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AN ENRICHMENT IMPLEMENTATION IN THE EDUCATION OF GIFTED STUDENTS: BIOMIMICRY WITH THE MACRO, MICRO, AND SUB-MICRO NATURE OF FRESHWATER CREATURES

(Research article)

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Abstract

Biomimicric implementations provide positive contributions to the development of many abilities such as problem solving, creative thinking and productivity by enabling students to look at nature from a different perspective. For this reason, in this study, it was investigated how the biomimicric applications of the macro, micro, and sub-micro nature of freshwater creatures were reflected in their arguments with special gifted students. The research was planned as a summer workshop in an institution that teaches with special gifted students in Ankara in the 2017-2018 academic year, and was carried out on the basis of case study from qualitative research patterns with eight gifted students. In a two-stage study, gifted students conducted microscopic and literature research on freshwater creatures in the first stage and made drawings about the macro, micro, and sub-micro nature of living things. In the second phase, they discussed their biomimicric prototypes in groups and explained them with their arguments. In the study based on document analysis, the data were obtained from students' worksheets and analyzed by content analysis. As a result of the research, it can be said that the concept images of gifted students develop with macro, micro, and sub-micro drawings and the quality of the arguments they construct has become more qualified during the process, and the application contributes to their creative and analytical thinking.

Keywords: Gifted students, science education, biomimicry, creativity, blending

Introduction

Countries that are in competition in science and technology have given more importance to the education of gifted students in their education policies in recent years. For nearly a hundred years, researchers have been trying to understand, define and measure the concept of special ability. (Subotnik et al., 2011). The concept of special talent is a sociological as well as a psychological concept. For this reason, the definition of special talent varies between individuals, between disciplines and societies. (Sak, 2017). Special gifted students are defined as "students who have extraordinary potential ability in at least one of the fields of general mental, special academic, creative-productive, leadership, art or psychomotor or who have achieved extraordinary success in at least one of these fields" (Sak, 2017). Again, gifted students can make a difference in creativity with their superior memory abilities and strong imagination, can use their knowledge effectively for different situations and be highly motivated for challenging tasks (Cavilla, 2019). In this respect, the education of these students, who can have a positive effect on the development levels of societies due to their characteristics, should be outside the standards. Therefore, two important features come to the fore in the education of gifted students. One of these is the acceleration of the higher level comprehension of gifted students, the other is the enrichment to provide mental development for these students who are outside the normal distribution (Renzulli, 2012).

Acceleration is based on taking into account the rapid development of gifted students and passing their classes earlier than their peers. Since only mental development is taken into account in this practice, the most commonly thought negative effect is that the student may experience physical, social and emotional problems. The student cannot meet the communication needs with their peers. Besides these negativities, the best part of speeding up is that it does not allow the child to get bored (Darga, 2018). Enrichment, on the other hand, is a strategy used to diversify educational opportunities and curriculum and to extend education beyond the content of the general education program (Schiever & Maker'dan akt., Sak, 2017). Enrichment types can be carried out with the transfer of course contents from upper classes, using the remaining time for different disciplines by narrowing the curriculum, long-term hands-on independent studies, field trips or after school programs (Sak, 2017). Thus, enrichment will help meet the needs of specially gifted students (Brevik vd., 2018). However, in the literature, it is seen that there are some myths about the education of gifted students. For example, it is emphasized that these students are already talented, there is no need for extra education for them, and they can improve themselves in any environment (Ataman, 2018). On the other hand, the continuity of special talent is the other myths in the education of gifted students in the literature where intelligence can be measured directly, special talent can be detected with a single scale, creativity cannot be measured, and gifted students do not have social and emotional needs. It is important common myths in the instructional context that differentiation from the myths in the literature can replace special talent programs, that there is only one curriculum for gifted students, and that the teacher can overcome the education of gifted students alone in normal classrooms (Borland, 2009; Hertberg-Davis, 2009; Kaplan, 2009; Reis & Renzulli, 2009; Sisk, 2009; Sunde-Peterson, 2009; Treffinger, 2009; Worrell, 2009). Contrary to these myths, gifted students need education in teaching environments enriched with their analogous peers who show high performance in subjects they do not see in their regular schools (Rogers, 2007).

