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Nature of science representation in scenarios created by prospective science teachers on socio-scientific issues

Ümit Duruk

Department of Science Education, Adiyaman University, 02040, Adiyaman, Turkey.

ABSTRACT

This study aims to categorize the scenarios designed on socio-scientific issues (SSIs) by prospective teachers who participated in an SSI-based instructional practice and to analyze these scenarios in terms of representing the nature of science (NOS) components. Sample of the study comprised SSI scenarios written by 30 third-year prospective science teachers enrolled at a public university in spring semester of 2018-2019 academic year. These scenarios were created during SSI-based instruction when half of the participants were assigned to the environment group and the other half to the genetics group. A total of 30 SSI scenarios were analyzed through the document analysis method. In the analysis of SSI scenarios, two different analyses were employed. In the first analysis, whether objective/positive/negative information balance was ensured across scenarios was examined. In the second analysis, scenarios were analyzed in terms of NOS representation attempts, consistency of these attempts and NOS representation scores. The later analysis included the empirical, tentative, inferential, theory-laden, creative and socio-cultural NOS components. At the end of the analyses, it was found that participants had trouble in differentiating SSIs from scientific issues. SSIs on which participants prepared scenarios varied, scenarios created by participants in the environment group were prepared with negative information whereas scenarios in the genetics group were in a balanced manner; and of the scenarios created by the two groups, the component with the highest percentage of consistent attempts was the empirical NOS whilst the component with the lowest percentage of consistent attempts was theory-laden NOS. Based on these findings, it was deduced that the SSI scenarios were not generally written in a well-balanced manner in terms of information types and there was a general trend of compatibility between the NOS representation scores and percentages of consistent attempts of two groups. Based on the results, a number of recommendations were proposed.

Keywords: Science education, nature of science, nature of science representation, SSI-based instruction, prospective science teachers.

E-mail: uduruk86@gmail.com. Tel: 90-506-305-16-83.

INTRODUCTION

The scientific literacy is at the core of reformist efforts made for science education at the international arena (Holbrook and Rannikmae, 2009; Sadler, 2004). As the nature of science (NOS) signifies the epistemology of science and the totality of values in science (Lederman, 1992), it is a common theme existing in a number of definitions of scientific literacy. As per a broader definition, NOS is an interdisciplinary approach which studies the meaning of science and how it works, the relations between science and society and the epistemological and ontological bases underlying scientific activities (Clough, 2006; McComas, 2015). Helping K-12 students from primary and middle schools develop informed understandings of NOS has been, and continues to be a key goal for reform efforts in science education (Abd-El-Khalick and Akerson, 2004). Nevertheless, research has consistently shown that both teachers and pre-college students failed to attain the desired understandings of NOS (Abd-El-Khalick, 2005; Abd-El-Khalick and Akerson, 2004).

Explicit-reflective NOS instruction approach had precedence in NOS instruction, and a number of contexts such as conceptual change (Abd-El-Khalick and Akerson, 2004; Mulvey and Bell, 2017), inquiry (Akerson and Hanuscin, 2007; Burgin and Sadler, 2016; Khishfe and Abd-El-Khalick, 2002), history of science (Rudge and Howe, 2009) and philosophy of science (Abd-El-Khalick, 2005) were effectively used in NOS instruction. One of the contexts relevant to NOS instruction is SSIs (Khishfe, 2017; Khishfe and Lederman, 2006; Sadler et al., 2004). When the scientific literacy is addressed within the context of SSIs, it demonstrates that students provide justifications for their claims while arguing about and expressing their concerns on these issues. There are findings which indicate that the science teaching through SSIs develop NOS understandings (Dawson and Venville, 2009; Sadler et al., 2004). Thus, SSIs provide an effective context in the development of scientific knowledge and scientific processes which directly or indirectly contribute to the attainment of scientific literacy (Sadler, 2009; Zeidler et al., 2011).

SSIs can be perceived as issues that are relevant to the real life, important to the society and connected to the targeted achievements of the instruction program (Atabey et al., 2018). From a broader definition, SSIs are contentious social issues which require multiple potential solutions based on different viewpoints but cannot be solved solely through scientific methods due to their social aspects and, by nature, are ill-defined (Carson and Dawson, 2016; Owens et al., 2019; Ratcliffe and Grace, 2003; Zeidler, 2014). SSIs also contain dilemmas which require ethical judgment (Zeidler et al., 2005). SSIs are issues the will make ethical and moral evaluations on these dilemmas possible (Gustafsson and Öhman, 2013).

