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The Effect of Using Scientific Scenarios in Teaching Socioscientific Issues in Science Course on Students' Logical Thinking Skills*

Fen Bilimleri Dersinde Sosyobilimsel Konuların Öğretiminde Bilimsel Senaryo Kullanımının Öğrencilerin Mantıksal Düşünme Becerileri Üzerine Etkisi

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ABSTRACT: In recent years, countries have focused specifically on improving thinking skills in their science education programs. One of the science lesson methods that can be used to activate the use of thinking processes is scientific scenarios. In this direction, the aim of the study is to investigate the effect of socioscientific subject-based instructional experience, which includes scientific scenarios in science lessons, on students' logical thinking skills. The study was carried out in the "DNA and Genetic Code" unit, which especially includes some socioscientific issues. The research was designed according to the quasi-experimental pattern with unequal control group among the pre-test-post-test control group designs, and it was conducted with a total of 36 eighth grade students from the experimental and control groups. The data were collected using the logical thinking group test and an individual information form. According to the study findings, it was understood that scenario-based teaching had an important effect on developing students' logical thinking and in passing their developmental period to the next stage. This finding shows that the processing of some socioscientific science issues with scientific scenarios is effective in increasing students' logical thinking skills.

Keywords: Logical thinking skills, science, scientific scenario, socioscientific issues.

ÖZ: Son yıllarda ülkeler fen eğitimi programlarında özellikle düşünme becerilerini geliştirmeye odaklanmışlardır. Düşünme süreçlerinin kullanımını aktif hale getirmede kullanılabilecek fen dersi yöntemlerinden biri de bilimsel senaryolardır. Bu doğrultuda çalışmanın amacı, fen bilimleri dersinde bilimsel senaryoların yer aldığı sosyobilimsel konu temelli öğretimsel deneyimin, öğrencilerin mantıksal düşünme becerilerine etkisini araştırmaktır. Çalışma, özellikle bazı sosyobilimsel konuları içeren "DNA ve Genetik Kod" ünitesinde gerçekleştirilmiştir. Araştırma, ön test-son test kontrol gruplu desenlerden eşit olmayan kontrol gruplu yarı deneysel desene göre tasarlanmış, deney ve kontrol gruplarından toplam 36 sekizinci sınıf öğrencisiyle gerçekleştirilmiştir. Veriler mantıksal düşünme grup testi ve bireysel bilgi formu ile toplanmıştır. Araştırmanın bulgularına göre senaryo temelli öğretimin öğrencilerin mantıksal düşünmelerini geliştirmede ve bulundukları gelişimsel dönemi bir sonraki aşamaya geçirmelerinde önemli etkisi olduğu anlaşılmıştır. Bu bulgu, fen dersindeki bazı sosyobilimsel konuların bilimsel senaryolarla işlenmesinin öğrencilerin mantıksal düşünme becerilerini artırmada etkili olduğunu göstermektedir.

Anahtar kelimeler: Mantıksal düşünme becerileri, bilim, bilimsel senaryo, sosyobilimsel konular.

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Countries have focused on developing various scientific process skills and thinking skills in science education programs in recent years. Countries such as Singapore, Kazakhstan (Yazıcıoğlu & Pektaş, 2019), America (National Research Council, 2014) and Canada (Özcan & Gücüm, 2020) are among the prominent countries in terms of these skills in science education programs. Similarly, with the revisions made in 2005, 2013 and 2018 an emphasis on teaching some skills was made also in science course programs in Turkey (Ministry of National Education [MoNE], 2005, 2013, 2018). These skills are scientific process skills, life skills and engineering and design skills. While scientific process skills, among these aforementioned skills, provide individuals with ways to learn science and reach concepts (Nugraha et al., 2018), in this process, the development of problem solving and thinking skills (Mahanal et al., 2019) and the use of engineering and design skills and the development of cognitive skills (Fiteriani et al., 2021) are associated with the point of producing a solution to the problem. In this whole process, resources have been added showing its relationship with scientific process skills, life skills and engineering and design skills, which are shown as thinking skills such as individuals use logical thinking processes in the process of evaluating situations related to problem solving, conducting scientific processes and making decisions (Osterhaus et al., 2020). All of the mentioned skills are closely related to thinking skills. Thinking skill is an important quality that enables people to perceive their environment and nature. It can be said that thinking is a mental process and a phenomenon of logic in which the unknown is obtained by establishing a connection between the propositions. Logical thinking is the key to making correct decisions and solving complex problems. Logical thinking skill, which is among the thinking skills, is described as the seventh skill that should be included in the 21st-century individuals among the 2020 cognitive abilities in the "World Economic Forum" report (Global Challenge Insight Report, 2016). In other words, one of the essential skills required to be found in the individuals of the future is considered as logical thinking skill. The vision of the renewed 2018 science curriculum states that developing high-level thinking skills, such as reasoning ability, scientific thinking habits and decision-making skills, can be achieved by using socioscientific issues (MoNE, 2018, pp. 9). Socioscientific issues in the science curriculum are issues that include social dilemmas with both scientific and social issues, which are open to discussion, do not have a definite answer, need to be addressed in a multifaceted way, and concern society (Zeidler et al., 2019). The fact that a subject can be a socioscientific subject, basically depends on two features. These features are social significance and scientific content (Eastwood et al., 2012). Lessons in teaching socioscientific issues; video demonstration (Bossér & Lindahl, 2019), with a question (Kim et al., 2014), reading a text, dilemma or scenario (Atabey & Topçu, 2017; Lin & Hung, 2016; Yahaya et al., 2016). The term scenario refers to texts that are frequently used in international exams such as PISA, which are presented to students thematically to complete high-level tasks related to the case / event / situation (Organisation for Economic Co-operation and Development [OECD], 2019, pp. 41). Socioscientific issue scenarios include topics that relate scientific concepts to daily life, do not have a single answer, and require more than one solution (Kolstø, 2001). In the content of the scenario, different ideas are presented impartially in a way that they do not prevail (Tsai, 2018), and preliminary information is provided on the subject (Dawson & Carson, 2017). Due to the aforementioned features, we decided to use scientific scenarios in teaching socioscientific issues in the study.

Romine et al. (2020) presented socioscientific issues with scenarios. The authors state that reasoning on socioscientific issues is the key to taking a conscious position. It is stated that scenarios are bridges in terms of competences such as students' understanding of complex situations, questioning, and seeing multiple perspectives in reasoning on socioscientific issues. In another study, Proudfoot and Kebritchi (2017) performed scenario-based learning and STEM applications in a mobile laboratory environment. Scenario-based learning is considered as an approach to improve learner engagement and understanding by engaging students with real-world learning experiences. The study revealed that a scenario-based e-Learning can positively affect students' interest and success in their courses. Ramirez-Villarin (2020), on the other hand, examines the relationship between students' attachment to place (regionalism) and socioscientific reasoning in socioscientific issues. While scenarios involving regional socioscientific issues were used in the control group, to examine this relationship, scenarios containing socioscientific issues belonging to different regions were used in the experimental group. The author used the number of evidence-based reasons students used in discussions to evaluate changes in their reasoning and decision-making skills. In the study, it was determined that the experimental group of students used more evidence-based reasoning in the discussions. Instead of one single study such as it is stated that students establish emotional bonds with local and global scenarios affecting the planet and gain environmental awareness. Kinslow et al. (2019) examined socioscientific reasoning change with a six-week intervention focusing on the environmental socioscientific issue. Socioscientific reasoning assessments were based on scenarios containing open-ended questions. Triangulation was used to explain student artifacts (e.g., written assignments and diary entries) collected throughout the course, increases documented through quantitative analysis. In this setting, students' pre / post-tests revealed statistically significant increases in socioscientific reasoning with medium to large effect sizes. The similarity between the prominent topics in the classroom and the scenarios used for evaluation is seen as a limitation of the study. Although the study provides evidence that there will be improvement in students' socioscientific reasoning, it does not provide evidence that they can pass on to a topic that is not similar to practice. In the context of this information presented by the literature, in this study, the effect of the socioscientific subject-based instructional experience in the science lesson on the logical thinking skills of the students will be examined.

