| Research Article / Araştırma Makalesi|

Determination of the Biomimicry Perceptions of Middle School 7th Grade Students through Drawings

Ortaokul 7. Sınıf Öğrencilerinin Biyomimikri Algılarının Çizimler Aracılığı ile Belirlenmesi[1]

Dilara VELİOĞLU[2], **Mehmet YAKIŞAN**[3]

Abstract

Purpose: The aim of the study is to identify the technological products that middle school 7th grade students intend to design inspired by the characteristics of animals through drawings.

Design/Methodology/Approach: Case study, one of the qualitative research methods, was used in this research. The study is conducted in a middle school in the city center of Samsun. The participants of the study consists of 30 students (18 girls, 12 boys) studying in the 7th grade of the related school. The worksheet "I choose it myself, I design it myself" was used as data collection tool. According to the worksheet, students were asked to draw the technological products they thought to design, inspired by the characteristics of the animals, as a picture. Content analysis was used in the analysis of the data of the study.

Findings: When the drawings of the technological products made by the students were examined, it was observed that they were mostly for the designs of military vehicles. It can be stated that the students were impressed by the war games they played on the internet and the war images they saw in the media. In addition, it was determined that students made design drawings of land vehicles and many technological products that they can use in daily life.

Highlights: In the study, it is thought that the students developed their different skills with the technological products they thought to design by detailing the characteristics of the animals they were inspired by and interpreting their own ideas with the theoretical knowledge they learned. It is important for students to be individuals who are interested in living things they encounter in daily life, can use science and technology, produce, question and grow up as science literate. Therefore, biomimicry applications can be increased in STEM education. Thus, students can be enabled to design real technological products inspired by living things.

Öz

Çalışmanın amacı: Ortaokul 7. sınıf öğrencilerinin hayvanların özelliklerinden esinlenerek tasarlamayı düşündükleri teknolojik ürünlerin çizimler aracılığı ile tespit edilmesidir.

Materyal ve Yöntem: Çalışmada, nitel araştırma yöntemlerinden durum çalışması kullanılmıştır. Araştırmaya Samsun il merkezinin bir ortaokulunun 7. sınıfında öğrenim görmekte olan 18'i kız 12'i erkek toplam 30 öğrenci katılmıştır. Veri toplama aracı olarak "Kendim seçiyor, kendim tasarlıyorum" çalışma kâğıdı kullanılmıştır. Çalışma kâğıdına göre öğrencilerden hayvanların özelliklerinden esinlenerek tasarlamayı düşündükleri teknolojik ürünleri resim olarak çizmeleri istenmiştir. Çalışmanın verilerinin analizinde içerik analizi kullanılmıştır.

Bulgular: Öğrencilerin yapmış oldukları teknolojik ürünlere yönelik çizimler incelendiğinde, en çok askeri araçlara ait tasarımlara yönelik çizimler olduğu gözlenmiştir. Öğrencilerin internette oynadıkları savaş oyunları ve medyada gördükleri savaş görüntülerinden etkilendikleri ifade edilebilir. Ayrıca öğrenciler kara araçları ve günlük hayatta kullanabilecekleri birçok teknolojik ürünlere ait tasarım çizimleri yaptıkları tespit edilmiştir.

Önemli Vurgular: Çalışmada öğrenciler, esinlendikleri hayvanların özelliklerini detaylandırarak ve kendi fikirlerini, öğrendiği teorik bilgilerle yorumlayarak tasarlamayı düşündükleri teknolojik ürünler ile farklı becerilerini geliştirdikleri düşünülmektedir. Öğrencilerin günlük hayatta karşılaştıkları canlılara karşı ilgisi olan, bilim ve teknolojiyi kullanabilen, üreten, sorgulayan ve fen okuryazarı olarak yetişen bireyler olmaları önemlidir. Bu yüzden FeTeMM eğitiminde biyomimikri uygulamaları artırılabilir ve böylece öğrencilerin canlılardan esinlenerek gerçek teknolojik ürünler tasarlamalarına imkân sağlanabilir.

