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Sample issue for the teaching of socio-scientific issues: The endangered Northern bald ibis

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Abstract

The prominence of socioscientific issues (SSI), that combine society with science, in education has grown in recent years. The northern bald ibis is important for science and society since it is an endangered species, it only inhabits one region in Turkey and has a limited population worldwide. This study aims to ascertain the impact of the implemented SSI program on participating high school students from the area where the endangered northern bald ibis can be found, insofar as their conceptual knowledge and their opinions about the SSI. The study used a one group pretest-posttest design. The participants for the study were 75 students from a state high-school in the Birecik district of Şanlıurfa province. The study used and SSI program centred around interaction. The conceptual knowledge form and the scenario called "Northern Bald Ibis Under Threat" were used as data collection tools before and after the SSI program. Quantitative data analysis was conducted using paired samples t test and content analysis was employed to analyse qualitative data. The quantitative findings of the study show that implementation of the SSI program enhanced the level of conceptual knowledge of the participating high students who live in the area inhabited by the northern bald ibis. The qualitative data obtained in the study show that the high school students' opinions changed following the SSI program. Before the SSI program the students stated that they though hunting was the reason the northern bald ibis was going extinct whereas after the SSI program the students stated opinions related to agricultural pesticides as a reason for extinction. When it comes to suggestions to protect the northern bald ibis, this study observed that student opinions shifted from suggestions related to taking better care of the species before the program, to protecting the environment after the program. It was also observed that at the end of the SSI program students had a broader perspective on the issue and evaluated the issue using more scientific terminology.

Keywords: Socioscientific issues; SSI program; environmental education; conceptual knowledge, opinion

1. Introduction

Questions such as "Are cell phones bad for us? Should animals live in zoos? Which type of alternative energy is the best?" are familiar to science teachers but answering such questions scientifically is no easy feat (Kahn & Hartman, 2018). Since both societal and scientific factors play key roles in these quandaries, they are dubbed socioscientific issues (SSI). Topics related to biotechnology and environmental issues are grouped together as

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SSI to highlight the close relationship between science and society (Sadler, 2004). Today's societies are often faced with SSI such as GMO, nano-technologies or climate change that create political and moral dilemmas. Offering students opportunities to gain experience about this type of content in order to enable all people to become scientifically literate has become a necessity of science education (Albe, 2008). Meaning, a student who gains experience with a socioscientific issue will be better equipped insofar as attitude and implementation when they later face another socioscientific issue (Sadler, 2009). In short, it is vital that students are informed of SSI so that they may become scientifically literate (Atabey & Topçu, 2017).

The controversial nature of socioscientific issues is caused by facets that reflect well thought out and rational occurrences. Socioscientific issues that have equally likely solutions can be approached differently by rational and thoughtful individuals due to personal priorities, principles and prejudices. Individual perspectives can prompt people to see socioscientific issues very differently and cause them to advocate for opposing solution strategies (Sadler & Zeidler, 2005a). The content of socioscientific issues include the ethical aspects of science, the moral judgement of the students and the emotional development of the student (Zeidler et al., 2002). Ethical thinking enables the connection between scientific and non-scientific areas of study and furthermore between the students and the social, material, organic and physical world they inhabit (Zeidler, Herman, & Sadler, 2019). SSI teaching also aids students in developing high level cognitive abilities such as critical thinking, decision making or knowledge the nature of science (Evagorou, Güven, & Muğlaoğlu, 2014).

The role of the teacher in teaching socioscientific issues is to encourage the student to make evaluations using proof based alternative arguments. The greatest challenge for a science teacher in the teaching of such issues is to be critical of their own beliefs in order to make way for the creation of new perspectives. Teachers are responsible for offering their students opportunities to question their own belief systems so that they may make connections between the real world and the social world (Zeidler & Nichols, 2009). There are many defining factors within SSI teaching that are directly tied to the teacher. Teachers' attitude towards science education and their knowledge of SSI are two of the main factors in their competence in teaching SSI (Han Tosunoğlu & İrez, 2019). The teacher's choice of topic is also just as important as the current state of resources and the willingness of the teacher (Hancock et al., 2019).