Literature Review

Socioscientific Issues

Socioscientific issues, which are based on science, are based on problems that can be encountered in real life, which are controversial and do not have a clear solution. Socioscientific issues, which first came to the agenda in the 1970s, have become one of the focal points in science lessons today (Levinson, 2006). It is aimed to include the teaching of socioscientific issues (National Research Council, 2012; Sadler & Zeidler, 2009), which is one of the important goals of modern education, in the curriculum of many institutions (American Association for the Advancement of Science, 1990; MoNE, 2013; National Research Council, 2012) and organizations around the world and to raise conscious individuals on these issues. The importance of teaching socioscientific subjects in raising individuals with scientific knowledge is emphasized. (Driver et al., 2000). However, in Turkey, despite the emphasis on science-society-environment with the teaching reform in 2005, in the 2013 science program revision (Aydın & Silik, 2020; MoNE, 2013), it was clearly addressed as one of the skills that should be acquired (MoNE, 2013) in order to explain the relationships between science-technology-society-environment (Topçu, 2015). Finally, in renewed 2018 science curriculum objectives in Turkey, with the statement “reasoning ability using socioscientific issues, develop scientific thinking habits and decision-making skills” (MoNE, 2018, pp. 9), necessity and importance of teaching socioscientific issues are clearly stated. The aforementioned program emphasized that socioscientific issues help improve judgment and decision-making skills in addition to scientific thinking (Özcan & Kaptan, 2020). In this context, by including socioscientific issues, it is aimed to improve students’ ability to question, reasoning (Kinslow et al., 2019), analyze-synthesize-evaluate (Drummond & Fischhoff, 2017), and understand the relationships between socioscientific issues (Owens et al., 2020). Learning environments in which science teaching is provided through socioscientific issues are related to students’ knowledge of these subjects (Lewis & Leach, 2006), increase their knowledge of scientific content (Jho et al., 2014; Klosterman & Sadler, 2010), and improve decision-making skills (Dauer et al. , 2017; Gutierez, 2015; Ladachart & Ladachart, 2021; Zo’bi, 2014), supports the development of higher-order thinking skills such as logical thinking (Cian, 2020; Zeidler et al., 2019) and encourages them to develop positive attitudes towards science (Pelch & McConnell, 2017; Sadler, 2009). In addition, socioscientific issues are seen as contexts that include the learning process that enables students to bridge social contexts through their school experiences (Sadler et al., 2017). Socioscientific issues may be related to daily life and may be encountered in the immediate environment, as well as related issues that take place in many parts of the country or the world. It should not be forgotten that individuals may have to take responsibility for society or make decisions in situations that affect the future of the country (Stefanova et al., 2010), and socioscientific issues should be integrated into teaching practices at an early age (Zeidler, 2014).

The Relationship Between Logical Thinking Skills and Scientific Scenario

In the information society, individuals are expected to have new skills and competencies to cope with their problems. These expected skills and competences are called 21st century skills (Aygün et al., 2016; Bakırcı et al., 2018). Among the skills that are among the 21st century skills, it includes the skills necessary for logical thinking, establishing the cause-effect relationship of facts, events or situations (Ding, 2018), understanding scientific knowledge and concepts, and perceiving the nature of science (Dawson & Carson, 2017; Koerber et al., 2015). Koray and Azar (2008) state that logical thinking includes mental processing skills such as abstraction and generalization used in the problem solving process. Ding (2018) states that reasoning skill is called scientific reasoning, scientific thinking, logical thinking or critical thinking in the literature. Despite the different discourses mentioned, reasoning skill consists of sub-skills (correlational reasoning, proportional reasoning, control of variables, probabilistic reasoning, and combinatorial reasoning). Correlational reasoning dentifies relationships between variables in an event, identifies combinations, identifies all possible combinations of events, and solves ambiguous situations by considering variables associated with the ultimate result (Ash-Shiddieqy et al., 2018). Proportional reasoning requires thinking about the proportions of learners in relation to a whole (Newcombe et al., 2018). Probabilistic reasoning is the estimation of all the results that will be obtained when an event is repeated in a broad context from the initial state to the final state (Erlina et al., 2018). Combinatorial reasoning is the process that systematically considers all theoretical and empirical relationships (Aini et al., 2020) to construct complex structures (Adey & Csapó, 2012) from a set of specific elements satisfying explicitly given or deduced conditions. In this study, logical thinking skills were used as an action to analyze a situation, to use reasoning skills to examine a problem objectively, and to find a logical solution. It is stated that there is a link between individuals' ability to use these reasoning skills mentioned in the developmental process and their individual development.

According to Piaget's theory, the individual perceives and interprets the events in his environment and society according to his logical thinking skill. This skill develops in parallel with mental development (Woolley et al., 2018). According to Piaget's cognitive development theory, four stages should be overcome respectively in the cognitive development of individuals. These developmental stages are, respectively, sensory-motor, pre-operational, concrete operations and abstract processes. The last two stages, in particular, are considered as the basic structure of logical inference for cognitive development (Guey et al., 2010). Piaget states that in cognitive development stages, one cannot move to another stage without passing one stage. The reason for this is that the previous stage is the precursor of the developmental skills in the next stage.

It is stated that the ages of individuals to enter and complete these developmental stages may differ from individual to individual, and when the stages are completed, the individual completes his development (Senemoğlu, 2011). It is generally stated that individuals between the ages of 7-11 are in the concrete operational period. Despite this, it is also known that there are individuals who cannot advance to a higher level even though they are in the higher age group or who perform skills at a higher level despite being at a lower level (Lazonder & Janssen, 2021; Osterhaus et al., 2020). In fact, Denison and Xu (2014) suggested that even babies can use proportional information to make decisions in probabilistic comparison situations. Individuals in the period of concrete operations can grasp logical principles and apply what they grasp to concrete entities, events, facts, or situations (Bybee & Sund, 1990). Individuals use logical thinking skills in solving concrete problems at this stage. Considering the ages of the middle school students who constitute the sample level of this study, it can be said that they are at the end of the concrete operations period and are about to move to the abstract operations period. Students who encounter a problem in their environment, life or classroom environment will use their knowledge, skills and abilities to find a solution (Karpudewan & Roth, 2018; Owens et al., 2020). In this context, Piaget states that individuals interpret the events around them according to their logical thinking skills (Güler, 2010). Students will try to understand all aspects of the event to solve the dilemma or problems they face. After examining the situation from a critical point of view, it can be thought that they will try to interpret the event or situation by using their logical thinking skills and go on the way to produce solutions. In this case, it is clear that students will use their logical thinking skills on controversial and dilemma issues. King and Socioscientific issues, which are one of the most specific examples of dilemmas in science education, are issues that are closely related to the society, contain moral and ethical aspects, have scientific, social and ethical dimensions (Tsai & Jack, 2019), and it is difficult to make a full and definite judgment (Dawson & Carson, 2017).