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[2]**Corresponded Author,** Ondokuz Mayıs University, Institute of Graduate Studies, Department of Mathematics and Science Education, Samsun, TURKEY; dilara.velioglu61@gmail.com, https://orcid.org/0000-0001-9583-0100
[3]Ondokuz Mayıs University, Faculty of Education, Department of Mathematics and Science Education, Samsun, TURKEY; yakisan@omu.edu.tr, https://orcid.org/0000-0002-5359-2826

INTRODUCTION

Education is one of the permanent structures in the provision of social needs. Therefore, the education system should be able to develop in accordance with the current conditions required by the age. In particular, it should not give information to students as it is. In schools, first of all, students should gain new knowledge by producing it themselves. In this respect, it is important to acquire and maintain twenty-first century skills (Louis, 2012). The aim of the renewed curriculum is to educate people with twenty-first century skills such as creativity, innovation and entrepreneurship (Thomas, 2014).

Today, due to the development of twenty-first century technology, it is emphasized that science, technology and economy should be taught with a holistic perspective and interdisciplinary approach studies in the fields of education should be increased (NRC, 2011). Creativity, critical and computational thinking, mathematics and engineering abilities are twenty-first century skills that should be taught to students (Yılmaz, Gülgün, Çetinkaya ve Doğanay, 2018). One of the interdisciplinary approaches that is effective in acquiring twenty-first century skills and producing solutions to the problems encountered is STEM education. STEM stands for science, technology, engineering, and math. These four symbols represent the different areas of STEM education. (Bybee, 2010). It is important that the disciplines of science, technology, engineering and mathematics are integrated. Because STEM education enables students to do research, learn lifelong and become scientifically literate individuals (Çorlu, Capraro ve Capraro, 2014). Therefore, the purpose of STEM education is to enable students to become STEM literate and to provide students with problem-solving skills (Fan ve Ritz, 2014).

In the MEB (2018), Secondary Education Biology Curriculum, one of the goals that should be given to students is to enable students to use the knowledge and skills they learned in the lesson in daily life. In addition, it is to teach students about living organisms and to support them to become aware of technologies developed by being inspired by living things. Similarly, to ensure that students are enthusiastic about technologies. The discipline that represents the development of new technologies inspired by living things is biomimicry. The aim of this discipline is to produce solutions to needs by using nature's methods and imitating its processes. Biomimicry fully or partially imitates the color, texture and functions of living things in nature (Kuday, 2009).

Biomimicry was recognized towards the end of the twenty-first century and includes many disciplines such as anatomy, botany, zoology, physics and chemistry (Banger, 2016). Although biomimicry is often combined with architecture and other disciplines, it is particularly related to the disciplines of nature, biology, technology and engineering. For example, a building made by examining the structural features and circulatory system of an organism creates a product of innovative and sustainable design (Karabetça, 2016). When the designs inspired by nature are examined, many examples of biomimicry have been seen. These are: structures inspired by the branches and roots of the tree in architecture, and ceramic surfaces inspired by corals and bone tissues (Genç, 2013). Living organisms and their characteristic features have been beneficial for the creation of technological products that people need. At the same time, the discipline of biomimicry has started to be used in educational sciences and various researches have been started recently. Yakışan and Velioğlu (2019) and Yıldırım (2019) found in their research that biomimicry has a positive effect on students' twenty-first century skills.