When the enrichment / differentiation studies conducted in the literature in the education of gifted students were examined, Kim (2016) evaluated the effectiveness of enrichment programs developed for gifted students between 1985 and 2014. In the meta-analysis of 26 studies, it was determined that mostly enrichment environments have a positive effect on the academic achievement and socio-sensory development of gifted students. Again, Altıntaş and Özdemir

(2015) found that the academic achievement of gifted students who received differentiation-based education was higher than the students in the control group. In another study, it was determined that enrichment activities positively contributed to the scientific literacy levels of gifted students (Komek et al., 2015). In another study, it was shown that the STEAM-based enrichment program significantly improved the creative thinking abilities and emotional intelligence of gifted students at the primary level (Oh et al., 2016). Tüzün and Tüysüz (2019a) found that the black-box experiments they use as an enrichment medium in the education of gifted students contribute positively to the development of their critical thinking abilities. It is understood from the studies conducted in the literature that the enrichment environments integrated into the education of gifted students contribute positively to their cognitive and affective development. Gifted students can find the environment in which they can show their high-level qualities and develop these qualities in science lessons (Taber, 2007) because enrichment environments that develop their abilities, interests and motivations to do science in the real world and provide a full understanding of scientific concepts can be offered to them. . However, enrichment environments prepared in science are very important for gifted students to acquire scientifically correct images, conceptual pictures, and scientifically correct submicroscopic perception. Because, learning becomes difficult when submicroscopic perception is not developed (Nakhleh, 1992). In addition, although it is difficult to define, determine and evaluate creativity, developing creativity, which is shown as one of the most important abilities of the 21st century in the education of gifted students, should not be ignored (Robinson et al., 2014). In this way, it can be thought that the granular nature of the concepts of science can be processed with the superior creativity abilities of gifted students, and they can contribute to both their reinterpretation of these concepts and the development of their own creativity features. Related to this, a gifted student designing a meteor detection device using his own creativity from the organism structure examined under the microscope of Daphnia creature can be cited (Tüzün & Tüysüz, 2019b). Studies in the literature emphasized that enrichment environments in science education are important in supporting the cognitive and affective development of gifted students (Stake & Mares, 2001). For example, in their study, Erdem-Gürlen and Özdemir (2019) determined that when sixth grade students with special talent process the electricity transmission unit with an enriched education program, they contribute positively to the students' scientific process abilities development and their success increases. Again, the participants stated that they enjoyed the enrichment program more because of the activities they had not encountered before. In another study, it was determined that the enrichment education, which was realized by integrating the STEM approach of gifted students into the 5E model, positively contributed to the scientific creativity, scientific process abilities and engineering abilities of the students (Ayverdi, 2018). However, in the literature, it is stated that the number of enrichment studies for science education of gifted students is insufficient (Dönmez & İdin, 2017) In this respect, the ability of gifted students, who will assume the most important role in the scientific and economic development of countries, to learn science concepts at high level, it is more It requires further enrichment studies.

In this research, enriched applications that are created by blending the macro, micro, and sub-micro nature of freshwater creatures for students with special abilities; their effect on creating concept images and developing their creativity based on biomimicric of freshwater creatures has been investigated. In this context, "How can the concept images and creativity of gifted students be developed in an enriched science teaching environment?" and "How to monitor the creativity development of gifted students in biomimicric-based enriched science teaching environment?" research questions were sought. It is thought that the detailed description of the research process will contribute to guiding researchers and teachers working in the field of education of gifted students to construct their teaching environments in a similar way.

Method

Research Design

In this study, one of the qualitative research methods, case study design was used. Case study is defined as “the method in which one or more events, settings, programs, social groups or other interconnected systems are examined in depth” (Büyüköztürk et al., 2010, p. 20). While examining the situation under study in depth, it is very important to study the context of the situation and to examine its relationship with connected systems (Stake, 1995). In this study, the process of enhancing the concept images and creativity in enriching the teaching environments of gifted students was determined as a situation to work in depth.

Participants

The study was planned as a summer workshop in the 2017-2018 school year, and was carried out with a total number of eight volunteer students at the age of 10 (six girls and two boys) in an institution offering education for gifted students in Ankara, Turkey. The participants were selected via purposive sampling method.

Data Collection and Analysis

Worksheets were used as data collection tools in the data collection process. The worksheets used in the first stage are worksheets that enable gifted students to draw by blending macro, micro, and sub-micro nature of freshwater creatures. An example of the worksheets used in the first stage is presented in Figure 1.

Please, draw blending macro, micro, and sub-micro nature of a shrimp.

Please, explain your drawing below.

……

……

Figure 1. A sample activity sheet in the first stage

The worksheets used in the second stage are worksheets that enable students to draw biomimicric drawings inspired by the organisms of freshwater creatures and then construct their arguments about their biomimicric designs. An example of the worksheets used in the second stage is presented in Figure 2. In addition, gifted students noted their views on the activities in one sentence on their worksheets.

Please, make biomimicric drawings of your inspiration by the nature of shrimps.

Please, construct your arguments below:

1. Assumption :
2. Data :
3. Rationale :
4. Support :
5. Disproof :

Figure 2. A sample activity sheet in the second stage

The content validity of the data collection tools was checked by four experts in field education, and the reliability was ensured by the harmony between the data analysis.