Teachers used the mentioned subjects in a limited number of classes, it is expressed that the reasons for this are that they are not supported in terms of applications (Hofstein et al., 2011), and the lack of teaching environments and how to implement the applications (Sadler et al., 2017). One of the most important points in planning socioscientific education is the presentation of socioscientific issues to teaching (Presley et al., 2013). The texts used in socioscientific subject teaching in the literature are based on case studies (Knight & McNeill, 2015), dilemmas (Shea et al., 2015) or short stories (Tomas & Ritchie, 2015). The most common usage expression for these texts is scientific scenario (Atabey et al., 2018). These scenarios should allow making moral and ethical inquiries about social issues of life, and should have an appealing structure and valid scientific content (Gustafsson & Ohman, 2013). In addition, scenarios should be appropriate to the class level, program requirements and subject (Lenz & Wicox, 2012), and should contain information about the subject (Kalypso & Constantinou, 2014). Students should be able to discuss, defend their own ideas and make evaluations on the ideas of their friends using the information on the subject through the scenarios provided (Dawson & Carson, 2017). It is especially very important to give opposite ideas about the subject we want the students to discuss, reasoning and decide on using logical filters (Bossér & Lindahl, 2019). Based on this, it can be said that a good scenario pattern prepared in the teaching of socioscientific issues is the most important keystone in terms of developing various skills (such as discussion, questioning, judging, reasoning, logical thinking) that students are expected to acquire in the teaching phase.

The Place of the "DNA and Genetic Code" Unit in Socioscientific Issues

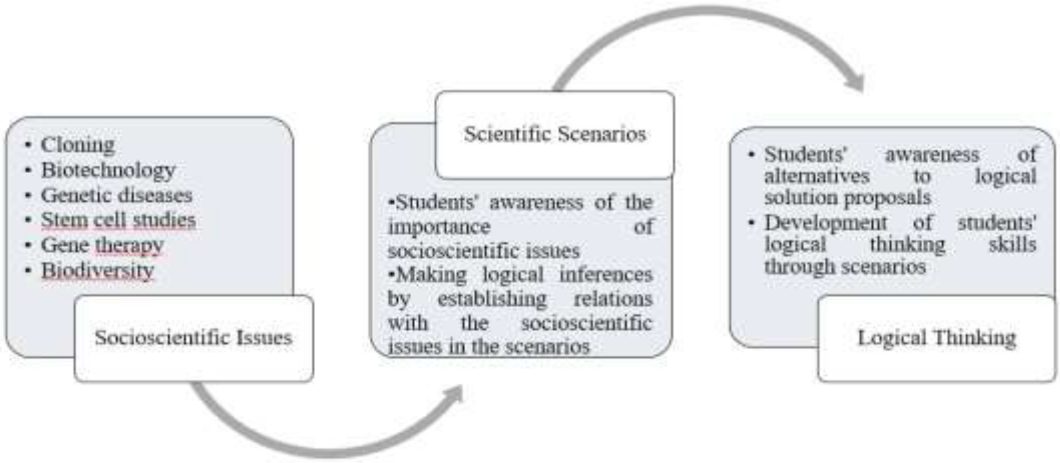
Socioscientific issues (SSIs) are complex and open-ended dilemmas regarding the environment, health, society and economics. In a curriculum that focuses on socioscientific issues, science concepts emerge in an interdisciplinary context that emphasizes the interconnections between science, environment, health and society. Examples of socioscientific issues include energy, nuclear energy, climate change, the use of genetically modified foods, air and water pollution, and (Karpudewan & Roth, 2018). Some of the socioscientific issues that are frequently expressed, discussed and on the agenda, in all segments of society today, can be defined as: genetic tests, genetically modified organisms (GMOs) expressed as the manipulation of the living organism's gene sequences (World Health Organization [WHO], 2005) by transferring genes from plants, animals, bacteria and viruses with the aim of bringing new properties to living creatures or changing existing characteristics, (GDO), stem cell studies, gene therapy (Woolley et al., 2018), cloning, vaccination, genetic engineering applications (Chen & Xiao, 2020) and biodiversity (Bermudez & Lindemann-Matthies, 2020).

In the secondary school 8th grade's science programs in Turkey, related concepts such as nucleotide, gene, DNA, chromosome, inheritance, mutation, modification, adaptation, selection, variation, which are in the "DNA and Genetic Code" unit of the high school 8th grade level, genotype-phenotype characteristics, subtopics such as crosses and character prediction are related to socioscientific issues

(MoNE, 2018). In order to establish connections between the aforementioned interrelated concepts, sequential thinking and sequential ordering of information will require the active use of logical thinking skills, and the active use of reasoning and logical thinking skills to discover the relationships between them. In addition, it was thought that giving the students a pattern with step-by-step scientific scenarios about real-life events related to the concepts in the unit, would attract the attention of the individuals during the activities and require them to use their logical thinking skills actively by focusing on the situation. The structure that summarizes the theoretical framework of the study and modeling of the research question is presented in Figure 1.

Figure 1

Modelling of Research Structure



Argumentation in the teaching of socioscientific issues (Dawson & Venville, 2009; Rebello et al., 2013; Suephatthima & Faikhamta, 2018; Zeidler & Nichols, 2009) or scenario (Carson & Dawson, 2016; Khishfe, 2014; Kinskey & Zeidler, 2021; Lin & Hung, 2016; Ottander & Simon, 2021; Saad et al., 2017; Zeidler & Nichols, 2009) seems to be widely used. In this study, the sentences the use of scientific scenarios in the teaching of socioscientific issues was deemed appropriate. "In this direction, the aim of the study is to investigate the effect of socioscientific subject-based instructional experience, which includes scientific scenarios in science lessons, on students' logical thinking skills."

Method

Research Design

The study was conducted in the science course in the secondary school in the Aegean region of Turkey during the second semester of academic year 2018-2019. In this study, quasi-experimental design with the pretest-posttest control group, one of the experimental models, was used. Quasi-experimental researches are interpreted as real-life studies (Vanderstoep & Johnston, 2009). It is not possible to make random selection in real-life environments. In the designs where random selection cannot be applied, researchers make use of quasi-experimental design (Marczyk et al., 2005).

Participants

In teaching some of the socioscientific issues in science classes, the working group of this research in which the effect of scientific scenario use on logical thinking skills of 8th grade students is examined, is composed of students in a medium-size school of Manisa. There are 18 (10 girls and 8 boys) students in the experimental group and 18 (9 girls and 9 boys) students in the control group. Accordingly, it can be said that the distribution of female and male students in the experimental and control groups is balanced. The students in the study group are in the age range of 12-14.