In education, the science of biology is one of the most important tools in helping the students understand themselves and their environment. To this end, students learn about how the heart works, how water travels through the human body, how to tell what area a plant likes to live in by observing its foliage or what problems a species of animal is likely to face due to changes in their habitat. All plants and animals have habitats that offer them the best chance of survival and most of the time these habitats are shared

with humans. While water is the habitat of the fish, the sky is the habitat of the bird. Birds, which are one of the main rulers of the skies, share the skies with humans. According to Kinslow and Sadler (2017) students can form relationships with birds in a multitude of ways such as by observing birds in the school playground, keeping birds as pets or classifying birds. However sometimes humans have insufficient knowledge about these living beings we share the same sky, same water, same land with, even if they are included in the curriculum. Uzel (2019) states that students living in the same area as he northern bald ibis do not know the species very well, to the point that they have insufficient or incorrect knowledge on these animals. The northern bald ibis only nest in Birecik, Şanlıurfa (Kuru, 2013). Also, the Northern Bald Ibis (*Geronticus eremita*) has been listed as a critically endangered, globally threatened species since 1994 (BirdLife International, 2018). This endangered and protected species has an important place in Turkish fauna. Furthermore, there is work being done to repopulate this species and it is protected and watched over by the general public (Mundan & Çetin, 2012). Due to these properties the northern bald ibis is important both socially and scientifically, making the study of this species a socioscientific issue. This study focuses on the northern bald ibis as a socioscientific issue. Socioscientific issues are a good resource for learning and teaching biology (Nurtamara, Sajidan, & Suranto, 2019). Moreover, when the relevant literature is examined, it has been identified that within the field of SSI, SSI teaching is the least studied area (Genç & Genç, 2017) with more emphasis placed on descriptive studies, nuclear energy and GMOs being the most researched topics (Değirmenci & Doğru, 2017) and prospective teachers being the most researched group (Özcan & Kaptan, 2020).

This study aimed to identify the impact of the implemented SSI program on high school students living in the same area as the endangered northern bald ibis insofar as their conceptual knowledge and opinions about socioscientific issues. With this in mind the problem of the study was identified as "Do students' conceptual knowledge and opinions about SSI change after an SSI program is implemented to high school students living in the same area as an endangered species?". The following sub-problems were researched according to the main problem identified:

1. Is there a change in the conceptual knowledge of high school students living in the same area as an endangered species following the SSI program?

2. What are the opinions of high school students living in the same area as an endangered species on SSI before and after the SSI program?

2. Method

2.1. Research design

This study was an experimental study, conducted using the one group pretest-posttest research design. In this design, measurements are made before and after the experiment, following the application of an independent variable to a single group (Karasar, 2012). In short, experimental studies are aimed at ascertaining the impact of the differences revealed by the researcher on the dependent variables (Büyüköztürk et al., 2012). The one group pretest-posttest experimental research design to evaluate impact of the implemented SSI program on the conceptual knowledge of the students and their opinions about socioscientific issues.

2.2. Participants

The endangered northern bald ibis species, discussed in the study, can only be found in the Birecik (Şanlıurfa) region. The purposeful sampling method was used to identify the participants in the area for the study. The participants for the study were comprised of 75 students studying at a state high school in the Birecik district of Şanlıurfa Province. As subjects related to the environment such as biological diversity, ecosystems, current environmental issues etc. were included in the 10th grade biology curriculum for the 2018-2019 school year, the program was implemented to 10th grade students. While the initial participants for the study was made up of 80 students, the participants were eventually made up of 75 students, taking into account full participation in all implementations. As the high school in question is an all-male high school, the participants are homogenous when it comes to the gender of the participants. Gender is not an affecting factor in students' abilities to make individual decisions as it pertains to an SSI program (Rizal, Siahaan, & Yuliani, 2017) so, the gender make-up of the group is not a drawback. The aim, content, timeframe of the study alongside importance of confidentiality, attendance and volunteering were conveyed to the students in a preliminary meeting. Also, the students' privacy was protected by numbering them S1, S2, …, S75.