The data collected in the study were analyzed by content analysis. Content analysis can be defined as a set of methodological tools and techniques applied to a wide variety of discourses. These tools and techniques gathered under the name of content analysis can be described above all as a controlled interpretation effort and generally as a deductive "reading" tool. This reading is based on the analysis of discourse examples with defined boundaries (Bilgin, 2006).

- The drawings made by the students by blending macro, micro, and sub-micro nature were coded under the specified categories and frequency-percentage calculation was made.
- In arguments structured by students, Toulmin (2003) argument model components (claim, data, reason, support, rebuttal) were taken as codes, combinations of these codes with those in the student worksheets were calculated on the basis of the structures argumentation levels and the quality of the arguments was determined ak (Erduran et al., 2004).
- In the literature, the claim code Level 1, data, justification or support codes in addition to the claim code, Level 2, Level 2 codes as well as weak rebuttal code Level 3, Level 2 code as well as Level 4, Level 2 codes The rebuttal codes are structured as Level 5 (Erduran et al., 2004).

Implementation process activities and information about the process are given in Table 1.

Table 1. Implementation content

Session	Content
1	Introducing students to basic concepts: Explanation of the macro, micro and sub-micro nature of matter with examples. Explaining the holistic images that will be revealed by blending the macro-micro-submicro nature of freshwater creatures (Atasoy, 2004). Explanation of argumentation worksheet applications (Toulmin, 2003) and the activity process.
2	Introducing the use of pocket microscope. Explanation of biomimicric applications with examples: Speed train inspired by the beak of the bird Self-cooling buildings inspired by termite nests Helicopter inspired by dragonfly Sunshades made from orchid Jellyfish water purifiers
3	Shrimps activity
4	Snail activity
5	Fish activity
6	Leech activity
7	Frog larva activity
8	Freshwater pinworm activity
9	Algae activity

The procedure of the activities was as follows:

<u>Stage one:</u>

- to observe the creature in its natural habitat
- examination of the creature preserved in ethyl alcohol by pocket microscope
- literature on the sub-micro nature of living things

making macro, micro, and sub-micro drawings of the living creature on the work sheet

<u>Stage two:</u>

a. ***Student group discussions***

In these discussions, students followed their own and their friends' thinking by presenting their arguments about the functions of biomimicric designs inspired by the organism of the creature in their minds, and supported or made counter-arguments to each other's arguments.

b. ***Drawing the biomimicric designs on the worksheet***

Students also individually structured the function of biomimicric designs on the worksheet as an argument on the basis of Toulmin's (2003) argument model components.

Findings

Gifted Students' Abilities of Blending Macro, Micro, and Sub-Micro Nature

The drawings of gifted students about blending the macro, micro, and sub-micro nature of each freshwater creature were coded and then categorized and frequency-percentage calculation was made. Accordingly, the drawings that contain all the codes of depicting any molecule in a living thing, depicting the microscopic image of the living thing, and depicting the living thing are included in the full scientific drawing category. Drawings that contain the code of depicting the living thing, but also either contain the code for depicting the microscopic image of the living thing or that contain the code for depicting any molecule in a living thing, are partially classified as scientific drawing. In addition, the code of depicting the living thing and the code of depicting the microscopic image of the living thing, as well as the code for the incorrect depiction of any molecule in a living thing, are partially included in the scientific drawing category. In case the drawing only contains the code of depicting the living thing, the category of insufficient drawing is applied.

In addition, at the end of the literature, gifted students used the B vitamin molecule for shrimp, ziconotide or genuanine molecule for water snail, vitamin A or ammonia molecule for fish, human blood hemoglobin for leech, melanin or methane molecule for frog larva, fresh water hair. They decided to paint the protein for the worm and the cellulose molecule for the algae. Since some molecules are very complex and although participants have passed abstract thinking earlier than their peers with special talent, the participants' portrayal of one or two specific functional groups in the molecule was considered a sufficient code for the full scientific drawing category. The categories, frequency (f) and percentages (%) obtained are given in Table 2.

Tablo 2. Gifted Students' Abilities of Blending Macro, Micro, and Sub-Micro Nature

Freshwater creatures	**Full Scientific drawing**		**Partial Scientific drawing**	**Yetersiz çizim**
	%	**%**	**%**	
Shrimps	37.5	62.5	-	
Snail	50.0	50.0	-	
Fish	87.5	12.5	-	
Leech	50.0	50.0	-	
Frog larva	50.0	37.5	12.5	
Freshwater pinworm	62.5	25.0	12.5	
Algae	50.0	50.0	-	

When Table 2 is examined, the percentage of gifted students who make full scientific drawings, that is, blend the macro, micro, and sub-micro nature of living things, did not fall below 50% in other activities, except for the first activity. Therefore, it can be said that students are sufficient in forming a concept image. The first activity can be considered as the process of getting used to. In addition, in the mini semi-structured interviews held with the students before the application, it was observed that the students did not have microscopic visual experience of living things and they did not know the molecules in living things. From here, it can be said that students' concept images developed in the process.