Development of Scenarios

Scenarios based on the subject and scope suitable for the achievements of the "DNA and Genetic Code" unit have been prepared by examining the media reports, scientific news, and studies in the literature. After the topics of the scenarios were determined, they were written in a way that could be understood by most of the 8th grade students. The scenarios are written in short, simple language and provide sufficient content to scientifically understand the problem. The students were asked to make a decision from the perspective of the script characters. It is aimed that students benefit from their own knowledge instead of just reproducing the information in the script. Event patterns and roles of heroes in prepared scientific scenarios; it starts with an introduction that will attract students' attention, encourages students to think and allows them to structure their knowledge. Therefore, it is important to establish a cause-effect relationship in scenarios, run the problem solving process, and include operations requiring abstraction, generalization, and analysis in this process. Nine scenarios prepared before being applied to the students were examined by three teachers and two academicians who are experts in the field. These teachers and field experts gave feedback on the content and terminology of the scenarios. Based on his feedback, minor text changes were made. Information about the content of the nine scenarios is as in Table 1.

Table 1

The Course Process of The Applications, The Scientific Scenarios Used in The Process and The Content of The Scenarios

Lesson Process	Scientific Scenarios Used	The Subject Content Of The Scenarios Related To The Unit
October 15-21, 2018	Let's Learn DNA Language	Structure of DNA
October 22-28, 2018	Who Do I Look Like?	Gregor Mendel and Crossover/Genealogy
Oct. 29-Nov. 4, 2018	The New Member of Our core Family	Gender Determination / Genetic Diseases / Consanguineous Marriage
	Explosion of Chromosomes	Chromosome/Mutation
November 5-11, 2018	What is this Colour Change!	Phenotype/Modification
November 12-18, 2018	Visit to the land of Frozen	Adaptation
November 19-25, 2018	Minor Changes	Gene Transfer/Cloning
November 26-30, 2018	Professor's Historic Decision	Biotechnological Applications
	Sleeping Sickness: Huntington	Gene Therapy

When Table 1 is examined, it is seen that a total of nine different scientific scenarios were applied in the study. Two scientific scenarios were used in the weeks of October 29- November 4 and November 26-30, and one scientific scenario was used in the other weeks. Concepts in the content of the aforementioned scenarios (Structure of DNA, Gregor Mendel and Crossover / Pedigree, Sex Determination / Genetic Diseases / Consanguineous marriage, Chromosome / Mutation, Phenotype / Modification, Adaptation, Gene Transfer / Cloning, Biotechnological Applications, Gene Therapy) are individually given in Table 1. In this case, it is seen that the scenarios deal with different socioscientific issues within the scope of the unit in terms of subject content.

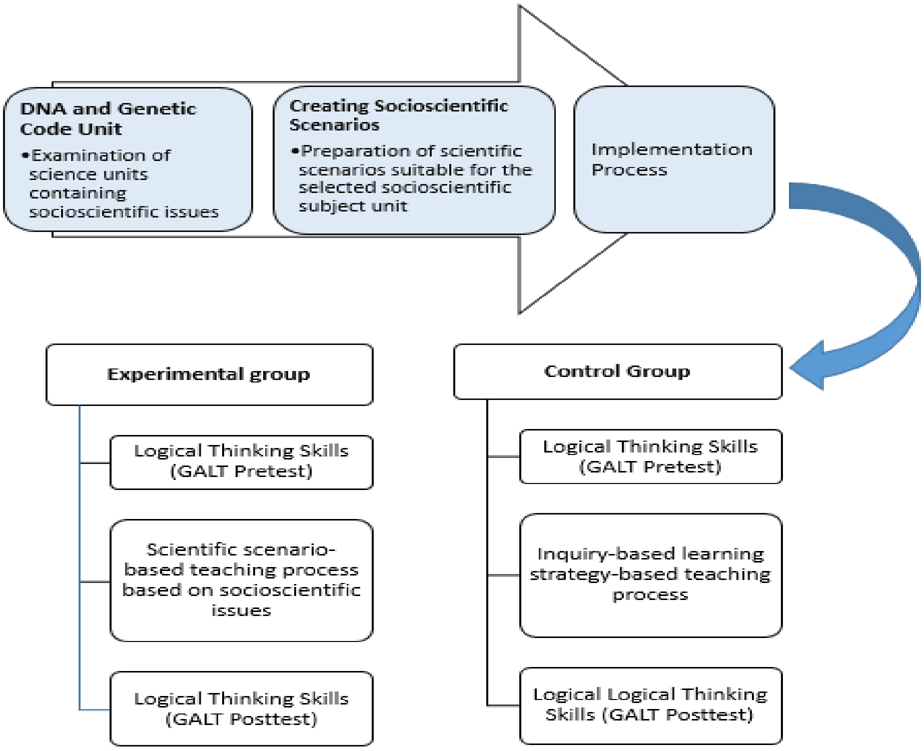
To give a little more detailed information about the scenarios, in the scientific scenario called “Let’s Learn the Language of DNA”, the dream of the character named “Elif” and the structure of DNA, nucleotides, genes and chromosomes are discussed through her magic glasses that magnify everything in this dream fifty million times. In the scientific scenario named “Who Do I Look Like?”, the character named “Emre” watches the scientist documentary “Gregor Mendel” and the subject of the character’s eye colour different from the eye colour of his parents, family tree, hereditary characteristics, external appearance (phenotype) and crosses are mentioned. The scientific scenario called “The New Member of Our Core Family” begins with the analysis of the factors that determine the sex and the rate of determining the sex of the sibling who will be born of the character “Zeynep”. In the scenario that deals with genetic diseases that may occur due to consanguineous marriage, the path followed by the character named “Zeynep” was given and the questions were asked to be answered. In another scientific scenario called “Explosion of Chromosomes”, the dispersal of the beads of the pearl necklace of the teacher named “Fatma” and the arrangement of the chromosomes were correlated. In the scenario, mutations and their effects that will occur because of misalignment of beads are compared to chromosomes. In the scientific scenario called “What’s This Colour Change!”, the friendships of the characters “Felix” and “Özgür” living in different countries are mentioned. Two friends with different skin colours are arguing that the skin colour change is due to the effect of the sun’s rays and is not permanent. With this event, the concept of modification in the scenario and examples related to it (primrose) are discussed. The scientific scenario called “Visit to the Land of Frozen” deals with the adaptations of the creatures living in the polar regions on the journey of two brothers named “Tuğba” and “Mete” with a time machine. In the scientific scenario called “Minor Defects”, the gene transfer performed by the engineer named “Mr. R” on strawberry is discussed Tissue and organ donation, cloning issues are explained with the character of Mr. R, who uses a potion to go to the future for studies on living things. The scenario named “Professor’s Historical Decision” deals with the social examination of the effect of wild African cats on natural selection, which a scientist copied using biotechnological methods at a meeting. The scientific scenario called “Sleeping Disease: Huntington” deals with the fact that an individual named “Melih” from the couple who wants to have a child has a genetic disease. The scenario includes the applicability of a gene therapy method that has not been done before and the development of biotechnological methods. One of the scenarios used within the scope of the study is presented in Appendix 2.

