

A NATURAL SELECTION ACTIVITY TO MOBILIZE SCIENTIFIC CREATIVITY: CLIPPY ISLAND*

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ABSTRACT

Scientific creativity contains new concepts and linkage between them and products that emerge at the end of these processes by considering scientific knowledge and skills peculiar to scientific creativity. Scientific creativity is necessary to do inventions to meet the needs of humans and to solve problems encountered. Scientific creativity is an ability that can be improved and is important for solving complex problems. There is a need for activities which can be performed in classroom environment to improve students' scientific creativities. Purpose of this study is to present an application, designed based on 5E model of constructivism, to activate scientific creativities of 8th grade students related to Natural Selection sub-topic in Cell Division and Heredity unit and Adaptation and Evolution topic. Student and teacher opinions were collected after implementation of the activity. Data analysis revealed that activities like this one can improve students' scientific creativity and can promote scientific literacy.

Keywords: scientific creativity, cell division and heredity unit, natural selection.

BİLİMSEL YARATICILIĞI HAREKETE GEÇİRMeye YÖNELİK BİR DOĞAL SEÇİLİM ETKİNLİĞİ: TOKA GAGALILAR ADASI

ÖZ

Bilimsel yaratıcılık; bilimsel yaratıcılığa özgü becerileri kullanıp, bilimsel bilgiyi göz önünde bulundurarak, yeni kavramlar ve kavramlar arası bağlantıların kurulmasını içeren süreç ve süreç sonunda ortaya çıkan ürünü kapsayan bir kavramdır. Bilim alanında insanların ihtiyaçlarını karşılayacak yeni buluşların yapılması, karşılaşılan problemlerin çözülmesi açısından bilimsel yaratıcılığa ihtiyaç vardır. Özellikle son yıllarda, insanların karşılaştıkları karmaşık problemleri çözebilmeleri için farklı bakış açılarına sahip olmaları ve dolayısıyla yaratıcı düşünceleri önem taşımaktadır. Bilimsel yaratıcılık, geliştirilebilen bir özelliktir. Öğrencilerin bilimsel yaratıcılıklarını geliştirmek için sınıf ortamında uygulanacak etkinliklere ihtiyaç vardır. Bu çalışmanın amacı, ilköğretim 8. Sınıf öğrencilerinin bilimsel yaratıcılıklarını harekete geçirecek, doğal seçim ile ilgili olarak, yapılandırmacı yaklaşımın 5E modeline göre hazırlanmış bir uygulama sunmaktır. Etkinlik, 8. Sınıf öğrencileri ile gerçekleştirilmiş olmakla birlikte, lisede de yapılması uygundur. Uygulama sonrası, öğrencilerin ve öğretmenin düşünceleri alınmıştır. Öğretmen ve öğrencilerin görüşleri de göz önünde bulundurulduğunda, bu tür etkinliklerin öğrencilerin bilimsel yaratıcılıklarını geliştirebileceği ve bilimsel okur-yazar bireyler yetiştirmeye katkıda bulunabileceği söylenebilir.

Anahtar kelimeler: bilimsel yaratıcılık, hücre bölünmesi ve kalıtım ünitesi, doğal seçim.

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INTRODUCTION

The technological and social changes in recent years have changed people's perceptions about knowledge. Thus, "creative man" who possesses versatile talents and skills has replaced the "producer man" (Osho, 2005; Üstündağ, 2014). Torrance (1962) defined creativity, usually difficult to characterize, as follows:

The process of sensing gaps, or disturbing missing elements, forming new hypotheses, and communicating the results, possibly modifying and retesting the hypotheses (p.16).

This definition indicates that Torrance (1962) views creativity as a process. The type of creativity necessary for scientific discoveries is scientific creativity that has a slightly narrower scope than the overall creativity. Scientific creativity requires revealing the widest possible knowledge in nature and technology, internalizing this knowledge, enjoying doing experiments, and thinking freely and critically (Orhon, 2011). Hu and Adey (2002) state that scientific creativity differs from other creativity domains in terms of creative scientific activities, creative problem solving and creative scientific experiments. Ayas (2010) mentioned some skills specific to scientific creativity. These include scientific ability, hypothesis building and testing, problem constructing and solving, analogy, associative thinking, and plural thinking.