Sample drawings from student worksheets are presented in Figures 3, 4 and 5 in order to strengthen the findings given in Table 2.

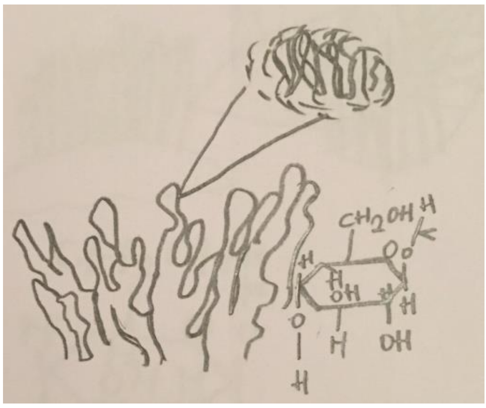


Figure 3. Full scientific drawing of algae by gifted student, S1.

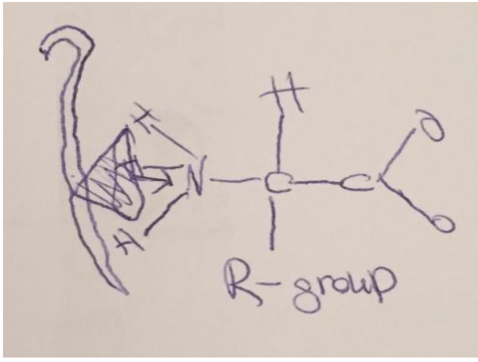


Figure 4. Partly scientific drawing of a gifted student with the code of S7 on fresh water pinworm (In the molecule, the amine functional group is correctly portrayed, but the carboxyl functional group is wrong.

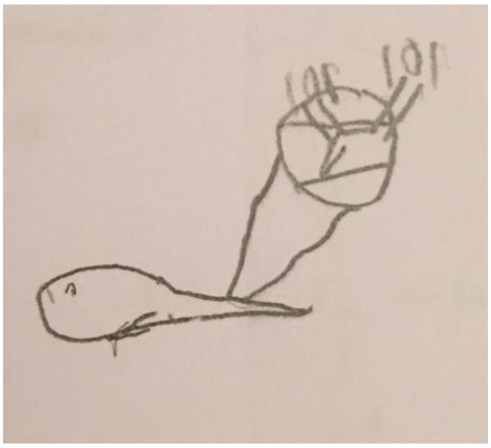


Figure 5. The insufficient drawing of the gifted S5 student about frog larvae (The molecule is not pictured.)

Arguments Structured by Gifted Students on Biomimicric Designs

First of all, a description was made of the biomimicric designs that the gifted students constructed for freshwater creatures. Findings are presented in Table 3.

Tablo 3. Biomimicric Designs of Gifted Children

Student	Shrimps	Snail	Fish	Leech	Frog larva	Freshwater pinworm	Algae
S1	Garbage collector boat	Vacuumed bac	Fish collector ship	Surgery robot	Cleaning robot	Nano-robot	Water chlorinating robot
S2	Space ship	Caravan	Magnetic scanner	Smell vacuuming	Laughter device	Water collector	Fish nest
S3	Shopping basket	Surgery tool	Airplane	Vacuum cleaner	Earthquake safety robe	Hook	Sea garbage collector
S4	Lost property finder	TV antenna	Poisonous gas collector rabot	Vacuum cleaner	Medicine dosage adjuster	Bacteria collector robot	Home robot
S5	Sheltered vehicle	Mobile pharmacy	Sheltered sea vehicle	Medicine robot	Sea garbage collector	Surgery robot	Sea garbage collector
S6	Dust cleaner	Fly collector	Exploring submarine	Surgery recording device	Surgery tool	Nano-robot	Hazardous water plants collector
S7	Garbage collector submarine	Dust collector robot	-	Surgery robot	Cleaning robot	Nano-robot	Feet defender water robot
S8	Car	Mini car	Under-water camera	Blood purifier	Under-water camera	Horse	See-weed man

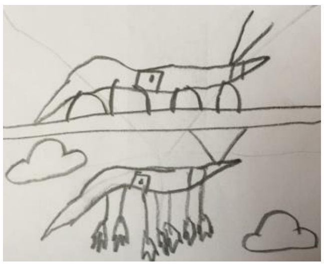
Table 4 presents the findings obtained by analyzing the arguments that gifted students have structured on biomimicric designs through content analysis.

