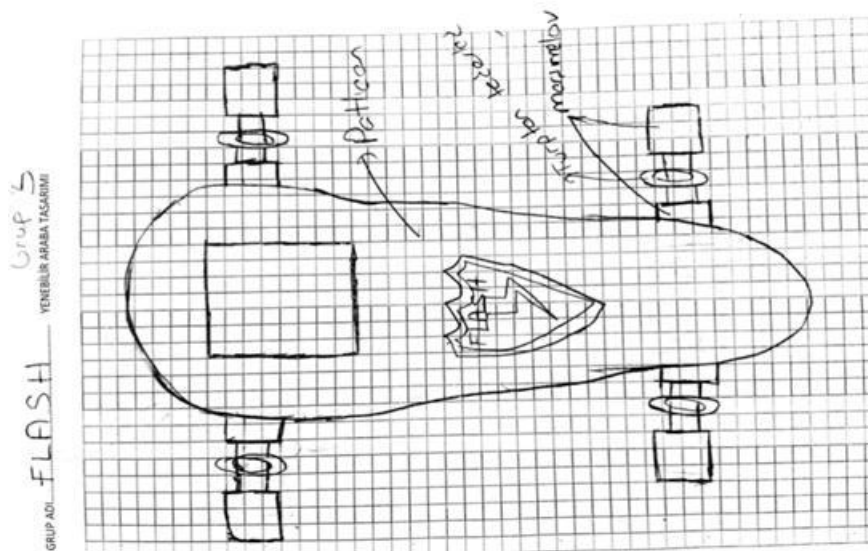
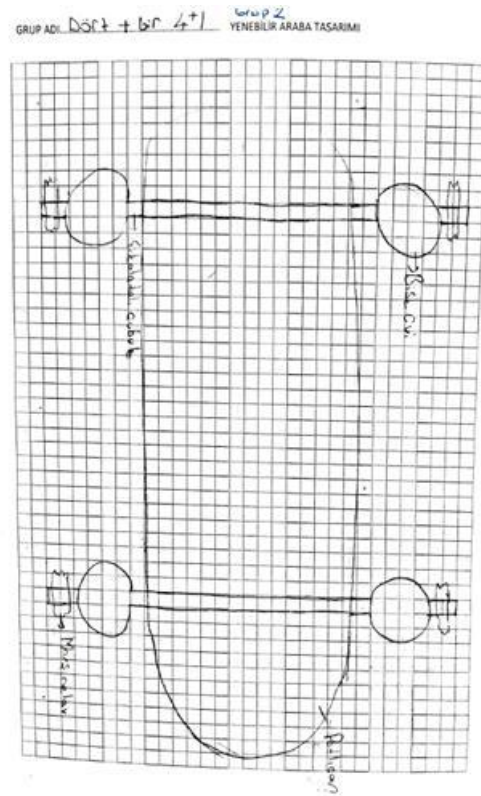
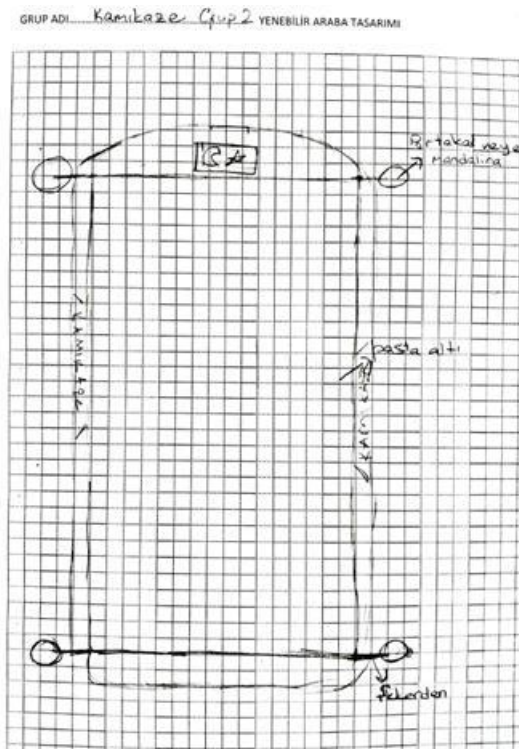
Arabınızı başarıyla kurmak için yapılması gereken görevleri tartışın. Takım üyelerini görevlendirin. Ekip üyelerinin birden fazla görevi olabilir. Aşağıdaki tabloyu tamamlayın

Görev	Ekip Üyesinin Adı	Görev Tanımı
Model Araştırması	[Redacted]	Yenebilir araba için bilgisayarda araştırma yapacak sonuçları arkadaşları ile konuşup tartışacak.
Araba yapımı	[Redacted]	Araba parçaları yerine geçen yiyecekleri araba form soktu.
Malzeme toplaması	[Redacted]	Gerçek olan malzemeleri düzenleyip getirdi
Araçlar kaynakları	[Redacted]	Araçlar kaynakları araştırarak bilgi aktarmında buldu