Drawing is one of the best methods used to determine the ideas in the minds of children. The advantages of the drawing method are that its description is shorter in duration and more in terms of information content (Atasoy, 2004). Especially preschool, primary and secondary school students can express their ideas better with drawings and pictures than writing. Therefore, children's pictures are a good communication tool to understand them. In addition, pictures allow students to reflect their knowledge and skills well (Yavuzer, 2010). Ormancı and Balım (2014) used the drawing method to determine secondary school students' ideas about the subject of matter. In the study, students' understanding of the subject and their misconceptions were determined by drawings. Eyceyurt Türk and Tüzün (2017) investigated high school students' images about scientists and the functioning of science. In their studies, the researchers had the students make drawings and revealed the mental pictures of the students. Reflected in the form of pictures are mental images of abstract phenomena that individuals create in their thoughts (Ergen, Boyraz, Batmaz ve Çevik Kansu, 2020). Metaphors are used to reveal mental images of groups such as students, prospective teachers and teachers. Metaphors are pedagogical tools that educators use in concept teaching in recent years (Saban, 2008). Yılmaz and Yanarateş (2020) determined pre-service teachers' metaphorical perceptions about the concept of water pollution through triangulation. At the end of this study that was carried out for the determination of metaphoric perceptions, the perceptions of prospective teachers were analyzed from a fair number of different perspectives. Similarly, Alkış Küçükaydın and Uluçınar Sağır (2018) researched mental images on science learning. The aim of their study is to reveal the mental images and adopted methods and techniques of the preschool teacher candidates towards science teaching and learning. In the study, pre-school teacher candidates made drawings.

Purpose of the Study

The purpose of this research is to determine what kind of technological products 7th grade students can design, inspired by the characteristics of animals, in solving the problems they encounter in their daily lives. In addition, it was aimed to reveal the mental images of the students by asking them to draw the technological products that they thought to design inspired by the

characteristics of animals. Also, it is aimed to integrate the knowledge they have learned in science course with engineering and technology to gain the skills to use them to solve some of the problems they encounter in daily life.

METHOD/MATERIALS

This study is a case study to determine the technological product designs that the students participating in this practise will prepare inspired by the characteristics of animals. Qualitative research method was used in the study, and student drawings made in accordance with the case study were examined.

Research Group

The study was carried out in a public secondary school in Samsun Province in the fall semester of the 2019-2020 academic year. The study group consisted of 30 students, 18 of whom were girls and 12 boys, who were in the seventh grade of the same secondary school. Seventh grade students were preferred for the study because they are in the age range which they can use their imagination in the best way and reveal their creativity. The students who participated in the practise were selected by the appropriate sampling method.

Data Collection

The data of the study were obtained directly from the students who participated in the research. "I choose myself, I design myself" working paper is used for the data collection tool. In the research, firstly, a biomimicry video which contains the characteristics of living things and the technological products designed from these features was shown to the students. Afterwards, the "I choose and design myself" worksheet was distributed to the students. Apart from the creatures and biomimicry products in the video they watched, the students were asked to answer the question "What kind of technological products can be designed specific to the field of biomimicry inspired by the characteristics of animals?" and to select an animal and draw the technological products they intend to design from its features on the worksheet and briefly explain their drawings. In the study, which took one class hour, the students were given the opportunity to express their thoughts by drawing in their own way. No guidance was given to the students in the study and the study was followed monitored by one of the researchers in the classroom.

Data Analysis

In the research, the students explained the technological products that they thought to design inspired by the characteristics of animals, by drawing. Content analysis of the data obtained was made from the pictures drawn by the students and the explanations they wrote. The drawings of different students are categorized according to the similarities of the technological products they intend to design. The frequencies of the categorized technological product designs were determined and tabulated. Student drawing examples of technological product designs in each category are presented by interpreting. The data of the study show parallels with the participants and contexts. The quality of the data was checked by the researchers, and the data that were not related to the drawings that were asked from the students within the framework of the activity were removed and the analysis was carried out accordingly. Expert opinion was taken for the questions and activities in the worksheet included in the practise of the research. A consensus was agreed among the researchers on the place and process of the practise. This research is compatible with the characteristics of the case study design. During the analysis, categories which related to similar designs, were constituted by taking into account the drawings and explanations made by the students. The categories were classified in terms of the inspired animal and the designed product, and were assigned by constituting appropriate codes. The coding of students' drawings for technological products was done separately. Afterwards, the researchers made checks on the suitability of the coding and the categories constituted, and determined that they were largely similar. During these procedures, the codings on which both researchers did not agree were rearranged and largely agreed. In this way, consistency was achieved among the researchers in the analysis of the study's data.