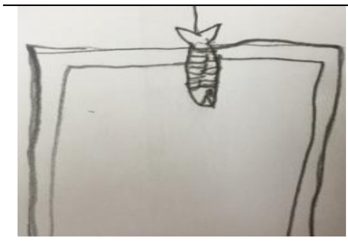
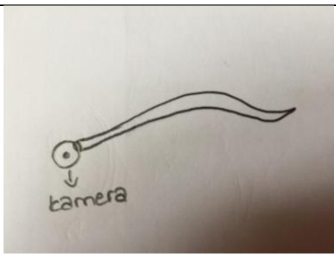
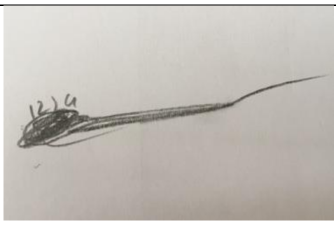
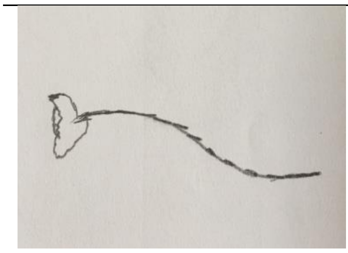
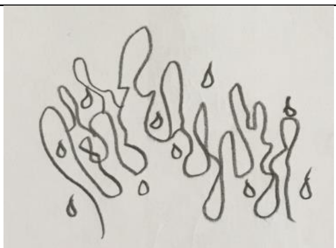
Table 4. Analysis of the arguments that gifted students have structured about their biomimicric designs

Freshwater creatures	**%**					
		Level 2			**Level 4**	
	-	**AD**	**AR**	**ADR**	**ADU**	**ADRU**
Shrimps		12.5		12.5		75.0
Snail				25.0	37.5	37.5
Fish	12.5			37.5		50.0
Leech				62.5		37.5
Frog larva	12.5	25.0		25.0		37.5
Freshwater pinworm	12.5		12.5	50.0		25.0
Algae		12.5		25.0		50.0

In Table 4, Toulmin argument model components are used as assumption (A), data (D), rationale (R), support (S) and unproof (U) codes, combinations are made with existing codes in student arguments, the categories are leveled and the frequency (f)-Percentage (%) calculations have been made. For example, an argument in the IVD category in Table 4 contains the claim, data and justification codes from the Toulmin argument model components. Likewise, an argument in the category of İVGÇ includes claim, data, justification and rebuttal codes from the Toulmin argument model components. In Table 4, the quality of IV, IG and IVD arguments is defined as Level 2, and the quality of IVF and IVAF arguments as Level 4. There is no Level 1 category in Table 4, as there is no category consisting only of claims. In addition, there is no Level 5 category, as students do not have the status of submitting weak rebuttal to their claims, data, justifications, supports, and Level 3 category, claim, data, reason, and support. In Table 4, 75.0% for the first activity, 75.0% for the second, 50.0% for the third, 37.5% for the fourth, 37.5% for the fifth, 25.0% for the sixth, and the last 50.0% of them structured level 4 quality arguments. From here, it can be said that gifted students can make a robotic design (claim) using the organism (data) of each living thing, construct a function, function (justification) of a limb of an organism in their robotic designs (justification), and question situations where robotic design may be inadequate (refutation). However, the students were insufficient in providing support for their justifications, that is, constructing different functions and functions to different limbs of the creature in their robotic designs. It is here that the students' claims are contributed to the development of their creativity by providing data justification and refutation; it can be said that the quality of students' arguments is Level 4. Sample drawings and arguments from student worksheets are presented in Table 5 to support these findings.

Table 5. Sample biomimicric designs and arguments of gifted students

	The argument of the gifted student coded S2: My biomimicric design is spacecraft (claim). I designed a spacecraft similar to the organism of the shrimp (data). There are experiments on the arms of the shrimp, and there are different experiments on each arm (rationale). If the software of my spacecraft is corrupted, the execution of the experiments I designed in space will be unfinished (refutation).
	The argument of the gifted student coded S6: My biomimicric design (that can be used at home) is a snail-swallowing snail machine (claim). I was inspired by the snail organism (data). Mosquitoes go towards the snail with light in its mouth at night. The machine stores them alive, and then the mosquitoes are released into nature (justification). Mosquitoes cannot be collected (rot) if the software of the machine is corrupted.