Teaching Channel (n.d.). *STEM design challenge: Edible cars*. Retrieved from <https://www.teachingchannel.org/videos/engineering-design-process-stem-lesson>

Appendix 6

Sample Design Templates Completed by Groups



Appendix 8

Sample Nutrition Facts Calculation Table Completed by Students

Grup Adı: Yenebilir Araba Yarışması - Kalori Hesap Cetveli

4+1

ARABA PARÇASININ ADI (aks- tekerlek- gövde- kapı vb.)	BESİN GRUBU Karbonhidrat- yağ-protein (Birden fazla besin grubunu içeriyorsa miktarı çok olan içerisine diğerlerini dahil ediniz)	MIKTARI (Gram)	BESİN DEĞERİ(kalori)/gram	SAHIP OLDUĞU ENERJİ MIKTARI
4 Tekerlekli in şifreli masi için (Marsmolu)	Karbonhidrat	16gr	318 kcal/100gr	$\frac{16 \times 318}{100} = 50,88 \text{ kcal}$
8Aks (Güçlü Kebab)	Karbonhidrat	6gr	145 kcal/100gr	$\frac{6 \times 145}{100} = 8,7 \text{ kcal}$
Gövde (Patlıcan)	Vitamin	10gr	25 kcal/100gr	$\frac{10 \times 25}{100} = 2,5 \text{ kcal}$
Tekerlek (Bisküvi)	Karbonhidrat	40gr	100 kcal/100gr	$\frac{40 \times 100}{100} = 40 \text{ kcal}$
TOPLAM				268,07

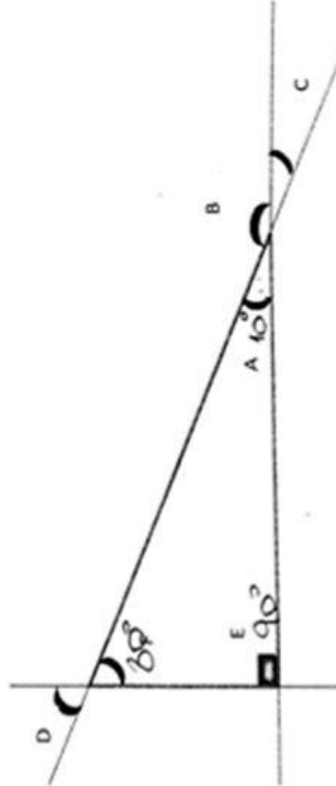
DEĞERLEMEN
NOTU.

Vitaminler için enerji hesaplanıyorduk!
İçerisinde bulunan karbonhidrat için yapılmıştı

Appendix 9

Calculation Table Completed by Students

Grup Adı: Grup.....2.....YENEİLİR ARABA YARIŞMASI MATEMATİKSEL HESAPLAMALAR	
ARAÇ PARÇASI	Hesaplayınız
ON TEKERLEK	<p>Ölçünüz</p> <p>On tekerlek çapı:.....5.....</p> <p>Arka tekerlek çapı:.....5.....</p> <p>On tekerlek yarıçapı:.....2,5.....</p> <p>Arka tekerlek yarıçapı:.....2,5.....</p>
ARKA TEKERLEK	<p>Hesaplayınız</p> <p>Tekerlek 1 tur dönerse araç kaç cm ilerler? (on arka tekerlek çapları eşit değil ise ön tekerleğe göre işlem yapınız.)</p> <p>Çemberin çevresini aşağıdaki eşitlikle hesaplayınız($\pi = 3$ alınız).</p> <p>$\zeta = 2\pi r$</p> <p>2.3.2,5 = 15</p>
PLATFORM	<p>Hesaplayınız</p> <p>Araç tekerlekleri platformdan aşağıya ininceye kadar kaç tur döner?</p> <p>8 tur döner</p> <p>120 : 15 = 8 tur</p>
<p>(ters açılar, 180 derece, dik açı, bütünler açı)</p> <p>1- A açısının bütünler açısı10°.....</p> <p>2- A ile C10°.....açılardır.</p> <p>3- E açısı90°.....açıdır.</p> <p>4- A+E+F açılarının toplamı180°..... derecedir.</p> <p>5- Komşu açılar :</p> <p>6- A ile F açısıbütünler.....açılardır.</p>	



Appendix 10

Edible and Renewable Car Contest Reflection Sheet

Student Name:

Answer the following questions. You can include sketches to explain. You may use the back of the paper or a separate paper.