FINDINGS

In the research, the drawings of the technological products that 7th grade students thought to design inspired by the characteristics of animals were analyzed as in Table 1 and interpreted together with their thoughts about their designs.

Table 1. Analysis of technological product drawings designed by students inspired by the characteristics of animals

Categories	Inspired Animals	Drawn Products	f	Σ f
1. Military Vehicles	Chameleon	Observer	2	
	Ant	Agent	1	
	Millipede	Military vehicle	1	
	Horse	Tank	1	8
	Dog	Military vehicle	1	
	Elephant	Tank	1	
	Turtle	Helmet	1	
2. Land Vehicles	Turtle	Mobile home	3	
	Worm	Underground vehicle	1	
		Mobile home	1	7
	Pitbull	Tractor	1	
	Mouse	Underground vehicle	1	
3. Tools Used in Daily Life	Firefly	Lamp	2	
	Giraffe	Camera	1	5
	Worm	Drill	1	
	Kangaroo	Cleaner robot	1	
4. Tools Specific to the Living Senses	Elephant	Sound device	2	
	Mole	Saw	1	4
	Parrot	Talking robot	1	
5. Underwater Vehicles	Fish	Submarine	1	
		Cleaner	1	3
	Octopus	Cleaner	1	
6. Air Vehicles	Butterfly	Drone	2	3
	Dragonfly	Plane	1	

Technological products designed by secondary school 7th grade students inspired by the characteristics of animals are classified in six categories and shown in Table 1. These are: "Military Vehicles", "Land Vehicles", "Tools Used in Daily Life", "Tools Specific to the Living Senses", "Underwater Vehicles" and "Air Vehicles". The most drawn technological product design was "Military Vehicles" drawn by 8 students. Then, 7 students designed "Land Vehicles" and 5 students designed Tools Used in Daily Life, respectively. In addition, it was determined that 4 students designed "Tools Specific to Their Living Senses", 3 students designed "Underwater Vehicles", and 3 students designed "Air Vehicles".

When Table 1 was examined, it was determined that the most inspired animal by the students was the turtle. In total, 4 students drew their helmet and house designs using the characteristics of the turtle. It has been determined that the second most inspired animal is the elephant and the worm. 3 students were inspired by the elephant and 3 student by the worm.

The drawings and thoughts of the students in the categories of "Military Vehicles", "Land Vehicles", "Tools Used in Daily Life", "Tools Specific to Living Senses", "Underwater Vehicles" and "Air Vehicles" are given below.

1. Findings of Student Drawings in the Military Vehicles Category

When the drawings of the students who were considering designing military vehicles were examined, it was determined that the students were inspired by the chameleon, millipede, ant, horse, dog, elephant and turtle. 1 student designed a military vehicle from a centipede and 1 student designed a military vehicle from a dog, and 1 student designed a tank from an elephant and 1 student designed a tank from a horse. In addition, 1 student drew ant agent technological product and 1 student drew turtle helmet technological product. Students mostly likened chameleon to military vehicles. In total, 2 students designed observers inspired by the chameleon. The drawing of one of the students who designed a chameleon observer is shown in Fig. 1.
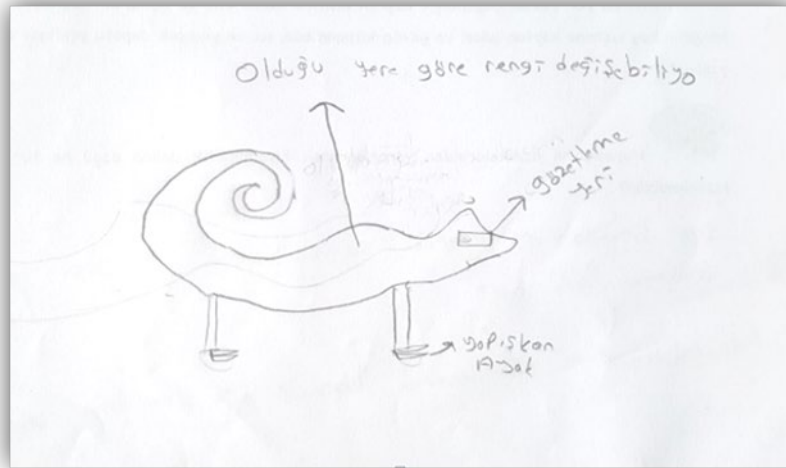
Figure 1. Student drawing of chameleon observer design