2.3. Implementation of the study

The central focus of this study is "the northern bald ibis". This topic is important for society and science since the northern bald ibis is endangered, it can only be found in one area of Turkey and its population is limited worldwide. Thus, it falls within the boundaries of socioscientific issues. An SSI program was utilised to inform students about the northern bald ibis. This SSI program was developed by Lee et al. (2012) and

Lee et al. (2013) and centres around student interaction. The SSI program has two main traits.

I. Dialogical and interaction-based process: This process aims to give students a multifaceted perspective through group discussions. The students refer to all types of scientific information and documentation to prove their point of view and disprove conflicting opinions. This process not only gives the students an opportunity to look at the issue from different perspectives but also enables them to question their own opinions. The discussion topics presented to the students were also prepared with this in mind.

II. Personal, social and global dimension: The topic is discussed at the personal, social and global level. The students evaluate the topic according to themselves, their families and immediate connections at the personal level, their region or their country at the social level, and internationally or worldwide at the global level.

The implementation of the study took a total of 6 weeks, 1 week for pretests, 4 weeks for implementation of the SSI program and 1 final week for posttests. The SSI program was carried out by biology teachers working in the same high school and who had completed a post graduate degree (Figure 1).

Figure 1. Visual representation of study implementation

Throughout the four weeks allocated for the SSI program, one topic concerning the northern bald ibis was focused on each week. The topics in chronological order were The Northern Bald Ibis in the World and in Turkey, The Northern Bald Ibis and Birecik, Environmental Pollution and the Northern Bald Ibis, Protecting the Northern Bald Ibis. Each topic was presented to the student in two stages.

Stage 1: The topic was introduced using a short introductory presentation, a short documentary and news articles. Special attention was given to including basic concepts included in the curriculum. At this stage, it is important to bring the students pre-existing knowledge into the fold and make the topic interesting.

Stage 2: The students were split into two groups of 3 or 4 according to the total number of students. The group members were changed for each discussion topic. Thus, the students had the opportunity to group up with different people each time and share their

various opinions. The students were encouraged to better defend their opinions and more effectively disprove the opinions of others. Then, the students were asked a discussion question. Every group was asked to discuss the topic amongst themselves and reach a consensus if possible. The students were given homework that would require them to use any and all documents, films, advertisements, books, documentaries and the like to better prove their opinions in the following week.

While the SSI program was being presented to the students, their relationship with nature, the current situation, past problems and possible future challenges were discussed. The students were encouraged to use different sources to argue their point of view. They were also asked to evaluate and share the information they gathered on the topic personally, familially, according to their inner circle, their home town, their country and the world alongside their feelings and personal experiences.

2.4. Data collection tools

The study had two data collection tools. The first was the "Conceptual Knowledge Form". First, the environmental topics covered in the grade 10 biology curriculum for the 2018-2019 school year that could be included in the topic of the northern bald ibis were identified. These topics were made into a list. These 18 concepts were evaluated by the researcher, the teachers carrying out the program and two educators in the field. The list was narrowed down by consensus to 8 concepts that could be included in the content concerning the northern bald ibis. These concepts were endemic species, endangered species, pesticide, bioaccumulation, biodiversity, ecological footprint, carbon footprint and water footprint. The students were asked about each concept in the question format "What is ….? Explain.". The time it took to answer the form used as pretest and posttest varied between 5-20 minutes.

The second data collection tool used was the "Northern Bald Ibis Under Threat" scenario found under the "Socioscientific Issues Evaluation Form" developed by Çavuş (2013). The Socioscientific Issues Evaluation Form is based on socioscientific issues students may encounter in everyday life. The original form includes the socioscientific issues of organic agriculture, addiction, endangered species, environmental issues, products containing GMOs, and nuclear power plants. The form is made up of three parts, the first two including demographic and descriptive information and the third including 11 open ended questions related to the socioscientific issues. This study used the northern bald ibis scenario in the endangered species topic. There are two open ended questions pertaining to this scenario. The questions for this scenario were presented to the students before and after the SSI program. The time taken to answer these questions was around 10-20 minutes.