	The argument of the gifted student coded S2: My biomimicric design is a fish scanner (claim). I made a design similar to the fish's organism (data). I cover the surface of the fish with metal-sensitive sensors, for example when the magnetic perception of the magnet changes, the detector sounds (justification).
	The argument of the gifted student with code Ö1: My biomimicric design is the surgical robot (claim). It looks like the organism of the leech (data). It has a functional tip and a camera (justification). If the software crashes, my robot will also not be able to complete the surgery (bruising).
	The argument of the gifted student with S3 code: My biomimicric design is rope (claim). I was inspired by the organism of the frog's larva (data). It saves lives in earthquakes with sensors sensitive to sound and temperature (justification).
	The argument of the gifted student coded S4: My biomimicric design is a robot collecting bacteria (claim). Similar to the organism of a pinworm (data). It collects harmful bacteria in the body with its hook during operations (justification). If the selectivity of the software is not good, my robot may also collect beneficial bacteria (rot) despite the software.
	The argument of the gifted student with code Ö1: My biomimicric design is a water robot (claim). Similar to algae organism (data). Thanks to the software, it makes chlorination from the ends (justification). If my software crashes my robot will not work either (rot).

Result, Discussion, and Suggestions

In this study, the processes of developing creativity by specially talented students creating a concept image by blending the macro-micro-submicro nature of freshwater creatures, depicting biomimicric designs inspired by living things and structuring their designs as arguments were investigated.

As indicated in the content given in Table 5, the students questioned the organisms and determined the behavior, functions and other characteristics of an organism and structured their designs on them. Here, like a designer, students firstly defined what the content is, and discovered natural models for design. The process done here overlaps with the engineering design process in the STEM approach. In the STEM approach, it is emphasized that practices such as research and inquiry by students, developing problem solving and critical thinking abilities, and creating an original product design in collaboration using effective communication abilities make significant contributions to the development of 21st century abilities (Kong, YT, & In-Cheol, J. 2014).

It can be said that gifted students are creative in forming concept images from the analysis of their drawings. In the literature, Atasoy (2004) states that the importance of creating an image in students is extremely important in science teaching primarily in order to have an accurate perception of the nature of science. He emphasizes that acquiring an image about concepts in science teaching will cause the concepts to be remembered more easily, that student images also reflect their creativity and such practices contribute to the development of their creativity (Atasoy, B., Kadayıfçı, H., & Akkuş, H. 2007). The fact that the students' macro-micro-submicro perception of freshwater creatures was studied with the applications made in the study, in fact, formed the theoretical basis for the images they will use in their biomimicric designs based on their creativity. In this context, the application process includes a spiraling in order to develop images and creativity.

In the development of creativity, the literature suggests teaching students to identify and explain problems and new ideas, reorganize information, seek alternatives purposefully, evaluate ideas and solutions, and follow themselves (cited in Runco & Nemiro, Robinson et al., 2014). In this study, as a problem situation, the students were presented to develop biomimic designs from the organisms of living things in habitats, they were experienced group discussions in organizing information and looking for alternatives, and they were provided with argument structuring to evaluate ideas and criticize their own thinking processes. According to the findings obtained from the determination of the quality of the arguments structured following the biomimicric designs of the students in the study, on the basis of the components of the Toulmin argument model, it can be said that the development of creative thinking abilities was contributed (Aljarrah, 2017; Hennessey, 2005; Hertzog, 2003; Jamali, 2019; Nicholas, & Ng, 2008). It can also be said that this whole process plays an active role in developing creativity as a whole (Avcı, 2019).

In addition, it is stated in the literature that such practices have a positive effect on students' motivation, especially as they enrich the educational environment (Fortus & Vedder-Weiss, 2014). These activities, especially in the classroom, increase the interest of students by facilitating their learning in different areas and make the lessons fun (Demircioğlu, Özmen & Demircioğlu, 2004; Gelici & Bilgin, 2011).

Some of the expressions in the worksheets of the students about the applications show that they learned by having fun in the process. For example;

Ö1 coded student said, “I had not studied these creatures with a microscope before. The process was very enjoyable to me. I learned better by studying and researching the dimensions of the creature that I can see and cannot see. "

Ö2 coded student "The process of learning by drawing was very enjoyable because visual arts is my hobby."

Ö3 coded student "I learned by having fun in the process of examining freshwater creatures and making robotic designs."

Ö4 coded student "The learning process also made me happy."

Ö5 coded student said, “It made me very happy that freshwater creatures are in the learning process. I love animals."

Ö6 coded student "I learned by having fun in the process."

Ö7 coded student "The learning process felt very different to me." They summarized the process with their statements.

Thanks to the detailed description of the process, this research is expected to guide researchers and teachers working in the field of education of gifted students in terms of structuring teaching environments similarly.

However, it is obvious that there is a need for teaching environments where students can actively participate in the teaching process, use their imagination abilities, make original designs and showcase their creativity. It is extremely important to enrich the teaching environment by including studies that encourage students to research, produce and make inventions and reveal their talents and interests in these subjects.