In order to bring out the creative human type in scientific sense, it is important that scientific creative process is applied and creativity is supported with education. Science educators have worked on methods and techniques that improve creativity (Aktamış, 2007; Hu & Adey, 2002; Liang, 2002). Furthermore, the Ministry of National Education Science and Technology Curriculum (2006), the Ministry of National Education (MoNE) Science Curriculum (2013) and the National Education Basic Law 1739 aim to improve the creativity of the students.

The MoNE Science and Technology Curriculum (2006) and the MoNE Science Curriculum (2013) adopt a constructivist approach. Constructivism is a learning theory

and Davis (1990) refers to learning while talking about the five obstacles to creative thinking. According to Davis (1990), people are actually born creative, but habits and traditions created in the first years of socialization and education are obstacles to creative thinking. Unfortunately, the majority of educational institutions are not aware of their role in supporting creativity, with the general aim of education being to create environments that promote the creative thinking ability of human intelligence and educate people who will contribute to society. Existing educational philosophy is far from developing creativity (Orhon, 2011). Constructivism, however, emerged as an alternative to traditional learning approaches. The principles of the constructivist approach make learners more free in the learning environment. This shows that creativity can be improved more easily in the classrooms where the constructivist approach is used. According to Honebein (1998), different perspectives are very important in a constructivist learning environment. Different perspectives and new ideas are also important to cultivate creativity.

This study presents an activity designed based on the 5E model of the constructivist approach to activate the scientific creativity of the 8th grade students. The activity is related to natural selection within the Adaptation and Evolution topic under Cell Division and Heredity unit. The activity was evaluated according to teacher and student opinions. The techniques for improving creativity and the scientific process skills that are the cornerstone of the Science and Technology Curriculum have been taken into consideration when designing the activity.

The reason for selecting the Cell Division and Heredity unit in the study is that students experience learning difficulties and misconceptions about the topics in this unit, they struggle to make connections between operations and concepts, and the unit contains a large number of symbols with few opportunities to make experiments (Baker & Lawson, 2001; Kılınç, 2008; Knippels, Waarlo, & Boersma, 2005; Marek, 1986; Öz-Aydın, 2015; Saka, 2006; Sevim, 2006; Tatar, Cansüngü, & Koray, 2004). Evolutionary theory (natural selection), which is also included in this unit, is a difficult subject to

teach and learn (Beardsley, 2004; Gregory, 2009). Most students adopt the Lamarkist view of natural selection. Accordingly, lifelong traits can be inherited and transferred to new generations (Brumby, 1984). This view is not currently accepted and is replaced by the natural selection of Darwin and Wallace. Here are the propositions of Darwin to explain the evolutionary process:

1. Individuals who make up populations vary.
2. The variation among individuals is at least partly transferred from the parents to the offspring.
3. In every generation some individuals are more successful than others in terms of survival and reproduction.
4. Individuals do not randomly breed and survive. Individuals who were more successful in survival and reproduction were naturally selected (Freeman, Herron, & Nide, 2009).

The development of Darwin's theory with current research proposes that adaptation to environmental conditions depends on the genetic makeup of the populations, resulting in the interaction with the environment. When the areas inhabited by species and species confront with an environmental pressure, some of the individuals in the population will either disappear or will occupy new living spaces. However, some will survive because they have adaptive and superior characteristics, and they will be able to transfer these characteristics to the new generation. This phenomenon explains the concept of adaptation. Adaptation is the adaptive trait that develops as a result of natural selection (Futuyma, 2008). Students think that adaptation is only mediated by environmental factors, and they do not understand the importance of mutation. Mutations are genetic changes. These changes modify the normal combination of hereditary material. These mutations may not be beneficial or dangerous to individuals within the population. They may result with the abilities to adapt to changes in future environmental conditions (Futuyma, 2008).