Numerous researchers asserted that SSIs should be among the prioritized targets of science instruction (Kolsto, 2001; Zohar and Nemet, 2002), as a high number of instructional benefits of using SSIs were identified. As SSIs contain science topics which can be encountered in daily life, they motivate students to learn (Sadler and Zeidler, 2009) and, as they establish connections of the knowledge with students' lives, they pave the way for meaningful learning (Dawson, 2015). SSIs help students become scientifically literate individuals who are capable of making their decisions on the basis of empirical evidence (Sadler, 2004).

As well as being places where a range of pedagogical opportunities are provided to improve academic development, schools can be considered as environments where students somehow face social reality and build their perceptions of social reality. Accordingly, the use of SSIs as a pedagogical source can play an effective role in student's identification of the science instruction with this social reality and hence in its transfer to student's real life scenarios (Tsai, 2018). One of the prioritized goals of science education shaped on the basis of scientific literacy is to ensure that students actively partake in arguments on SSIs encountered by them during their daily lives and make evidence-based decisions (Hofstein et al., 2011; Lin and Mintzes, 2010; Tsai, 2018).

It is quite difficult to say that SSI-based instruction is systematically offered at schools (Reis and Galvao, 2004). It can be asserted that there are a number of reasons for this situation (Evren-Yapıcıoğlu, 2018). First, most science teaching programs which are currently in effect focus on teaching a higher amount of scientific knowledge rather than developing inquiry and thinking skills (Hanegan et al., 2008). Second is the lack of empirical knowledge which will provide sources and serve as guide for SSI-based instruction efforts at schools, particularly in the relevant literature on how SSI-based instruction is to be designed and performed (Sadler et al., 2004). On the other hand, most at times, perceptions toward science instruction may also create problems. In today's science education, science courses are perceived in most cases as courses where pure science content knowledge is transferred by teachers rather than as courses in which ethical awareness is raised and values are built by teachers (Bosser et al., 2015; Hofstein et al., 2011). Hence, most teachers are inclined not to address ethical, moral and political issues in science courses (Evren-Yapıcıoğlu, 2018). Most of the time, teachers perceive SSI-based instruction as difficult to understand and complicated, time-consuming and pedagogically challenging, and this perception makes it attractive for them to revert to classical science courses based on content transfer during which teachers think that their comfort zones are not challenged and they still exhibit strong commitment to their teaching routine (Christenson et al., 2014).

SSI-based instruction as a science teaching method is a useful way to help students improve skills which enable them to analyze, evaluate, and make inferences about SSI-related information in the mass media (Gul and Akcay, 2020). Despite being the potential implementers of SSI-based instruction in the middle schools with these kinds of information resources, prospective science teachers have difficulty in recognizing related learning outcomes in relation to SSIs (Evren-Yapıcıoğlu, 2016b). It is quite possible that it becomes very difficult for them to explicitly undertake NOS instruction in the context of SSI-based instruction. Moreover, research confirms that there has been no consensus on the extent where objective, positive or negative information on SSIs should be included while SSI scenarios are being written. However, to the best of my knowledge, only one study (Atabey et al., 2018) has been dedicated to investigating the balance of information types in SSI-related scenarios as educational resources. To address this gap in the literature, the present study goes beyond prior research by examining the balance in self-produced SSI scenarios. In addition, there is much to be learned about how NOS components are represented in these SSI scenarios.

Although there are numerous researches focusing on NOS representation in course books (Ramnarain and

Chanetsa, 2016; Wei et al., 2013), researches including self-produced SSI scenarios are rare. Given that these course books fared poorly in NOS representation, the question of how these self-reported SSI scenarios represent the NOS components emerged. To tackle this question, apart from the other close research, a relatively unknown analysis of NOS representation was employed. So, the results would pave the way for the future research to investigate NOS representation in various educational resources, as well as course books.

Based on the above study rationale, the study aimed to categorize SSI scenarios designed by prospective teachers who participated in an SSI-based instruction practice and to analyze these scenarios in terms of representing NOS components. In this respect, two questions guided the study:

1. Which SSIs were addressed in the scenarios prepared by prospective teachers and how was the objective, positive and negative information balance across these scenarios?

2. To what extent were NOS components represented in terms of SSI scenarios?

METHODOLOGY

This study employed document analysis approach in a qualitative manner (Abd-El-Khalick et al., 2008).

Research model

Under the document analysis method, deductive content analysis design was used. In this analysis design, what the analysis units are and to what extent these analysis units represent the content are quite important. While analysis units are investigated, ready-made codes are previously validated and the analysis is carried out with these codes (Fraenkel et al., 2012; Patton, 2002).