As shown in Figure 1, student "Ö.21" designed a watcher by making use of the chameleon's camouflage and its color changing feature. The student attached a camera to the chameleon's eye and added a peephole and sticky feet. The student explained his design as follows: "*When the chameleon observer encounters the terrorists, it will change its color and the weapon inside will not be visible and will shoot the terrorists*". In addition, the student stated that the camera he intended to place in the eye part was hidden and that this camera could be used for documentary shootings.

2. Findings of Student Drawings in the Land Vehicles Category

In the study, students who designed technological products related to land vehicles benefited from the features of turtle, worm, pitbull and mouse. The most inspired animal in this category is the turtle. 3 students designed a mobile home from a turtle.

The design made by one of the 3 students who drew a turtle mobile home from land vehicles is shown in Figure 2.
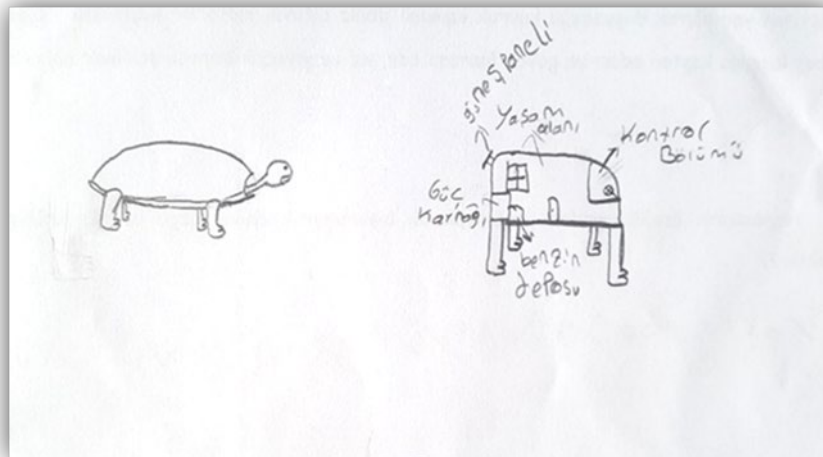

Figure 2. Student drawing of turtle mobile home design

Student "Ö.12" thought the outer hard shell of the turtle as the house of the turtle and designed a mobile home. The student explained her design as follows: "*I built a walking house inspired by a turtle. Because if we go to a far place, we can rest, or if we are too tired on the far road, we can pull over and sleep. Since the house is powered by solar panels, it stores energy during the day and can run on gasoline when the weather is bad.*"

In addition, 1 student designed a worm underground vehicle, 1 student a pitbull tractor, 1 student a mouse underground vehicle and 1 student a worm mobile home in this category.

3. Findings of Student Drawings in the Tools Used in Daily Life Category

Students who think about designing tools used in daily life were inspired by firefly, giraffe, worm and kangaroo. The most inspired animal in this category is the firefly and it was designed by 2 students. Students designed a lamp inspired by a firefly. In addition, 1 student designed a giraffe camera, 1 student a worm drill and 1student a kangaroo garbage collector cleaning robot.