Process

The research was carried out in an 8th grade on the "DNA and Genetic Code" unit in the first semester of the 2018-2019 academic year. One of the ten specific objectives of science teaching programs in Turkey is expressed as "making decision ability using socioscientific issues, develop scientific thinking habits and decision-making skills" (MoNE, 2018). Therefore, the whole process of the study has been shaped in line with the specific purpose mentioned. However, the goal of the said unit is expressed as following by Turkey-Ministry of Education (2018): "In this unit, it is aimed for students to explain the concepts related to DNA and genetic code and to discover the relationships between them, to be aware of the applications of inheritance, mutation, modification, adaptation, selection, variation, genetic engineering and biotechnology, and to gain knowledge and skills about discussing their positive/negative effects". For this reason, suitable scientific scenarios were created in the study for the purpose of the unit. The literature and expert opinions were used in the creation of scientific scenarios. In the next process, after the preliminary tests of the data collection tools used in the research were carried out, the application phase was started. During the nine-week practice, nine scientific scenarios were used for the experimental group lessons, depending on the conceptual sequence and limitation in the relevant unit. The scientific scenarios and socioscientific issues that include the mentioned concepts are taught step by step, sticking to their place in the science program. The related unit learning outcomes and concepts are presented in the additional text are given in Appendix 1. Lessons in the experimental group were carried out with a scientific scenario-based teaching process based on socioscientific issues, and in the control group, with an inquiry-based learning strategy-based teaching process. In the research-based learning strategy-based teaching process, the activities in the Education Information Network, which is open to the use of teachers in Turkey, were used. It was aimed to teach the same unit concepts with the strategy-based activities mentioned in the control group. In both groups, applications were carried out within the scope of the science course, four hours a week. After this application process, post-tests were applied to both groups. The schematic representation of the application process is as in Figure 2.

Figure 2

Scheme of The Implementation Process

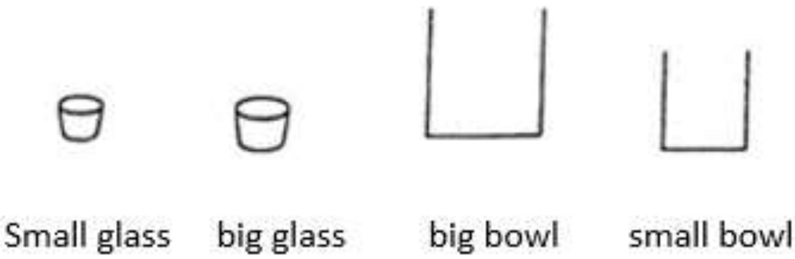


Data Collection

The Logical Thinking Group Test (GALT), originally developed by Roadrangka et al. (1983), was used to measure students' logical thinking skills in the study. The test was translated into Turkish by Aksu et al. (1991) and was created by selecting items with high validity and reliability from the tests that were previously developed in this field and measure different thinking skills. GALT measures six logical operations, including conservation of matter, correlational reasoning, proportional reasoning, control of variables, probabilistic reasoning, and combinatorial reasoning. The scale consists of 21 items in two stages. In the first 18 of these items, students are asked to choose the correct answer among the options in the first stage, and mark the reason for choosing the correct answer from the given options in the second stage. In the last three items of the scale, students are asked to answer the given situations with an explanation. An example of the questions in the scale is as follows:

Question 8: Glass Size 2

The figure below shows two glasses, one small and one large, and two bowls, one large and the other small.



It takes 15 small or 9 large glasses of water to fill the large bowl. The small bowl is filled with 10 small glasses of water.

How many large glasses of water does it require to fill the small bowl?

a) 4
b) 5
c) 6
d) Other

Reason:

1. Less than 5 small glasses of water are required to fill the small bowl. So less than 5 large glasses of water are required to fill the same bowl.
2. The ratio of large and small glasses will always be 5 to 3.
3. The small glass is half the size of the large glass. Therefore, the same small bowl is completely filled with approximately half the number of large glasses with water.
4. It is impossible to predict.

In the first 18 multiple choice questions of the test, the student who gave the answer correctly together with the reason is given 1 point, and the student who answered any of them incorrectly is given 0 point. Since the last three questions are open-ended, students are asked to write the correct answer. Considering the correct answers written by the students, the answers are scored as 1 and 0. The highest score students will get from this test is 21. In scoring the scale, the use of sources that developed the scale (Roadrangka et al., 1983) and adapted it to Turkish (Aksu et al., 1991) was applied exactly. The cognitive development periods of the students according to the scores they got from the GALT test are as in Table 2.

Tablo 2

Operational Levels of Students According to GALT Test Results

Scores from the GALT Test	Student's Operational Period
0-8 score	Concrete operational period
9-15 score	Transition period
16-21 score	Abstract operational period

The scores obtained from the GALT test are evaluated as concrete operations (0-8 score), transition (9-15 score) and abstract operations period (16-21 score) (Bitner, 1991; Hacıömeroğlu & Hacıömeroğlu, 2018). The reliability coefficient (Cronbach's alpha) of the mentioned scale was found to be .85 (Roadrangka et al., 1983), and the reliability coefficient was found as .88 (Aksu et al., 1991) in the Turkish version. In addition, the reliability calculation was made with the data in this study and the reliability coefficient (Cronbach's alpha) was found as .81. When the value obtained from this study is examined, it can be said that there is consistency between the answers given by the participants to the scale items (Pallant, 2017). The appropriate response time for the Logical Thinking Group Test is 60 minutes.

Data Analysis

First of all, the normality distribution of the pre-test and post-test scores of the groups was examined and interpreted by taking Shapiro-Wilk values into account. As a result of the analysis, it was found that the Logical Thinking Skills pre-test scores showed normal distribution in the experimental and control groups (p_{exper}=.230; $p_{control}$=.436). It is observed that the post-test scores do not show normal distribution in the experimental and control groups (p_{exper}=.024; $p_{control}$=.035). Then, in order to make sure that the groups were in the same place in terms of the dependent variable before the experimental procedure, it was tested for independent groups with the t-test whether the mean scores of the pre-test were equal or not. The t-test results of the logical group test (GALT) pre-test scores for the experimental and control group students and for the independent groups are given in Table 3.

Table 3

T-Test Results of The GALT Test Pre-test Scores for Independent Groups

Group	*n*	$\bar{X}$	*S*	*sd*	*t*	*p*
Experiment	17	.185	.125	32	1.195	.241
Control	17	.140	.091			

* *p*<.05

According to Table 3, it can be said that the logical thinking skill levels of the students in the "DNA and Genetic Code" unit in the science lesson before the experimental study were the same as the students in the control group ($\bar{X}$=.140) and the students in the experimental group ($\bar{X}$=.185). Before the experimental study started, it was observed that there was no significant difference between the logical thinking skill levels of the students (*t*=1.195; *p*=.241). It was observed that the mean scores of the logical thinking group tests were equivalent to each other in the experimental and control groups before the study. The operational period in which the students participated in the logical thinking group test was revealed with descriptive statistics (%, frequency). In order to determine whether the experimental process had an effect on the logical thinking group test (because the test did not provide the assumption of normality), the data were analysed with the Mann Whitney U-test. Before and after the experimental application, whether there was a significant difference in the logical thinking skills of the students according to the operational period they were in was analyzed with the Wilcoxon signed-rank test.