Biomimicric applications in schools will increase students' interest and curiosity in nature and contribute to the development of engineering process abilities by making positive effects on their creativity abilities, which are among the 21st century abilities. At the same time, such studies should provide opportunities for students to develop their potential abilities to develop their creativity and design new technological products, inspired by nature in a real world, beyond the walls of the school.

References

Aljarrah, A. (2017). Play as a manifestation of children’s imagination and creativity. *Journal for the Education of Gifted Young Scientists, 5*(1), 23-36. https://doi.org/10.17478/10.17478/JEGYS.2017.52.

Altıntas, E., & Ozdemir, A. S. (2015). The effect of developed differentiation approach on the achievements of the students. *Eurasian Journal of Educational Research, 61*, 199-216. https://doi.org/10.14689/ejer.2015.61.11.

Ataman, A. (2018). Giriş. A. Ataman (Ed.), *Üstün zekâlılar ve üstün yetenekliler konusunda bilinmesi gerekenler*, (ss. 1-30). Vize.

Atasoy, B. (2004). *Fen öğrenimi ve öğretimi.* Asil Yayın Dağıtım.

Atasoy, B., Kadayıfçı, H., & Akkuş, H. (2007). Öğrencilerin çizimlerinden ve açıklamalarından yaratıcı düşüncelerinin ortaya konulması: Çizimler ve açıklamalar yoluyla yaratıcı düşünceler. *Türk Eğitim Bilimleri Dergisi, 5*(4), 679-700.

Ayverdi, L. (2018). *Özel yetenekli öğrencilerin fen eğitiminde teknoloji, mühendislik ve matematiğin kullanımı: FeTeMM yaklaşımı*. Doktora tezi, Balıkesir Üniversitesi, Balıkesir, Türkiye.

Avcı, F. (2019). Doğa ve inovasyon: Okullarda biyomimikri. *Anadolu Öğretmen Dergisi, 3*(2), 214-233.

Bilgin, N. (2006). *Sosyal bilimlerde içerik analizi: Teknikler ve örnek çalışmalar.* Siyasal Kitabevi.

Borland, J. H. (2009). Myth 2: The gifted constitute 3% to 5% of the population. Moreover, giftedness equals high IQ, which is a stable measure of aptitude. *Gifted Child Quarterly, 53*(4), 236-238.

Brevik, L. M., Gunnulfsen, A. E., & Renzulli, J. S. (2018). Student teachers’ practice and experience with differentiated instruction for students with higher learning potential. *Teaching and Teacher Education, 71,* 34-45. https://doi.org/10.1016/j.tate.2017.12.003.

Büyüköztürk, Ş., Kılıç-Çakmak, E., Akgün, Ö. E., Karadeniz, Ş. & Demirel, F. (2010). *Bilimsel araştırma yöntemleri.* Pegem.

Cavilla, D. (2019). Maximizing the potential of gifted learners through a developmental framework of affective curriculum. *Gifted Education International, 35*(2), 136-151.

Darga, H. (2018). Üstün zekâlı / üstün yetenekli çocuklara erken çocuklukta uygulanabilecek eğitim modelleri ve uygulama örnekleri. A. Ataman (Ed.), *Üstün zekâlılar ve üstün yetenekliler konusunda bilinmesi gerekenler*, (ss. 86-117). Vize.

Demircioğlu, G., Özmen, H., & Demircioğlu, H. (2004). Bütünleştirici öğrenme kuramına dayalı olarak geliştirilen etkinliklerin uygulanmasının etkililiğinin araştırılması. *Türk Fen Eğitimi Dergisi, 1*(1), 21-35. file:///C:/Users/EEF/Downloads/34-Article%20Text-30-1-10-20191106.pdf

Dönmez, İ., & İdin, Ş. (2017). Türkiye’de fen bilimleri eğitimi alanında üstün yetenekli öğrencilerin eğitimi ile ilgili araştırmaların incelenmesi. *Journal of Gifted Education and Creativity, 4*(2), 57-74.

Erdem-Gürlen, E., & Özdemir, G. (2019). Üstün yetenekli öğrencilere yönelik zenginleştirilmiş fen bilimleri öğretim programına ilişkin eylem araştırması. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi, 49*, 231-255.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88,* 915-933.

Fortus, D., & Vedder-Weiss, D. (2014). Measuring students' continuing motivation for science learning. *Journal of Research in Science Teaching, 51*(4), 497-522. https://doi.org/10.1002/tea.21136

Guion, L. A. (2002). *Triangulation: establishing the validity of qualitative studies.* http://edis.ifas.ufl.edu.

Hennessey, B. A. (2005). Motivation and classroom climate: Promoting creativity in gifted children, *Gifted and Gifted International*, *20*(1), 41-46. https://doi.org/10.1080/15332276.2005.11673057.