2.5. Data analysis

The research conducted produced two types of data, qualitative and quantitative. The quantitative portion made up of the answers to the conceptual knowledge form was analysed using SPSS 22 statistics package program. Each concept on the conceptual knowledge form was graded as 0, 1 or 2. As per this scale, questions left blank or answered incorrectly received a 0, incomplete answers, answers with correct explanations but incorrect examples or incomplete answers and correct examples received 1 point, and complete, correct answers received 2 points. For example, if a student defined the concept of biodiversity as "the genetic diversity in an area/diversity of species/diversity of the ecosystem/diversity of genetics and species/diversity of species and the ecosystem/diversity of genetics and the ecosystem" they would receive 1 point. Thus, the lowest point total possible for the form was 0 and the highest was 16. Before analysis skewness and kurtosis values were calculated for the normal distribution assumptions. According to these calculations skewness was 1.233 and kurtosis was .408 for the pretest, and skewness was -.716 and kurtosis was .406 for the posttest. Parametric analysis is preferred in cases where skewness and kurtosis is between ±1.5 (Tabanchick & Fidell, 2013). Paired samples t test was used to identify whether or not there was a significant change in the students' point totals before and after the SSI program. Paired samples t tests are used in cases where two measurements are made or points garnered in experimental or screening studies (Büyüköztürk, 2012). A frequency distribution table showing the distribution of concepts before and after the SSI program was also used in analysing the quantitative data.

The qualitative data source for the study was the scenario titled "Northern Bald Ibis Under Threat", found in the Socioscientific Issues Evaluation Form. Two open ended questions were asked in this scenario. Content analysis was used to analyse the data obtained from the answers to these questions before and after the SSI program. Grouping similar data under certain concepts and themes is the basis of content analysis (Yıldırım & Şimşek, 2013). The reliability of the data analysis conducted on the open ended questions supplied to the students was calculated using the Miles and Huberman (1994) consensus and disagreement formula. The researcher and one educator in the field performed independent coding. The reliability between the two coders was found to be 83%. Frequency tables and direct quotations were also used in the presentation of the data.

3. Findings

This study focused on the change in conceptual knowledge and opinions about socioscientific issues of high school students living in the same area as an endangered species before and after the implemented SSI program. To achieve this goal, a conceptual

knowledge form and the northern bald ibis under threat scenario was implemented before and after the SSI program. This heading focuses in the data analysis results according to the sub-problems of the research.

3.1. Findings related to the first sub-problem of the study

The first sub-problem of the study was "Is there a significant difference in the conceptual knowledge of high school students who live in the same area as an endangered species before and after the SSI program?". The results of the t test related to this question are presented in Table 1.

Table 1. Results of t test for average pretest-posttest scores of high school students on the conceptual knowledge form

Test	N	$\bar{X}$	SD	df	t	p
Pretest	75	0.43	0.64	74	-43.319	.000
Posttest	75	12.73	2.46			

A significant difference was identified between the pre and post SSI program conceptual knowledge of high school students living in the same area as an endangered species ($t_{(74)}$=-43.319; p<.05). This result shows that the SSI program was effective in enhancing the conceptual knowledge of the high school students.

Frequency distribution for the scores the students received on the conceptual knowledge form before and after the SSI program are provided in Table 2.

Table 2. Distribution frequency of scores received on the conceptual knowledge form filled out high school students before and after the SSI program

Concepts	Test	0 points	1 point	2 points
		f	f	f
Endemic species	Pretest	73	2	-
	Posttest	1	18	56
Endangered species	Pretest	60	15	-
	Posttest	-	12	63
Pesticide	Pretest	71	4	-
	Posttest	-	10	65
Bioaccumulation	Pretest	75	-	-
	Posttest	6	30	39

Biodiversity	Pretest	66	9	-
	Posttest	5	34	36
Ecological footprint	Pretest	75	-	-
	Posttest	7	31	37
Carbon footprint	Pretest	75	-	-
	Posttest	5	24	46
Water footprint	Pretest	75	-	-
	Posttest	2	28	45

Looking into the point distribution of the students' answers regarding the 8 concepts they were asked about, it was identified that none of them received the full two points on any of the questions when they answered the questions before the SSI program (Table 2). After the SSI program it was found that they left blank or answered incorrectly, thus receiving 0 points on, questions related to ecological footprint (f=7), bioaccumulation (f=6), carbon footprint (f=5), biodiversity (f=5), water footprint (f=2) and endemic species (f=1). Apart from these frequencies all concepts were either partially or completely answered correctly.