Non-parametric tests are used in cases where the number of samples is small or the data do not show normal distribution (Pallant, 2017). In cases where a normal distribution is provided, the use of parametric tests is always recommended as a better option (Can, 2019). Effect size is useful because it provides an objective measure of the significance of the effect (Field, 2009). For this reason, effect size values were calculated because they increase the comprehensibility of the results (Büyüköztürk, 2014).

Ethical Approval of the Study

All necessary ethical permissions were obtained before the data of this study were collected. The research was carried out by the Ethics Committee of Science and Engineering Sciences of Manisa Celal Bayar University with the ethical permission dated 01/10/2018 and numbered 46544. In addition, all participants were informed about the study and the students participating in the research were included in the study on a voluntary basis. In addition, since the participants were between the ages of 12 and 14, permission was obtained from both the students and their parents with the "parent consent form" and "voluntary participation form" documents for ethical consent for the study.

Results

Statistical information about the periods in which the experimental and control group students took part in pre and post-tests in terms of their logical thinking skills are given in Table 4.

Table 4

Statistical İnformation of The Experimental and Control Group Students in terms of Their Logical Thinking Skills

	Pre-test				Post-test			
	Experimental group		Control group		Experimental group		Control group	
	f	%	*f*	%	*f*	%	*f*	%
Concrete Period (0-8 scores)	16	94.12	17	100	13	76.47	17	100
Transition Period (9-15 scores)	1	5.88	0	.00	3	17.65	0	.00
Abstract Period (16-21 scores)	0	.00	0	.00	1	5.88	0	.00
Total	17	100	17	100	17	100	17	100

* Since there was a lack of post-tests of one student in both experimental and control groups, these students were not included in the analysis.

According to Table 4, it is seen that all (100%) of the control group students took part in the concrete period, before and after the experimental process. It is observed that 94.12% of the experimental group students took part in the concrete period and 5.88% in the transition period before the experimental process After the experimental process, it is understood that 76.47% of the experimental group students took part in the concrete period, 17.65% in the transition period and 5.88% in the abstract period.

The minimum and maximum values of the logical thinking skills pre-test and post-test scores of the experimental group and control group students are given in Table 5.

Tablo 5

Minimum Maximum Values of Students' Logical Thinking Skills Pre-Test and Post-Test Scores by Groups

		Pre-test			Post-test		
Group	*n*	Median	Minimum	Maximum	Median	Minimum	Maximum
Experiment	17	3	0	10	4	0	16
Control	17	3	0	7	3	1	6

According to Table 5, it is seen that while the highest score the students in the experimental group got from the pre-test was 10, it increased to 16 points in the post-test. Although the students in the control group got the highest seven points in the pre-test, it was observed that the highest scores in the post-test were six. It is observed that the maximum score obtained by the experimental group students in the lessons carried out with the scientific scenario-based teaching process based on socioscientific issues has increased significantly.

Mann Whitney U-test results of logical thinking group test post-test scores for experimental and control group students are shown in Table 6.

Table 6

Mann Whitney U-Test Result of Logical Thinking Group Test Post-Test Scores According to the Group

Group	*n*	Median	Minimum	Maximum	*M-W U*	*p*	Effect size *(r)*
Experimental	17	4.0	0	16	110.500	.036	.36
Control	17	3.0	1	6			

* $p<.05$

According to Table 6, at the end of the experimental study, a significant difference was found between the scores of the students in the logical thinking group test, (U=110.500, $p<.05$). Considering the rank averages, it is understood that the students in the experimental group, where the courses were taught using scientific scenarios, had higher logical thinking than the control group students who were applied to the current science curriculum. It shows that the effect size of this difference is r=.36, the difference has a great effect and 13% of the total variance is explained by the use of scientific scenarios in the teaching of socioscientific issues.

Statistics related to the results of the Wilcoxon signed ranks test regarding whether the operational period in which they are present shows a significant difference according to the logical thinking skills of the students before and after the experimental application are given in Table 7.

Table 7

Wilcoxon Signed-Rank Test Results Regarding The Logical Thinking Group Test Scores of The Students in The Experimental and Control Groups

Groups	PostTest-PreTest	*n*	Rank average	Rank total	*z*	*p*	Effect size *(r)*
Experimental	Negative Rank	0	.00	.00	2.00*	.046	.343
	Positive Rank	4	2.50	10.00			
	Equal	13					
Control	Negative Rank	0	.00	.00	1.00*	.317	
	Positive Rank	1	1.00	1.00			
	Equal	16					

* Based on negative ranks

The results of the analysis show that there is a significant difference between the pre-experiment and post-experiment scores that the students in the experimental group got from the logical thinking group test, [z=2.00, p<.05, r=.343]. Considering the rank average and total of the difference scores, it is seen that this observed difference is in favour of the positive ranks, that is, the post-test score. The effect size of this detected difference, r=.343, shows that the difference has a moderate effect. It is seen that there is no significant difference between the pre-experiment and post-experiment scores that the students in the control group got from the logical thinking group test, [z=1.00, p>.05].

Discussion and Conclusion

In the study, the effect of science teaching activity practices carried out with scientific scenarios within the scope of the science lesson “DNA and Genetic Code” unit on the logical thinking skills of 8th grade students was evaluated. According to the results obtained from the study, it is seen that scientific scenario applications improve students’ logical thinking skills. Before the experimental process, it is understood that both the experimental group and the control group students were mostly involved in the concrete period. After the experimental process, although there was no change in the control group, it was observed that two of the students in the experimental group went through the transition period and one went into the abstract period. When Table 4 and Table 5 are examined together, it is seen that the highest score obtained by the control group students before the application was seven, and the highest score obtained after the application was six. All of the control group students are in the concrete period before and after the application. When it comes to the students in the experimental group, it is seen that the highest score obtained before the application was 10, while this score was 16 after the application. While the period the students are in is a concrete and transitional period before the application, it is seen that there are students who get into the abstract period after the application, and there are some students who are in the transition period among the students in the concrete period. This may be effective in noticing the problem situation in the scenarios during the teaching process, seeking solutions, making decisions, and making discussions while doing this, and logical thinking being active in the mental process in the whole process. In his study, Ramirez-Villaren (2020) showed that the number of evidence-based justifications used by students in discussions increased in the teaching practice in which scenarios involving socioscientific issues were used, and there was a positive development in their reasoning and decision-making skills. Cian (2020), on the other hand, states in his study that students carry out different logical thinking after the teaching practice with scenarios on socioscientific issues of environment and genetics. Kinslow et al. (2019) encountered a similar situation in their studies and interprets the development of students' reasoning skills as a reflection of students' development of multiple perspectives and inquiry skills in order to understand the dilemmas of scenarios used in socioscientific issues, and thus an increase in their reasoning skills.