The design of the student who made a kangaroo cleaner robot from technological products that can be used in daily life is shown in Figure 3.
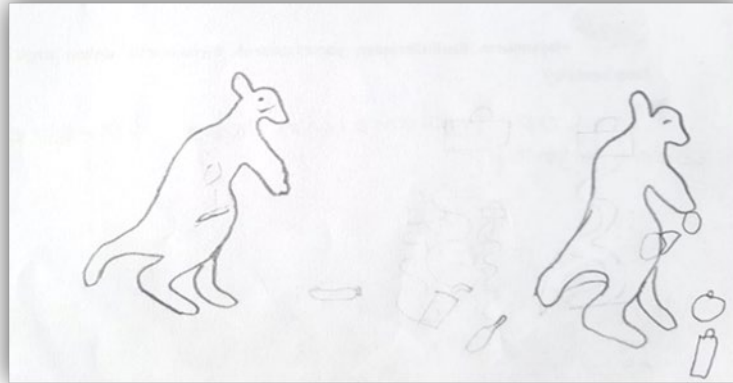

Figure 3. Student drawing of kangaroo cleaner robot design

Student "Ö.23" designed a cleaning robot that collects kangaroo garbage as shown in Figure 3. The student explained her design as follows: *"I was inspired by the kangaroo's ability to carry its baby in its pouch. I made this design to collect garbage, be clean and not have to worry about vacuuming the floor."*

4. Findings of Student Drawings in the Tools Specific to the Living Senses Category

The students who designed the technological products in this category were inspired by the senses of the elephant, mole and parrot. 2 students each designed a sound device inspired by the ears of elephants. Two students each designed a sound device inspired by the ears of elephants. The students thought that elephants hear better because of their large ears. Therefore, students drew their technological products in this way.

The drawing of the audio device designed by one of the students is shown in Figure 4 below.
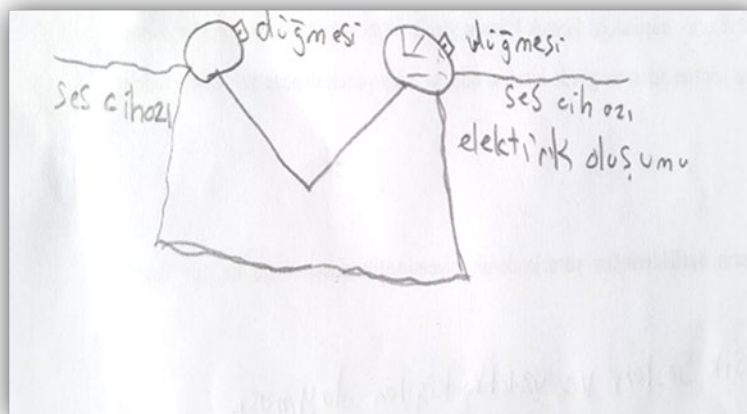

Figure 4. Student drawing of elephant sound device design

The student numbered "Ö.3" who drew the design shown in Figure 4 named the design *"I hear matic"*. The student explained his design as follows: *"I made the audio device to hear distant voices and low voices. This device also allows the elderly to hear very well. The elderly cannot see and hear very well. For example, if the elderly cannot see the car coming in traffic, they can hear the sound of the car and come back thanks to this device."*

In addition, 1 student designed a mole saw and 1 student a parrot talking robot.