3.2. Findings related to the second sub-problem of the study

In this study a scenario named "Northern Bald Ibis Under Threat" was presented relevant to the sub-problem "What are the opinions of high school students living in the same area as an endangered species on SSI before and after the SSI program?".

The first half of the scenario called "Northern Bald Ibis Under Threat" was presented to the students and the students were asked to list the reasons why the northern bald ibis was going extinct. The results pertaining to the content analysis of students' answers to this question before the SSI program is provided in Table 3.

Table 3. Results obtained from content analysis of high school students' answers given before the SSI program, explaining why the northern bald ibis is going extinct

Themes	Codes	f
Human impact	Hunting	31
	Maltreatment	18
	Habitat	7
Environmental impact	Lack of food	13
	Air pollution	11
	Agricultural pesticides	7
	Environmental pollution	4
	Noise pollution	3
Species impact	Difficulty breeding	12
	Illness	8
	Migration	3

When the answers provided by high school students before the SSI program as to why the northern bald ibis is going extinct were analysed, three themes were identified (Table 3). Under the human impact theme, the code "hunting" (f=31) had the highest frequency and the code "habitat" (f=7) had the lowest frequency. It was identified that under the theme environmental impact the code "lack of food" (f=13) had the highest frequency. In the third theme, species impact, the code "difficulty breeding" (f=12) was the most frequent while the code "migration" (f=3) was least frequent. Some examples of students' statements given before the SSI program and related to the reasons why the northern bald ibis is going extinct are provided below.

S13: Northern bald ibis being shot due to bad hunting practices (Hunting).

S16: People ruthlessly harming the northern bald ibis are causing the northern bald ibis to go extinct (Maltreatment).

S5: As inhabited areas have grown the habitats of the animals have shrunk (Habitat).

S51: They are free animals but they are kept in cages. Living in cages kills them (Habitat).

S42: They died of starvation because they couldn't find food (Lack of food).

S48: They can't live in dirty air (Air pollution).

S73: When their mate dies, they can't find another one so they can't breed (Difficulty breeding).

S57: They get deadly diseases and die (Illness).

Analysis of student statements shows that bad hunting practices, caging the animals or limiting their habitat are the main human impact stated as a reason the northern bald ibis is endangered. Lack of food and inability to find a mate, illness, air pollution etc. are also provided as reasons the northern bald ibis is going extinct.

Content analysis results of the answers the students provided after the SSI program on the reasons why the northern bald ibis is going extinct are presented in Table 4.

Table 4. Results obtained from content analysis of high school students' answers given after the SSI program, explaining why the northern bald ibis is going extinct

Themes	Codes	f
Human impact	Hunting	17
	Habitat	15
	Maltreatment	14
Environmental impact	Agricultural pesticides	69
	Air pollution	44
	Water pollution	31
	Environmental pollution	19
	Noise pollution	9
	Land pollution	7
	Waste pollution	2
Species impact	Illness	3
	Migration	2

It was observed that the answers of high students as to why the northern bald eagle is going extinct given after the SSI program converged on three themes (Table 4). It is seen that the codes "hunting" (f=17), "habitat" (f=15) and "maltreatment" (f=14) fell under the theme human impact and had close frequency values. The theme with the largest number of codes was environmental impact. In the theme environmental impact, the code "pesticides" (f=69) had the highest frequency while "waste pollution" (f=2) had the lowest frequency. Under the theme species impact the codes "illness" (f=3) and "migration" (f=2) were observed. Some examples of students' statements given after the SSI program and related to the reasons why the northern bald ibis is going extinct are provided below.