Within the scope of another sub-problem of the study, the scores obtained by the students in the logical thinking group test were re-evaluated by considering the score categories of the periods. As a result of the analysis of how the experimental and control group students' score changed before and after the experimental process, it was determined that the increase in the experimental group was statistically significant. In this case, it can be stated that science teaching with scientific scenarios is effective for students to move up from the developmental period they are in. According to Piaget, when the student in the concrete period does not show enough cognitive development, he continues to stay in the concrete period. Therefore, the development of students' logical thinking skills is very important in terms of learning, considering the skills of individuals in the concrete, transitional or abstract period. In the study of Eskandar et al. (2013), it is seen that most of the students are at the level of concrete thinking and only a few students reach the transition level in the analysis of the pre-test results. When the studies on logical thinking skills are examined, it is understood that most of them are at the level of concrete thinking of secondary school students (Baser, 2007; Soylu, 2006; Yenilmez et al., 2006). The study of Tajudin and Chinnappan (2015) also shows that the majority (94%) of secondary school students (16-17 age group) have their cognitive levels at the level of concrete operations. It is stated that students' low logical thinking skills are seen more in exam-based education systems (Fah, 2009). Therefore, it can be stated that school evaluation systems that emphasize only the acquisition of content knowledge cause students to have a low level of logical thinking skills.

According to Piaget's mental development theory, considering the developmental stages that individuals are expected to find according to ages, it is seen that 8th grade students are expected to be in the abstract processing period, that is, to have similar characteristics to adult individuals. In this case, they will be able to benefit society through social interactions. This requires the ability to make decisions in logical ways and to solve problems by adhering to analytical thinking (Salami, 2021). Exposing children to problem situations creates a process that supports their abstract thinking (Berk, 2013). Some studies show that students' logical thinking skills are developed, especially in solving problems given as daily life problems involving abstract concepts (Borges et al., 2017; Gulacar et al., 2013). There are studies showing that logical thinking develops differently in children of the same age (Lazonder et al., 2021), the developmental pattern is not equally applicable to all children, and that general linear progress is made by some, not all children in a class (Koerber et al., 2015). In a different study, students' logical thinking skills were divided into levels as high, medium and low. It is stated that 35% of the students are high, 29% are medium and 36% are low (Kılıç, 2009). It is stated that individuals with low logical thinking skills have difficulties in perceiving and learning the facts, events, situations or concepts that require abstract thinking (Lawson & Renner, 1975). In addition, it is stated that logical thinking skill is important in understanding science concepts, and it is the most effective predictor of success in solving genetic problems (Cavallo, 1996). Johnson and Lawson (1998) reveal that the important predictor of students' success in biology subjects is their logical thinking skills. Dawson and Venville (2013) state that in their study, genetics, which includes socioscientific issues, can help students to think and reason logically. Cian (2020) and Shea et al. (2015) investigated the effects of students' reasoning about genetics on teaching and learning and they found that they produced logical conclusions in different ways. In this study, the concept, facts and events within the scope of biology are included in the content of the unit where the experimental application is performed. In this case, the development in the logical thinking skills of the students in this study sample can be expressed as an important predictor in the acquisition of the mentioned concepts.

In the study, there is no significant difference between the logical thinking skill levels of the students before the experimental process, due to the analysis performed to evaluate the effect of the use of scientific scenarios in teaching socioscientific issues on the development of students' logical thinking skills. After the experimental process, it was observed that there was a significant difference between the logical thinking skills of the experimental group students in which scientific scenarios were used in teaching compared to the control group students using the current science teaching program ($p < .05$) and the experimental group students' logical thinking skills were higher. This situation shows that the teaching of the lessons with the use of scientific scenarios in the teaching of socioscientific issues in the science course is effective in developing students' logical thinking skills. In this context, although there are different learning teaching methods, techniques and activities in the literature, when the studies using scientific scenarios are examined, it is seen that some of them have an effect on the development of logical thinking skills, and some of them have no effect on the development of logical thinking skills. Aydın and Kaptan (2014) examined the development of logical thinking skills of groups in which argumentation-based education was applied using scenarios. The authors found that by presenting the scenarios, the group in which the argumentation was made developed the logical thinking skills significantly. Similarly, it is stated that there is a significant difference in logical thinking skills in the groups where the scenarios are used in project-based learning and the traditional method, and project-based learning is effective on developing logical thinking skills (Sert-Çıbık, 2006). Zeidler et al. (2009) also reported that the SSI-based teaching (socioscientific issues (SSI)), which they applied for a year, had a positive effect on the development of reflective judgment of senior high school students. Students' being exposed to problem situations supports their abstract thinking (Berk, 2013), and their logical thinking skills can develop by being able to examine the situation in a versatile way. When the nature of the logical thinking skill scales developed and applied at the secondary school student level in the international literature for the last decade is examined, it is seen that the use of scenarios and the construction of the scales on the script are indispensable (Croker & Buchanan, 2011; Ibrahim et al., 2016; Lazonder & Janssen, 2021; Lazonder et al., 2021; Osterhaus et al., 2020; Woolley et al., 2018). It is thought that the use of scientific scenarios is important in both developing logical thinking skills and observing existing logical thinking skills.

Implications

As a result of this study, it has been understood that the socioscientific subject-based instructional experience in the science lesson, which includes scientific scenarios, has a supportive effect on students' logical thinking. Of particular interest in this study is the way students reasoning through socioscientific scenarios. With scientific scenarios, students have been exposed to situations similar to real life problems for the subjects and concepts in the "DNA and Genetic Code" unit. It is thought that thinking about solutions to these problems individually and as a group during the lesson, sharing the solutions they found with other students, and making argumentation during the process are thought to be effective in the development of logical thinking skills.

The results of this study were obtained with a limited number of students and nine scientific scenarios in a six-week period. Although it is seen that students' logical thinking skills develop at the end of the instructional process they experience, it is necessary to be careful in making broad claims about how the use of scientific scenarios will affect the development of logical thinking skills of other students. For example, sudden changes in society due to the pandemic process that the whole world is experiencing can rapidly change the way individuals think, discuss, and use logical processes on socioscientific issues related to genetics, such as genes and mutations in this study. Factors limiting the work as the study is limited to the use of logical thinking processes by the participants and its reflection, as a result of the discussions held over scientific scenarios on the subject and scope of the "DNA and Genetic Code" unit, and the educational experiences in which these discussions took place' are specified.

Considering the results obtained from the study, it is thought that the teaching method and activities supporting the development of students' logical thinking skills should be used meticulously by teachers, in classroom practices. In this context, longitudinal studies can be carried out to support students' logical thinking skills, studies for teachers, and activity development activities. In addition, long-term longitudinal studies can be carried out with the use of scientific scenarios in teaching socioscientific issues, as well as different methods suggested in the literature, apart from scenarios. In addition, it is recommended to conduct studies investigating the effect of covering socioscientific issues with scenarios on decision-making skills, critical thinking skills, argumentation skills, and so on. Especially in the literature, there is a need for case studies using multiple methods to eliminate the ambiguities about the methods to be used in teaching socioscientific issues. Thus, it is thought that the concerns of teachers regarding the handling of socioscientific issues in lessons can be eliminated.