This activity is prepared based on natural selection concept and aims to contribute to the students' scientific thinking, to enhance their learning by eliminating misconceptions and to activate their scientific creativity. In the

conceptual sense, the stages of activity have been carried out in accordance with the modern suggestions of natural selection, which are updated according to today's accepted synthesis, and adaptation focuses not only on environmental factors but also on mutation.

The activity targets the following content standards of the MoNE Science and Technology Curriculum (2006):

1. Explain the adaptation of living creatures to their surroundings with examples.
2. Identify why similar organisms in the same habitat develop similar adaptations.
3. Give examples of adaptations of living creatures to environmental changes that may contribute to biological diversity and evolution.
4. Describe mutation and modification and explain the differences between them with examples.

The reason for designing the activity on 2006 curriculum is that it was implemented during the 2011-2012 academic year in which the 2006 curriculum was used. This topic is now placed in the MoNE High School Biology Curriculum (2013), and the activity could be implemented for teaching the 12th grade standard "Discusses how life can be affected over time with climatic changes that may occur in nature." The vision of the Science Curriculum (2013) is grounded on knowledge, skills, affection, and science-technology-society-environment learning areas.

The activity also aligns with the the 7th grade standard "Discuss the factors that threaten biodiversity based on research data and recommend solutions." within the "Human and Environmental Relations" unit. In the domain of processes, both the scientific process skills (comparison-classification, observation and deduction) and life skills (analytical thinking and creative thinking) are integrated into the activity. The activity mainly aims to enhance students' comparison-classification skills. It also aims to contribute to responsibility regarding the affective domain, and to support sustainable development consciousness in the science-technology-society-environment domain.

ACTIVITY IMPLEMENTATION

Instructional design is based on two main goals: to provide learners with natural selection and to develop and evaluate their scientific creativity at the same time. The lesson plan prepared for this fiction was made according to 5E model. The engage, explore, and explain phases of the lesson plan were designed by the researchers. Particularly at the explore phase, we aimed to engage students in making comparisons and thus aimed to improve the students' scientific process skills while also activating their creativity. The work done in the elaborate and evaluate phases was adapted from another work (Furness, Sutherland, Chalk, Bulleid, Bamford, & McGhie, n.d.). The activity was piloted in a middle school located in the center of Balıkesir and also at Balıkesir University Necatibey Faculty of Education and necessary changes were made taking into account the opinions given by the students and prospective teacher. The actual implementation of the activity was conducted at a different middle school in the center of Balıkesir, to a group of 30 students by one of the researchers in three class sessions. Teachers and students were asked open-ended questions to get their thoughts on the activity after the implementation. The opinions of the students were taken in writing at the end of the course. The teacher was interviewed and expressed opinions about the lesson.

The activity was implemented using the phases of 5E model: Engage, Explore, Explain, Elaborate, and Evaluate. At the time of application, in order to attract students attention, according to engage phase of 5E model 5E, students were asked whether they know creatures that were living in the past, but not alive in our time. Drawing on students' responses, the class questioned why these creatures are not alive now and the students were encouraged to think about whether species are stationary on Earth or not and about natural selection.

In the explore phase, live specimens of the same species but in different environments are shown using projection. Again using the projection, living species of different species living in the same environment are shown. Similarities and differences between living creatures of the same species but living in

different environments are questioned. Similarly, the similarities and differences between different living species living in the same environment are questioned. By considering similarities between living creatures, students discuss the effects of environment on this situation. They also discuss why living creatures might have gained their common characteristics by taking into consideration environmental characteristics. In this study, students use comparison-classification skills from scientific process skills. Bono (1997) states that comparisons provide the opportunity to reach new results and develop creativity. The time spent on engage and explore phases is about 25 minutes.

The explain phase involved defining the concept adaptation drawing on student discussions and explaining the species are not constant on the Earth and there are endangered creatures (Dinosaur, Dodo bird etc.) with examples. Examples of adaptation of living creatures to their environments are given. Besides, the contribution of adaptation to the biological diversity and the issues of modifications and natural and artificial selection are discussed. The time left for the explain phase is about 10 minutes.

After the discussions, the lesson proceeds with the elaborate phase that includes the main activity. Two tables are placed side by side. Two cards, one showing "north island" and the one showing "south island" are placed on the tables. Photograph 1 shows the layout of the tables and their contents.