S34: They are shot by some hunters when they migrate (Hunting).

S15: Because their habitat is shrinking, factories, industrial areas are growing, buildings and settlements are multiplying (Habitat).

S39: They can't find soft rocks to nest on (Habitat).

S25: People are less aware than before and they are not valued (Maltreatment).

S72: Most of them are gone because of pesticides (Agricultural pesticides).

S53: Their food chain was faced with breaking down because of DDT (Agricultural pesticides).

S48: Because of air pollution like car exhausts, factory smoke (Air pollution).

S3: Carbon footprint: We could lower carbon emissions for the northern bald ibis and for us (Air pollution).

S22: Our water footprint has grown. 2500 litres of water is used for one t-shirt we wear. The world is experiencing water scarcity (Water pollution).

S17: Our ecological footprint harmed the natural system (Environmental pollution).

S10: Plastic bottles, bags etc. are polluting the environment. It takes years for one piece of plastic to decompose in nature. Also, earth loses its nutrients and minerals (Environmental pollution).

S40: Noise pollution also endangers their lives (Noise pollution).

The statements students made about why the northern bald ibis is going extinct shows that the northern bald ibis being shot, industrial development, lack of awareness, use of DDT, growth of carbon, water and ecological footprint etc. were used as explanations.

It was identified that student opinions as to why the northern bald ibis is going extinct changed after the SSI program. In general, all the themes and most of the codes were the same. However, the total frequency of the codes and the frequency in common codes were significantly different. While hunting (f=31) was seen as the main reason for the endangerment of the northern bald ibis before the SSI program, agricultural pesticides (f=69) were named the main reason after the program was completed. Also, the codes "lack of food" and "difficulty breeding" seen in analysis of the pretest answers were not present after the program. It was observed that after the program, students used scientific terms such as DDT, pesticide, food chain, and carbon, water and ecological footprint in their statements.

In the second open ended question in the "Northern Bald Ibis Under Threat" scenario related to the second sub-problem the students were asked about precautions that needed to be taken to protect endangered species. To this end, the students were asked "What would you suggest to protect the northern bald ibis?". Results of content analysis pertaining to answers given by students before the SSI program are provided in Table 5.

Table 5. Results of content analysis of high school students' answers given before the SSI program and related to precautionary measures to protect the northern bald ibis

Themes	Codes	f
Interventions related to human behaviour	Banning hunting	17
	Punishments	9
	Education	6
	Environmental protection	5
	Stopping the use of pesticides	4
	Valuing the species more	3
Interventions related to treatment of the species	Taking good care	20
	Feeding them well	17
	Constructing large habitats	15
	Keeping them in cages	12
	Outfitting them with tracking devices	10
	More breeding facilities	6
	Setting them free	6
	Preventing migration	6
	Medical treatment	4

According to the answers given by high school students before the SSI program, two themes were identified for the protection of the northern bald ibis. These to themes are interventions related to human behaviour and interventions related to the treatment of the species (Table 5). Under interventions related to human behaviour the code "banning hunting" (f=17) was the most frequent and "valuing the species more" (f=3) was the least frequent. In the theme interventions related to the treatment of the species, the codes "taking good care" (f=20), "feeding them well" (f=17) and "constructing large habitats" (f=15) were the most prominent. Ten students did not answer this question. Some examples of students' statements given before the SSI program and related to how the northern bald ibis can be protected are provided below.

S61: Hunting should be banned (Banning hunting).

S12: People who harm northern bald ibis should be punished with jail time or fines (Punishments).

S26: They should be made comfortable and treated well (Taking good care).

S41: We should feed them well so they don't go extinct (Feeding them well).

S21: To protect them we should build cages in forest areas to protect them from other predators (Constructing large habitats).

S54: We should keep them in cages so hunters can't shoot them (Keeping them in cages).

S14: When they are set free, they should be followed with a tracking device (Outfitting them with tracking devices).

S73: We should build breeding facilities to speed up their breeding (More breeding facilities).