Context

While writing scenarios on SSIs, first, the focus should be on the selection of scenarios well-suited to the learning outcomes under the SSI learning part of the existing science instruction program (Lenz and Willcox, 2012). Therefore, during practices, participants were frequently reminded that they would be asked to write an SSI scenario which they are familiar with, which was of environmental or economic importance and well-suited to the learning outcomes in the existing science instruction program (Dawson and Carson, 2017). However, reform efforts designed for SSI-based instruction remain limited solely to program development activities and thus, it cannot be assured that the prospective teachers are pedagogically prepared for the SSI-based instruction (Genel and Topcu, 2016). Even if the SSIs are more relevant to the science course, it is discerned that prospective science teachers do not have sufficient knowledge of instructional strategies on SSIs, let alone SSI-based instruction (Carson and Dawson, 2016; Türkmen et al., 2017). On the other hand, there are certain viewpoints suggesting that the use of SSIs in science teaching is a context effective in developing students' NOS understandings (Dawson and Venville, 2009; Khishfe and Lederman, 2006). Genel and Topçu (2016) asserted that more efforts should be devoted to the development of prospective teachers' planning skills relevant to SSI-based instruction. Hence, it can be inferred that, through a well-organized SSI-based instruction, it will be possible especially for prospective science teachers to get to know about SSIs, to write scenarios about them and to use them effectively during socio-scientific argumentation. In the direction of this main goal under this study, SSI-based instruction was implemented during the compulsory NOS course. This study was performed with the participation of 30 prospective science teachers who took no course on SSI in the past (Evren-Yapıcıoğlu, 2018). Current SSIs in general contain environment and health issues (Yahaya et al., 2016). That is why the participants were randomly assigned to two groups, namely, environment group and genetics group. Argumentation process was explicitly carried out in all activities in both groups. SSI-based instruction was offered to participants for four course hours in a week, for a total of five weeks.

During the first three weeks, Huntington disease, genetically-modified organisms, and golden rice in the genetics group; biomass power plants, nuclear power plants, and water fluoridation in environment group were posed in the context of SSIs. Participants in both groups made whole-class discussions, as well as their intra-group discussions and filled in the argumentation forms. Then, the participants in each group were divided into two groups (totally four groups) depending on whether their decision was positive or negative on SSIs, and then verbal argumentation commenced. These argumentation sessions continued throughout each lesson for a period of five weeks. Both genetics and environment groups participated in common activities including pseudoscientific scenarios in the last two weeks. In these activities, instead of SSIs, pseudoscientific issues that are thought to support these issues in terms of generating arguments and finding evidence for claims were included.

All participants were required to make argumentation in line with the pseudoscientific issues of crystal healing related to the health issues and water dowsing related to the environmental issues. During these discussions, if there were any relationship with NOS components, the spokesperson of each group took notes. These notes were emphasized explicitly in each group discussion and both verbal and written reflections on NOS components including empirical, tentative, inferential, theory-laden, creative, and socio-cultural NOS were provided.

Materials

Instructional materials should be arranged in light of students' interests, skills and prior knowledge base before being used in the instruction. As practitioners make use of these materials during instruction, their teacher knowledge base is enhanced accordingly (Davis and Krajcik, 2005; Van Driel and Henze, 2012). The material of this study was made up of SSI scenarios prepared at the end of the semester by prospective science teachers who took SSI-based NOS course.

Data analysis

To seek answers to the first research question, the analysis was conducted according to the method proposed by Atabey et al. (2018) and examined whether objective, positive and negative information was distributed in a balanced manner across SSIs. For this purpose, the existence and number of these information types were calculated across SSI scenarios created by participants. Subsequently, whether these information types were distributed in a balanced manner was interpreted on the basis of quantitative data.

To provide answers to the second research question, the analysis intended for identifying the level of NOS representations in these scenarios was carried out on the basis of empirical, tentative, inferential, theory-laden, creative and socio-cultural NOS components considered to be the most relevant to SSIs. Throughout the representation analysis, Analytical Framework on the Representation of NOS Components (Abd-El-Khalick et al., 2008; Ramnarain and Chanetsa, 2016) (Table 1) and NOS Representation Scoring Rubric (Ramnarain and Chanetsa, 2016) (Table 2) were employed, respectively.

Table 1. Analytical Framework on the Representation of NOS Components*.