1. What challenges did you encounter when building the prototype for your car?

2. How did you overcome these challenges?

3. How did you calculate the average speed of your car?

4. How would you change the design of your car to improve its performance?

5. What did you like about this work? What did you not like?

6. Describe how you worked as a group.

7. What would you change or improve in this study?

Teaching Channel (n.d.). *STEM design challenge: Edible cars*. Retrieved from <https://www.teachingchannel.org/videos/engineering-design-process-stem-lesson>

Appendix 11

Edible and Renewable Car Contest Rubric

Group Name _____
 Students _____

Category	1	2	3	4
Car Design	Does not meet design requirements	Meets some design requirements	Meets most design requirements	Meets all design requirements
Car Performance	Does not meet performance criteria	Meets some performance criteria	Meets most performance criteria	Meets all performance criteria
Connection: Team Name - Logo and Car	Weak or no connection	Basic connection	Strong connection	Very strong connection
Blueprint	Does not meet blueprint requirements	Meets some blueprint requirements	Meets most blueprint requirements	Meets all blueprint requirements
Job Chart and Procedure	Job chart may or may not be completed and/or procedure is missing	Job chart may or may not be completed and/or procedure is incomplete	Job chart is completed but procedure is basic and may be difficult to follow	Job chart is completed and procedure is detailed and easy to follow
Reflection sheet	Incomplete or does not include details and evidence	Complete and includes details and evidence for some questions	Complete and includes details and evidence for most questions	Very complete and includes details and evidence
Team work	Team had difficulty working together needed more than 4 reminders to stay on task	Team worked well together needed 3-4 reminders to stay on task	Team worked well together needed 1-2 reminders to stay on task	Team worked well together needed no reminders to stay on task
Car Cost	Higher than 10% of average cost of cars	Up to 10% higher than average cost of cars	Up to 10% less than average cost of cars	Less than 10% of average cost of cars
Car Energy	Less than 10% of average energy of cars	Up to 10% less than average cost of cars	Up to 10% higher than average cost of cars	Higher than 10% of average energy of cars

Total Score = _____/36

Teaching Channel (n.d.). *STEM design challenge: Edible cars*. Retrieved from <https://www.teachingchannel.org/videos/engineering-design-process-stem-lesson>

Appendix 12

Peer Assessment Rubric

The name of the evaluator: _____

The evaluated group member: _____

	4	3	2	1	Total
Participation	The student participated fully in group work	The student participated mostly in group work.	The student participated rarely in group work.	The student did not participate in group work	
Task Performance	The student fulfilled perfectly the task given within the group	The student fulfilled adequately the task given within the group	The student fulfilled a part of the task given within the group	The student did not fulfill the task given within the group	
Working towards team goals	Student worked continuously towards team goals	The student worked mostly towards team goals	The student worked rarely towards team goals	Student never worked towards team goals	
Cooperation	Group member always treated others respectfully and shared the workload fairly	Group member usually treated others respectfully and shared the workload fairly.	Group member sometimes treated others disrespectfully and did not share the workload fairly	Group member treated others disrespectfully and did not share the workload fairly	
Comments					

Intel Teach Program (2010). *Peer assessment collaboration rubric*. Retrieved from <https://www.intel.com/content/dam/www/program/education/us/en/documents/assessing-projects/assessment-plans/world-war-i/wwi-collaboration-peer-assessment-rubric.pdf>

Appendix 13

Semi-structured Interview Questions

Date and time (Start-End) Interviewer:

Hello

First, I would like to thank you for participating in the Edible and Renewable Car Contest activity. I would like to have an interview with you regarding this activity. I think that the results that will emerge from this research can help both students and teachers who will work in the future in a similar way. For this reason we want to learn your thoughts on this subject. I want to inform you about the interview.

- Part of what you say during the interview might be shared in research papers. Your name will be strictly confidential.
- Is there anything you would like to ask or want to mention before starting the interview?
- I would like to record the interview with your permission to avoid data loss if you do not mind.
- Interview will take about 30 minutes. I want to start with your permission.

Interview Questions

1- Can you tell us what you did in the activity of the Edible and Edible Car Contest?

- a) What was the most difficult thing about the activity?
- b) If you are asked to list things you like about the activity; how do you rank from the one you like the most?
- c) If you are asked to list things you do not like about the activity; how do you rank from the one you like the least?
- d) What are the different or similar aspects of the activity according to the activities in the science class you attend at school?

2- Imagine yourself as a teacher who organizes this activity. What would you do differently in the activity?

3- How did you use the engineering design cycle consisting of five steps in the activity when designing your vehicle?

- a) Why do you think that this design cycle repeats itself continuously?
- b) What would have happened if you designed your vehicle without using this cycle?

4- What can you say about similar and different aspects if we want to compare the works of scientists and engineers?