S66: They should be allowed to be free. They are definitely going to go extinct but they should at least live out the rest of their days better (Setting them free).

S38: They should be prevented from migrating during migration season (Preventing migration).

S18: Wounded or ill northern bald ibis should be taken to the veterinarian (Medical treatment).

It is observed that student answers given before the SSI program and related to precautionary measures to protect the northern bald ibis centred around hunting, constructing large habitats, and feeding and treating them well so they can live under better circumstances, giving them medical treatment, keeping them in cages and stopping them from migrating etc.

Results of the content analysis of the answers students gave after the SSI program pertaining to the second question provided in the scenario related to the second sub-problem and related to the question "What would you suggest to protect the northern bald ibis?" are provided in Table 6.

Table 6. Results of content analysis of high school students' answers given after the SSI program and related to precautionary measures to protect the northern bald ibis

Themes	Codes	f
Interventions related to human behaviour	Environmental protection	41
	Education	33
	Raising awareness in the media	32
	Stopping the use of pesticides	29
	Banning hunting	10
	State protection	8
	Conducting projects	3
Interventions related to treatment of the species	Constructing large habitats	35
	More breeding facilities	15
	Taking good care	8
	Outfitting them with tracking devices	8
	Setting them free	6
	Preventing migration	5

Students' suggestions for precautions to protect the northern bald ibis which were provided after the SSI program converged around two themes (Table 6). Under interventions related to human behaviour the code "environmental protection" (f=41) had the highest frequency while "education" (f=33), "raising awareness in the media" (f=32), "stopping the use of pesticides" (f=29) followed. Under the heading interventions related to treatment of the species the codes "constructing large habitats" (f=35) and "more breeding facilities" (f=15) had the two highest frequency values. Some examples of students' statements given after the SSI program and related to how the northern bald ibis can be protected are provided below.

S56: Factory chimneys should be equipped with filters, public transportation should be used, bicycles should replace motorised bicycles (Protecting the environment).

S11: Carbon footprint, water footprint, ecological footprint should be prevented, lessened (Environmental protection).

S40: People should know that if one species goes away it is bad for all of us. When the northern bald ibis is extinct, they are responsible for the bad results that will occur (Education).

S19: If all people are educated on this issue, we wouldn't need to do anything to protect them (Education).

S32: We should use social media to raise more awareness, we should warn young people (Raising awareness in the media).

S46: They should be shown more in cartoons, adverts and the news (Raising awareness in the media).

S9: The agricultural pesticide known as DDT should be banned (Stopping the use of pesticides).

S55: I suggest state representatives do better things and are more involved (State protection).

S64: Large farms should be constructed for norther bald ibis. One side of the farm should be rocky like their old nests. They should be able to live here like they lived in nature (Constructing large habitats).

S75: We need more breeding farms (More breeding facilities).

S26: People who are going to take care of northern bald ibis should be well educated, interested and they should have special vets (Taking good care).

S30: I suggest they are set free because nature is better for them than cages (Setting them free).

It was observed that after the SSI program the students used phrases such as air, pollution, informing people about the issue, using more media publications and intervention from authorities when discussing suggestions for precautions to protect the northern bald ibis.

It was ascertained that the SSI program impacted the students' suggestions on the protection of the northern bald ibis. While the main themes remained the same before and after the program, the total frequency of the codes increased significantly after the program. It was also observed that the frequency of the codes that were present in both the pretest and the posttest increased significantly after the program. In addition, the most common suggestion before the program was "taking good care" (f=20) while after the program the most prevalent suggestion was "environmental protection" (f=41). Also, after the SSI program the students didn't make suggestions related to punishment, valuing the species, keeping them in cages, feeding them well or medical treatment. It is also clear that interventions related to human behaviour were the most prevalent suggestions after the program. It was also observed that students approached the situation from a wider perspective and used more scientific terminology after the SSI program.