5. Findings of Student Drawings in the Underwater Vehicles Category

When the drawings of the students who designed underwater vehicles were examined, it was determined that 2 students were inspired by fish and 1 student was inspired by octopus. The students who inspired by the characteristics of the fish, designed a submarine and a cleaner. The student also inspired by the octopus, drew the cleaning technology product. The drawing of the student who designed a cleaner inspired by fish is shown in Figure 5.
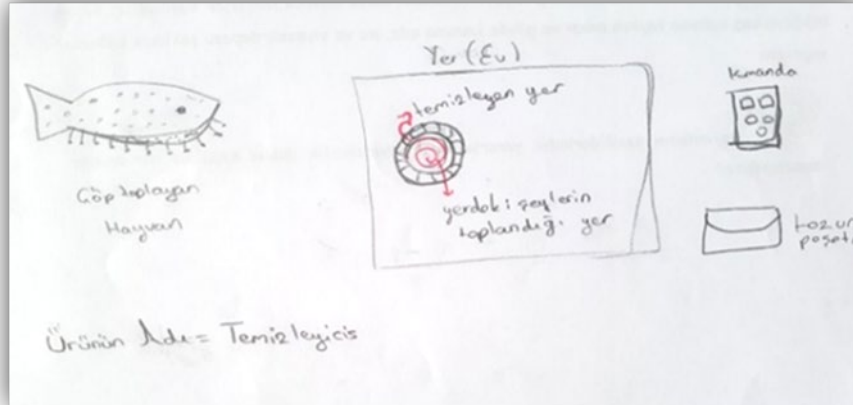

Figure 5. Student drawing of fish cleaner design

As seen in Figure 5, student "Ö.25" drew a fish cleaner design. The student explained her design as follows: *"The technological product I made is the animal robot that collects the garbage in the aquarium. It is a mechanical cleaner that vacuums. The fin is the part where the garbage is collected. Garbage is collected in a bag and this bag is changed when it is full. This mechanical tool works with a remote control. It increases our free time."*

6. Findings of Student Drawings in the Air Vehicles Category

Students designing air vehicles were inspired by various flying animals. The student who inspired by a dragonfly drew an airplane. 2 students who inspired by the butterfly made drone designs. The drawing made by one of the students who designed a butterfly drone is shown in Figure 6.
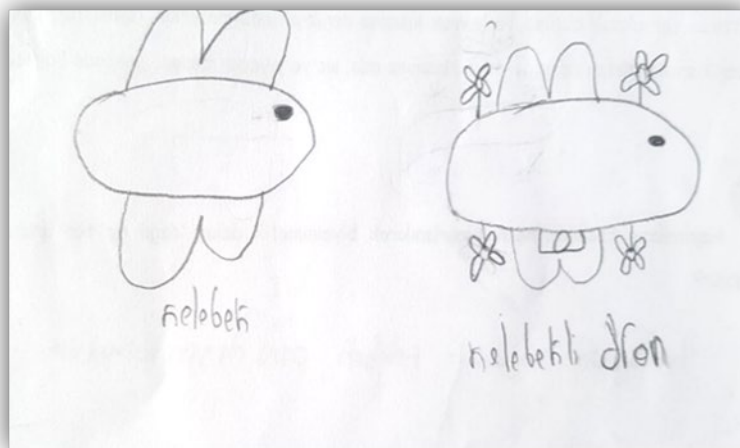

Figure 6. Student drawing of butterfly drone design

The student "Ö.1" explained his design of a butterfly drone as follows: *"My design is a product that helps the police to catch criminals. There is a hidden camera. Terrorists in the mountains will think he's a butterfly. Thanks to the camera, terrorists and criminals in the mountains can be found."*

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

It has been categorized in six groups as "Military Vehicles", "Land Vehicles", "Tools Used in Daily Life", "Underwater Vehicles", "Tools Specific to Living Senses" and "Air Vehicles". Eight designs were made in the military vehicles category, and it was the category with the highest number of designs. This category is followed by the categories of land vehicles design by 7 students and tools used in daily life by 5 students. Also, it was determined that 4 students designed "Tools Specific to Their Living Senses", 3 students designed "Underwater Vehicles", and 3 students designed "Air Vehicles".

It was determined that the students made drawings of the designs of observers, agent, tank, helmet and various military vehicles in the military vehicles category. In particular, it is understood that the students made drawings about war and defense technology designs in parallel with the war images they see in games such as war games and TV news and movies. Because, in the researches on the effects of games played on the internet, it has been determined that children are more interested in violent games (İşçibaşı, 2011). When the literature is examined, similar to our research, Yakışan and Velioğlu (2019) in their study on primary school 4th grade students, concluded that the students were influenced by the war games they played on the internet and the images of war they saw in the media, and they made designs for technological products to protect and defend themselves and people against war.