Photograph 1. *Layout of the Tables*



Photograph 2. *The Clasps used as Beaks*

Large, medium, small and the smallest clasps are placed on four plastic trays. The clasps used in the activity are shown in Photo 2. The trays are put on a separate table. Different clasps are put on the trays. The largest buckle is left out. Plastic cups for nourishment are prepared to give each student with the purpose of representing the bird stomach. The population record table is photocopied or projected (Appendix 1: population record table). Students are told that they will be members of a bird population in a fictitious place called Toka Gagalılar Island.

Explanation Before Implementation

On Toka Gagalılar Island, a bird species called Toka beaked lives. Toka beaked birds are simple creatures; they cannot fly and they survive by eating three types of beans grown on the island. The birds' beak size and need for food are different, and they all tend to live and reproduce. Toka beaked birds can have 5 different types of beak sizes. The students are told that there are 3 primitive (small, medium and large) and 2 mutants (the smallest and the largest) by showing them the clasps of different sizes. The mutant term is discussed. The meaning of mutation is explained. Differences between the concept of modification and mutation are discussed. Students examine the beaks that will ensure their survival in four seasons. The time for this pre-application explanation is approximately 15 minutes.

Implementation

The practice of accumulating as much food as possible in the 30 second feeding periods is explained to them. The rules of the activity are

projected with the help of projection, and are hung at a place where students can easily see (Appendix 2: activity rules). The food on the island is represented by beans of 3 different colors. Students are shown 3 different color beans. Different calorie values of beans are told to the students. These values are shown on the table (Appendix 3: food-calorie values).

Birds have different food requirements depending on beak size. Each beak species has a threshold value for survival. Birds with larger beaks need more food to survive than small-beaked birds do. Threshold values required for survival are displayed in tabular form in a visible place (Appendix 4: threshold values for survival). During the activity implementation, these tables are put on a board such that all students in the classroom could see them. Photograph 3 shows the board with the tables.



Photograph 3. *Food-calorie Values and Threshold Values Required for Survival*

The table (Appendix 4: thresholds for survival) can be used as a guide to calculate the cases of birds dying, surviving and reproducing. If Toka beaked birds die, the students leave their beaks and sit down. If Toka beaked birds survive, they are fed in the same island in the new season. If Toka beaked birds survive and reproduce, the same student can be fed in the new season and another student is given a clasp of the same size to feed during the new season. The data are recorded on the table by a student who will be assigned recording duty. Each student is given a beak (clasp) and a stomach (plastic cup) for pre-season practice so that the students can see how the activity will be done. The period for pre-season and for each season is approximately 10 minutes. With feeding periods of 30 seconds, this was the way for the students to count the food they had collected and to record the numbers of

surviving and dying creatures on the table. According to the size of the tables, the teacher should guide the students practice nutrition experience by forming two or more groups during the pre-season fiction.

Pre-Season Fiction

North Island:

4 handful white beans
4 handful green beans
4 handful blue beans
30 clasps in any size
30 plastic cups

South Island:

4 handful white beans
4 handful green beans
4 handful blue beans

Students experiment with how to use the clasps and cups to survive in a 30-second feeding period given to them in pre-season fiction. Then, each season is explained in detail and the activity is carried out in a 4-season feeding period. Season 1 begins with 6 students at North Island and 6 students at South Island. A student is also assigned to keep the population records. In other words, the activity starts with 13 students in total and the other students are audience. However, in the process, the number of students on each island changes, new students can be added to the island, and some students leave the island because they cannot provide the necessary criteria to live. The location of the students before Season 1 is listed in Appendix-5. The fictions of each season are presented below:

Season: Toka Gagalılar Island is Divided in Two

Season 1 Fiction:

North Island:

50 white beans
50 green beans
50 blue beans

South Island:

50 white beans
50 green beans
50 blue beans

For each island, six clasps (2 small, 2 medium, 2 large clasps), six cups

Scenario: The Toka Gagalılar Island goes through a major change. The rise of the water level divides the island into two sections, creating the South island and the North Island. The number of the birds is the same on both sides and they have the same amount of food

Instructions: The North Island sign is placed on one side of the island, the South Island sign is placed on the other side. Six students are

selected for each island in season 1. Each island begins with two small beaks, two middle beaks and two large beaks.