4. Discussion and conclusion

This study picked the northern bald ibis as a socioscientific issue and reached the conclusion that implementation of an SSI program enhanced the conceptual knowledge of high school students who live in the same area as the endangered northern bald ibis. Şahintürk (2014) found in an experimental study on middle school students that science activities supported by socioscientific discussion resulted in a meaningful increase in the

students' level of knowledge. It was also found that the students' opinions about socioscientific discussion experience positive growth. Similarly, Kırbağ, Zengin, Keçeci, and Kırılmazkaya (2012) found in an experimental study on middle school students that online argumentation on a socioscientific subject enhanced the students' success. Yavuz Topaluğlu and Balkan Kıyıcı (2017) ascertained that activities conducted outside of schools and related to socioscientific issues had a positive effect on middle school students' conceptual knowledge. Klosterman and Sadler (2010) found an SSI program for high school students had a positive impact on their level of knowledge. Zangori et al. (2017) conducted a study on high school students using a modelling-centred socioscientific issue (SSI) based curriculum. This study identified that the model had a very significant impact on helping the students understand the relationship between carbon cycling and climate change. The findings of the studies mentioned are in line with this study.

This study used and SSI program to research how students' conceptual knowledge and opinions about a socioscientific issue changed and the research ascertained that the SSI was effective. Sadler, Romine, and Topçu (2016) found that using an SSI as a teaching tool was effective in teaching students about scientific content. In addition, Nida, Rahayu, and Eilks (2020) conducted a study with teachers on SSI-based science education and found that teachers believe SSI-based pedagogies enhance the development of capabilities in students. Espeja and Lagaron (2015) found in a study where they implemented an SSI module that trainee teachers unfamiliar with SSI achieved complex conceptualization of SSI in a short amount of time, when the correct materials and strategies are used.

The SSI program in this study utilised discussions. The aim was for the students to strengthen their own opinions, disprove conflicting perspectives and be exposed to multiple points of view. Chung et al. (2016) showed that SSI instruction could contribute vastly to knowledge basic ideas, valuing the opinions of others and supporting their own ideas. Chang and Lee (2010) found that for the college students they studied, their values, worldviews, past experiences and families were effective in making decisions about SSI. Sadler and Zeidler (2005b) on the other hand found that an empathic approach was effective in the students' decisions on SSI. Dawson and Carson (2018) identified that at the end of the argumentation they used for the instruction of socioscientific issues students realised the necessity of backing up their opinions with scientific fact. These studies support the finding of this study.

This study used two open ended questions to see how students' opinions on the northern bald ibis as a socioscientific issue changed by the end of an SSI program. The frequency of codes obtained from both open-ended questions increased significantly after the SSI program. Before the program, the students said the main reason for the northern bald ibis going extinct was hunting, while after the SSI program, student opinions had

shifted, naming agricultural pesticides as the main factor in the extinction of the northern bald ibis. On the issue of how to protect northern bald ibis, before the SSI program, the most common suggestion was to take better care of them while after the program, the more common opinion was one related to environmental protection. Bakırcı et al. (2018) used the scenario "Northern Bald Ibis Under Threat" in a study on middle school students. It was found then that the students thought the northern bald ibis was under threat due to bad hunting practices and environmental pollution. That study also found that the students thought the best way to protect the species was to place the species under protection and ban the hunting of the northern bald ibis. Similarly, Çavuş (2013) found that middle school students thought the reasons the species was endangered was environmental problems and bad hunting practices. The students also said the most important factor in protecting the northern bald ibis was to protect their natural habitat. Seçgin, Yalvaç, and Çetin (2010), in a study on middle school students' opinions on environmental issues, identified that the students stated the factors for the reason behind extinction of species has bad hunting practices.

5. Suggestions

In this study it was observed that the conceptual knowledge of high school students who underwent the SSI program was enhanced and that their opinions had changed. In addition, since the one group pretest-posttest research design was used, the efficacy of the SSI program could not be tested against a control group. It is suggested that similar studies are conducted with a control group to contribute to the literature on the subject.

Furthermore, including socioscientific issues in educational environments, such as the northern bald ibis, which is special in its circumstance, is important to raise awareness about such animals and to help students better understand their immediate surroundings.

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