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Statement of Responsibility

Fatma Şaşmaz-Ören; conceptualization, determination of the problem situation, determination of the sample group, selection and application of data collection tools, design of the research process, development of activities, data analysis, verification, writing-examination and control, project administration. Ayşegül Karapınar; conceptualization, determination of the problem situation, selection of data collection tools, development of activities, methodology, research, data analysis-writing, writing-draft and original, writing-review and editing. Kübranur Sarı; development of activities, data collection, verification, research. Tuğba Demirer; development of activities, execution of the implementation process, data collection, verification, research.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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Appendices

Appendix 1: Learning Outcomes and Concepts of the "DNA and Genetic Code" Unit in which the Applications of the Study are Made

F.8.2.1. DNA and Genetic Code - (1. subtopic that is the same as the name of the unit)

Subject / Concepts: Structure of DNA, self-replication of DNA, nucleotide, gene, chromosome

F.8.2.1.1. Explains the concepts of nucleotide, gene, DNA and chromosome and establish a relationship between these concepts.

F.8.2.1.2. Shows the structure of DNA on the model.

F.8.2.1.3. Expresses how DNA matches itself.

F.8.2.2. Heredity- (2nd subtopic of the unit)

Subject / Concepts: Gene, genotype, phenotype, pure progeny, hybrid progeny, dominant, recessive, cross, gender, consanguineous marriages

F.8.2.2.1. Defines the concepts related to heredity.

F.8.2.2.2. Comments on the results by solving problems with single character diagonals.

F.8.2.2.3. Discusses the genetic consequences of consanguineous marriages.

F.8.2.3. Mutation and Modification -(3rd subtopic of the unit)

Subject / Concepts: Mutation, modification

F.8.2.3.1. Explains the mutation based on examples.

F.8.2.3.2. Describes the modification based on examples.

F.8.2.3.3. Makes inferences regarding the differences between mutation and modification.

F.8.2.4. Adaptation (Adaptation to the Environment) - (4th subtopic of the unit)

Subject / Concepts: Adaptation, natural selection, variation

F.8.2.4.1. Explains the adaptation of living things to the environment they live in by observing.

F.8.2.5. Biotechnology- (5th subtopic of the unit)

Subject / Concepts: Genetic engineering, artificial selection, biotechnological studies, impact of biotechnology applications on the environment

F.8.2.5.1. Associates genetic engineering and biotechnology.

F.8.2.5.2. Discusses the useful and harmful aspects of these applications for humanity with the dilemmas created within the scope of biotechnological applications.

F.8.2.5.3. Predicts what future genetic engineering and biotechnology applications might be.

Note: A kind of code is used in sciences programs in the Ministry of Education of Turkey. If we take in consideration F.8.2.1. as example;

'F' shows that it is a science lesson,

'8' shows that it is the 8th grade level,

'2' shows that it is the second unit,

'1' shows that it is the subject number and that for each one, the number following represents the gain number.

Appendix 2

Scenario 5 (November 5-11, 2018)

WHAT IS THIS COLOR CHANGE!

Greeland, one of the coldest regions of the Arctic, is a country that is covered with snow all year around, about 82% of which is made up of glaciers. Even in summer, Greenland receives the Sun's rays at an oblique angle, when the temperature is below freezing throughout the year. The geographical location, people, lifestyles and cultures of this country, where there is very little sunshine, cause many researchers and travellers around the world to turn their route to Greenland. One of these travellers is Özgür. Özgür travels countries and publishes his experiences in a tourism magazine. Özgür, who went to Greenland, encountered more difficult weather conditions than he thought while walking around the capital Nuuk, and was confused by the sadness of not finding anything to eat. Just then, a young man named Felix notices him. Felix approaches Özgür and asks how he can help. At that moment, Özgür observes Felix, as if he had not heard anything. Because he thinks that he has never seen another person with such a light skin colour before. Özgür, who comes to him later, responds to Felix's call for help and they go to dinner together. Felix mentions that he makes his living by hunting whales and polar bears, and that very few vegetables and fruits are grown in Greenland. For this reason, he says that people meet most of their nutritional needs from raw meat. Realizing that he can learn a lot about the city and country from Felix, Özgür asks Felix to help him with his research. Felix, who willingly accepted this, formed a very good friendship with Özgür over time. Özgür, who is very pleased with the friendship between them, never wants to leave Felix. Then, when Özgür comes to the end of his research, he offers Felix to return to Turkey together. Özgür is very confident that his offer will not be rejected, as he learned that his friend is curious about hot countries during their conversation. Özgür, who received a positive answer from Felix as he expected, was very happy and immediately started preparations. Unfortunately, the paths are quite long.

The duo, who set foot in Turkey after a long journey, arrive in Antalya, where Özgür's family lives. Felix is quite surprised when they arrive in Antalya, one of the hottest and sunniest regions in Turkey. Because all his life, he never went out of the house in thin clothes. However, people are very thinly dressed and the sun is very scorching. Felix enjoyed the hot weather and the sun for days and got rid of his thick clothes, and he liked this situation very much. But what is it! While changing in front of the mirror one morning, Felix notices that his skin has turned quite dark. In fact, there are tonal differences in the arm and neck parts where the shirt ends. Horrified, Felix immediately goes to Özgür's room and begins to ask questions one after another. What answers would you give to Felix if you were at Özgür's place?

1. Why has my skin colour changed so much?
2. Will my skin always stay like this?
3. Will these marks on my skin be on my children in the future?

With the answers he received from Özgür, Felix was convinced that this skin colour change was due to the effect of the sun's rays and was not permanent, and finally took a sigh of relief. This means that the sun's rays can change its external appearance, but this change can return to its former state over time. Felix, who thinks that it is time to return home, thinks how shocked his family will be. Although he has been planning for a long time, he cannot decide on the gift he will buy for his mother when he returns Felix, who got an idea from Özgür on this subject, finally decides to take a potted plant called primrose to his mother. Because this plant blooms with white flowers and his mother likes the colour white very much. As he has bought his gift, it is now time to go back home, Felix makes a promise to meet his beloved friend Özgür again and says goodbye and sets off. There is still an ocean to cross. As he gets closer to his country, it is possible to notice that the weather conditions are getting harsher and the temperature is decreasing. Worried that his flower will be affected by these weather conditions and die, Felix returns home after a long time with the flower that he has been protecting with great devotion along the way. He excitedly gives his mother the primrose she brought. The mother, who was very happy with the gift she received, put her flower in the most beautiful place of her home. A few days later, while Felix and his mother are having breakfast, his mother's eye catches suddenly the primrose. Because the new flowers of the primrose plant, which had white flowers before, are blooming red. Let us answer the following questions that occur in the minds of the mother and her son, who cannot make sense of this.

1. What is the reason why the newly opened flowers of the primrose are red? Does this have anything to do with changing the environment in which the flower is located?
2. If we take the primrose back to Turkey, will it bloom in white?
3. Has the chromosomal structure of the primrose changed? Please explain.
4. Is there a relationship between the reasons that Felix's skin colour changes and the reason why the newly opened flowers of the primrose are red? Please explain.
5. Can environmental conditions change the external appearance of living things? If your answer is yes, explain with examples.

References

The pictures used in the scenario were obtained from the following addresses, in order, from beginning to end:

- https://commons.wikimedia.org/wiki/File:Greenland_in_the_world_(W3).svg
- https://pxhere.com/tr/photo/488841
- https://pxhere.com/tr/photo/1045085