Expected Results: Small-beaked birds should be most effective in feeding because they can easily harvest beans, need fewer beans to survive and reproduce.

Season 2: New Variations through Mutation

Season 2 Fiction:

North Island:

50 white beans
50 green beans
50 blue beans

South Island:

50 white beans
50 green beans
50 blue beans

Scenario: A new variant appears in the population due to random mutation. By giving the mutants to two students, the smallest beak in the North Island and the largest beak in the South Island are introduced. (Tip: A very competitive student should not be given the largest beak, because at the end of the season he should not be alive.)

Instructions: The season starts with the number of students in each island survive after the first season. These are survivors from the first season, as well as their offspring. The activity is repeated and the populations are calculated.

Expected Results: In this second season, the smallest beak should be the most reproductive. They need very little food to survive and reproduce. The greatest beak should die.

Season 3: A Scarcity in the North Island

Season 3 Fiction:

North Island:

20 white beans
20 green beans
10 blue beans

South Island:

50 white beans
50 green beans
50 blue beans

Scenario: Due to drought, North Island experiences a food shortage and famine.

Instructions: The season starts with the number of students in each island left after the second season. These are survivors of the second season, as well as their offspring.

Expected Results: Due to lack of food the North Island population should decrease. The

smallest beaks are the most survivors, followed by small beaks.

Season 4: Stability

Season 4 Fiction:

North Island:	South Island:
50 white beans	50 white beans
50 green beans	50 green beans
50 blue beans	50 blue beans

Scenario: Conditions are equal on both sides of the island.

Instructions: The number of students in each island starts with the number at the end of the third season. These are survivors of the third season, as well as their offspring.

Expected Results: The population in the North Island should be balanced with the increase in the amount of food. After four feeding seasons, the populations of both North and South Islands should now look very different.

The results obtained are recorded in the Population Registration Table and discussed with the students. Once the fiction of each season is announced, the students are asked what they might expect at the end of the season. The lesson is assessed through asking students some questions about the activity:

1. Which kind of toka beaked bird was the most successful in general?
2. Which population grew at the end?
3. Compare the population in terms of numbers and varieties.
4. If populations started with the same number in each beak species, why did not they all grow the same?



Photograph 4. Implementation

In this lesson that was planned based on 5E model, the assessment took approximately 20

minutes. This assessment primarily included open ended questions posed at the end of the activity and listed above. Some additional open-ended questions related to content standards were also asked. Photograph 4 presents an implementation scene from the activity.

DISCUSSION and CONCLUSIONS

The activity was applied by the researcher and the opinions of the class teacher and the students were recorded. Here are the expressions used by the teacher during the interview after the lesson:

It was a very nice activity. It was an activity that appealed to higher mental skills and improved creativity. There is no such activity in the books I have used. The children also performed procedures. The children were also very interested. It is an activity that can be used in science schools, science workshops. I do not think I can use this activity in the future. Because we have time limitations on topics. This activity took too much time. But it was a great activity. The students also loved it. It is an activity that can be used more easily in classrooms where class size is less.

Students stated that the activity was engaging and educational, and they understood the importance of natural selection. For example, a student explained "I learned which species are easier to feed and can survive. I liked everything, it was perfect." (Appendix 6). Some students stated that they had difficulty in using the beaks. About this activity, which was used to mobilize scientific creativity, both the teachers and students expressed that they liked the activity and found it fun, and it helped them develop different perspectives. The different viewpoints here are extremely important in terms of scientific creativity. Herrmann (2003) notes that creativity is related to new and original ideas. It is therefore necessary to create environments that offer the opportunity to develop new and original ideas to improve one's creativity.

This activity is one of the many activities that were used within the scope of the first author's master's thesis. At the end of the study, students' scientific creativity scores and

academic achievement scores significantly increased (Ayverdi, 2012) (Appendix 7).