Hertberg-Davis, H. (2009). Myth 7: Differentiation in the regular classroom is equivalent to gifted programs and is sufficient. *Gifted Child Quarterly*, *53*(4), 251-253.

Hertzog, N. (2003). Impact of gifted programs from the students' perspectives. *Gifted Child Quarterly*, *47*(2), 131-143.

Jamali, U. A. Y. (2019). Fostering creativity using robotics among gifted primary school students. *Gifted and Gifted International*, *34*(1-2), 71-78. https://doi.org/ 10.1080/15332276.2020.1711545.

Kaplan, S. N. (2009). Myth 9: There is a single curriculum for the gifted. *Gifted Child Quarterly*, *53*(4), 257-258.

Kim, M. (2016). A Meta-analysis of the effects of enrichment programs on gifted students. *Gifted Child Quarterly*, *60*(2), 102– 116.

Komek, E., Yagiz, D., & Kurt, M. (2015). Analysis according to certain variables of scientific literacy among gifted students that participate in scientific activities at Science and Art Centers. *Journal for the Education of Gifted Young Scientists*, *3*(1), 1-12. https://doi.org/10.17478/ JEGYS.2015110568.

Kong, Y. T., & In-Cheol, J. (2014). The effect of subject based STEAM activity programs on scientific attitude, self efficacy, and motivation for scientific learning. *International Information Institute (Tokyo). Information*, *17*(8), 3629. ISSN 1343-4500

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education, 69,* 191-196.

Nicholas, H., & Ng, W. (2008) Blending creativity, science, and drama, *Gifted and Gifted International,* 23(1), 51-60. https://doi.org/10.1080/15332276.2008.11673512.

Oh, D., Bae, J., & Park, S. (2016). The effects of science-based enrichment STEAM gifted program on creative thinking activities and emotional intelligence of elementary science gifted students. *Journal of Korean Elementary Science Education*, *35*(1), 13-25. https://doi.org/10.15267/keses.2016.35.1.013.

Reis, S. M., & Renzulli, J. s. (2009). Myth 1: The gifted and gifted constitute on single homogenous group and giftedness is a way of being that stays in the person over time and experiences. *Gifted Child Quarterly*, *53*(4), 233-235.

Renzulli, J. S. (2012). Re-examining the role of gifted education and talent development for the 21st century: A four-part theoretical approach. *Gifted Child Quarterly, 56*(3), 150-159.

Robinson, A., Shore, B. M., & Enersen, D. L. (2014). *Üstün zekâlılar eğitiminde en iyi uygulamalar.* (Ü. Ogurlu, F. Kaya, Çev.). Nobel.

Rogers, K. B. (2007). Lessons learned about educating the gifted and gifted: A synthesis of the research on educational practice. *Gifted Child Quarterly*, *51*(4), 382-396.

Sak, U. (2017). *Üstün zekâlılar, özellikleri, tanılanmaları, eğitimleri.* Vize.

Sisk, D. (2009). Myth 13: The regular classroom teacher can "go it alone". *Gifted Child Quarterly, 53*(4), 269-271.

Stake, J. E., & Mares, K. R. (2001). Science enrichment programs for gifted high school girls and boys: predictors of program impact on science confidence and motivation. *Journal of Research in Science Teaching*, *38*, 1065-1088. https://doi.org/10.1002/tea.10001.

Stake, R. E. (1995). *The art of case study research.* Sage.

Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science*, *12*(1), 3-54.

Sunde-Peterson, J. (2009). Myth 17: Gifted and gifted individuals do not have unique social and emotional needs. *Gifted Child Quarterly, 53*(4), 280-282.

Taber, K. S. (2007). Science education for gifted learners? K. S. Taber (Ed.*), Science education for gifted learners.* (pp 1-14). Routledge.

Toulmin, S. (2003). *The uses of argument.* Cambridge University.

Treffinger, D. J. (2009). Myth 5: Creativity is too difficult to measure. *Gifted Child Quarterly, 53*(4), 245-247.

Tüzün, Ü. N., Tüysüz, M. (2019a). Kara kutu deneylerinin özel yetenekli öğrencilerin eleştirel düşünmelerine etkisi. *Türkiye Kimya Derneği Dergisi*, *4*(2): 81-94.

Tüzün, Ü. N., Tüysüz, M. (2019b). Özel yetenekli bireylerin öğretim ortamlarının zenginleştirilmesi farklılaştırılmasında kimya-biyoloji-astronomi-toksikoloji-teknoloji-sanat-bilim felsefesi örneği". *Bilim Armonisi*, *1*(2): 9-18.

Worrell, F. C. (2009). Myth 4: A single test score or indicator tells us all we need to know about giftedness. *Gifted Child Quarterly, 53*(4), 242-244.