Following military vehicles, the highest categories are land vehicles and tools used in daily life. Students drew houses, underground vehicles and tractors from land vehicles, and they drew designs of lamps, cameras, drills and cleaners from tools used in daily life. However, in the research, the students drew sound devices, saws, robots from the tools specific to their living senses; submarine and cleaner from underwater vehicles; drones and airplanes from air vehicles. Looking at the drawings of the technological products they have designed, it is thought that the students are influenced by their social environment and draw the designs of the technological products they need. Herdem, Aygün, and Çinici (2014) used the method of drawing cartoons to determine the perceptions of 8th grade students about technology in their studies. It was determined that the students gave examples from their immediate surroundings in the cartoons they drew. The immediate surroundings in which students live in daily life affects their mental images. This study is similar to our study.

Biomimicry discipline is open for improvement and practicable. Biomimicry is a discipline that enables to do more work with less energy and helps to protect nature (Kallioğlu, Karakaya and Durmuş, 2013). It is thought that when the discipline of biomimicry, which is both an innovative and useful field, is applied with STEM education, it can contribute to revealing different ideas by developing creativity, critical thinking and entrepreneurship skills while students design technological products, as in our study. Because, Yıldırım (2019) examined the views of pre-service science teachers about biomimicry practices in STEM education. According to the study, biomimicry practices in STEM education contributed to the development of individuals' creativity, cognitive and psycho-motor skills.

The study suggests that the students detailed the characteristics of the animals they were inspired by. Thus, with the theoretical knowledge they learned, they developed twenty-first century skills such as entrepreneurship, creativity and innovation, etc. with technological products designed by interpreting their own ideas. However, it can be stated that the study contributes to the students' being science literate by producing original ideas and benefiting science and technology. Gencer (2015) research is similar to our research in that science and engineering practice in science education contributes to the development of science literate individuals and the development of twenty-first century skills. When the literature was examined, it was seen that Yavuz (2019) in his study on 4th grade students, the science course applied with STEM education provided students with twenty-first century skills such as critical thinking, creativity and communication. Similarly, Çalışıcı (2018) researched the effect of STEM education on students' scientific creativity in his study. According to the this research, it has been determined that STEM practises had a positive effect on students' scientific creativity by improving their memory, and increased their awareness of technology. These studies on STEM education support our study.

STEM education has recently focused on the necessity of raising science literate individuals. (NST, 2013). Therefore, STEM education is an interdisciplinary approach that combines science-technology-engineering-mathematics and aims to raise individuals who are open to communication and produce (Buyruk & Korkmaz, 2016). In addition, the lessons taught with STEM education practises help students to look from a multi-faceted perspective. Stem should be preferred in schools as it will facilitate the daily life of students. Individuals who are science and technology literate can be more effective when using information, paying attention to the benefits and harms of science and technology, and making decisions and producing something new.

It is important for students to be individuals who are interested in living things which they encounter in daily life, who can use science and technology, who produce, question and grow up as science literate. In this respect, it is necessary to increase biomimicry studies in order to provide students with these competent features. In order to achieve even more effective results, biomimicry studies in STEM education can be applied to individuals of all age groups and can be a guide for all future studies. Because individuals who grow up in this way will be able to offer solutions and increase quality of life to produce the technology that humanity needs and to use it in solving problems related to the future. Therefore, students should be encouraged, supported and guided to produce different technological tools inspired by living things in order to solve real life problems.

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was produced from Dilara VELİOĞLU's master thesis. Assoc. Prof. Mehmet YAKIŞAN served as the consultant of Dilara VELİOĞLU in this process and guided the whole work.

Ethics Committee Approval Information

Ethics Committee Approval Certificate was obtained for this study by Ondokuz Mayıs University Social and Human Sciences Ethics Committee with the registration date of 18.04.2019 and the decision number 2019-132.

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