Ustundag (2014) mentions that some teaching techniques develop creative thinking. These techniques have also been taken into account in the activity described in this paper. However, since scientific creativity involves not only creative thinking but also the scientific dimension of the topics, the scientific process skills are also considered in the course of designing the activity. The students used the skills of comparison-classification, observation, prediction and deduction in this

activity. This activity involves the knowledge, skills (scientific process skills, life skills), affective dimension (responsibility), and science-technology-society-environment (sustainable development consciousness) learning areas included in the vision of Science Curriculum (2013), and it is also aligned with the content standards of the Secondary School Biology Course Curriculum, hence the activity could be implemented in primary and secondary classrooms with modifications.

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Appendix 1

Population Registration Table

	North Island					South Island				
	The smallest beak	Small beak	Medium beak	Large beak	The largest beak	The smallest beak	Small beak	Medium beak	Large beak	The largest beak
Season1	0	2	2	2	0	0	2	2	2	0
Season2										
Season3										
Season4										
Final Population										

Appendix 2

Rules of the Activity

Toka beaked birds have 30 second of feeding time.
Toka beaked birds have to collect one bean at a time and they should put them into the plastic cups.
Toka beaked birds can not use their beaks as a scoop. Fraudulent results will be ignored.
If the Toka beaked birds die, the survivors pass to the next season and they reproduce according to the calories they collect in a season. Calories from one season is not transferred to the next season.

Appendix 3

Nutrient-Calorie Values

Food Type	Calorie Value
Blue bean	10
Green bean	5
White bean	2

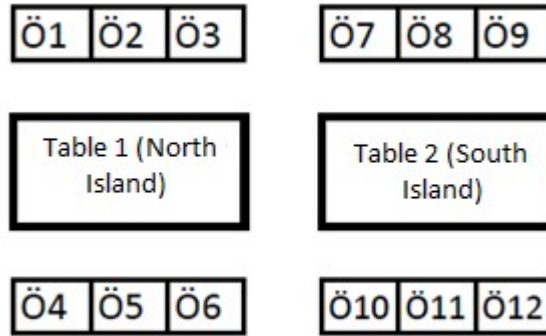
Appendix 4

Threshold Values for Survival

Beak Size	Death	Survival	Survival and Reproduction
Large	Less than 75 calories	75	150
Medium	Less than 50 calories	50	100
Small	Less than 25 calories	25	50
The largest	Less than 100 calories	100	200
The smallest	Less than 10 calories	10	20

Appendix 5

Location of Students before Season 1 (Ö# represents students)



Appendix 6

A Student's Comments on the Clippy Island Activity

Hangi türlerin daha kolay beslendiğini ve ayakta kalabileceğini öğrendim.
 Herseyini beğendim çok güzel eksiklerdi.
 Ben bu kadar iyi yapamazdım çok güzel olmuş.
 Başarımdan dolayı biraz zorlandım.

Appendix 7

The Results of the Analysis for the Two Items in the Academic Achievement Test That are Directly Related to the Activity

Table 1 is for Academic Achievement Test (ABT) Question 9, Table 2 is for ABT item 10. The highest score that can be taken from Question 9 is 7, from question 10 is 6. Table 3 is for the Scientific Creativity Test.

Table 1. Comparison of Pre-Test to Post-Test in Terms of Scores From Question 9 in ABT

	Kişi sayısı (N)	Ortalama (X)	Standart Sapma (SS)	t	sd	p
Ön test	30	1.07	1.999	-11.669	29	.000
Son test	30	5.67	1.583			

Table 2. *Comparison of Pre-Test to Post-Test in Terms of Scores From Question 10 in ABT*

	Kişi sayısı (N)	Ortalama (X)	Standart Sapma (SS)	t	sd	p
Ön test	30	0.00	0.000			
Son test	30	3.23	2.944	-6.015	29	.000

Table 3. *Comparison of Pre-Test to Post-Test in Terms of Scores From The Scientific Creativity Test*

	Kişi sayısı (N)	Ortalama (X)	Standart Sapma (SS)	t	sd	p
Ön test	30	55.80	20.419			
Son test	30	62.90	22.112	-2.436	29	.021