NOS Components	Functional Definitions Used in SSI Analysis
Empirical	Scientific assertions are derived from phenomena relevant to the natural world and consistent with these phenomena. Scientists make use of observations and experiments in order to validate their assertions. Phenomena may not necessarily be suitable for the use of experiments in each branch of science (i.e. astronomy).
Tentative	Rather than being absolute and final, all scientific knowledge types such as cases, rules and theories are resilient against change and have reliability. Based on new data or reinterpretation of the existing data, there can be changes in scientific knowledge.
Inferential	Observations are descriptive expressions about natural phenomena which are accessible through sense organs and on which all observers can easily agree (i.e. fall of an object on earth when released). Interpretations about observations are inferences (i.e. Rutherford's Atomic Model). Inferences are expressions about phenomena which are not directly accessible through sense organs (i.e. the reason for objects to be inclined to fall is the gravity).
Theory-laden	Scientists' professional commitment, beliefs, existing knowledge base, educational backgrounds and expectations affect their studies. These characteristic features influence the problems which they select for studying, their research methods, observations and inferences which they base on these observations. Along with such features, the role of theories which have the power to create scientific knowledge becomes important. Contrary to the common belief, science never starts with objective observations.
Creative	Science does not totally rest on reason and is not a perfectly systematic activity. Scientific knowledge is produced on the basis of explanations developed by scientists under the influence of imagination. It is closely related to the inferential NOS component. Scientific models about atoms, lines of force and species are useful models rather than being the plain truth.
Socio-cultural	Scientific activities are human endeavors. The scientist who is part of socio-cultural constructs perform his/her scientific activities under the influence of several cultural factors such as politics, philosophy and moral values and is heavily affected by these factors.

*****Derived from frameworks proposed by Abd-El-Khalick et al. (2008) and Ramnarain and Chanetsa (2016).

Table 2. NOS representation scoring rubric.

Score categories	Representation indicators
3 points: clearly stated, informed and consistent representation	Clear statements reflecting informed representation Consistency in selected parts and sections in terms of the relevant component Consistency with other relevant components
2 points: clearly stated, partially informed representation	Clear statements reflecting the informed representation but deficient in terms of representation Consistency in selected parts and sections in terms of the relevant component Deficient representation as the course book establishes no link with other related components
1 point: indirect, informed and consistent representation	Clear statements reflecting the informed representation can be discerned from the course book (i.e. deficient in structured reflective or clearly-stated explanations, activities, examples or examples in science history) or through inferences. Inconsistent with indirect representation which is discerned through inferences and absence of other, direct or indirect, messages
0: no representation	No direct or indirect practice intended for the relevant component Deficient in materials in terms of conveying messages to the book reader (statements, examples, historical examples and so on)
-1 point: indirect, erroneous representation	Erroneous representation which can be discerned through inferences from the book
-2 points: clearly stated representation and/or representation through indirect messages	Indirect, informed representations discerned through inferences from certain parts of the book and representing them again in other parts of the book through obvious errors Clear statements which express contradictory messages about the same component
-3 points: clearly stated, mistaken representation	The use of openly-erroneous clear statement or statements about a specific component.

Source: Ramnarain and Chanetsa (2016).

RESULTS

Results in relation to the first research question

This section presented the results based on the following question: “Which socio-scientific issues were addressed in the scenarios prepared by prospective teachers and how was the objective, positive and negative information balance across these scenarios?” The results were presented separately under the environment group and genetics group. In each table, successively, scientific issues proposed by the participants, SSIs on which participants created scenarios and lastly the numbers of objective, positive and negative types of information on SSIs were included. Participant names were shortly coded with the letter K. For instance, while K-3 is a participant of the environment group, K-11 partakes in the genetics group.

Table 3 shows that similar issues in the SSI literature such as environmental pollution and greenhouse gases, particularly the global climate change, were perceived by the participants of environment group as scientific issues. Current issues such as zombie bacteria and viruses and plant fossil discovered in glaciers are among the examples given by participants as scientific issues. It was discerned that SSIs on which participants were interested in creating scenarios varied. Relatively novel issues like the establishment of nuclear power plants, biogas production from wastewater, establishment of biomass power plants and solar eclipse were among these issues besides similar issues such as melting glaciers, agricultural spraying, air-conditioning refrigerants, conservation of water sources and prohibition of smoking. Scientific scenarios proposed by participants and SSIs on which participants created scenarios did not make up a pattern based on each participant because it was discerned that nearly half of the participants selected compatible scientific and SSIs whereas the rest did not attach importance to the compatibility of selected issues.

While creating SSI scenarios, it is important that objective, positive and negative information should be distributed across scenarios in a balanced manner and thus students shall not be urged to make decisions in a specific direction (Atabey et al., 2018).

Table 3 shows that participants created the scenarios primarily by using information which reflected a negative

Table 3. Results in relation to participants of the environment group.

Environment group	Scientific Issue	SSIs	Number of objective/ positive /negative information /opinions on SSIs
K-1	Global climate change	Establishment of biomass power plants	4/4/8
K-3	Global climate change	Melting glaciers	8/1/6
K-4	Global climate change	Solar eclipse	2/3/3
K-5	Environmental pollution	Agricultural spraying	5/3/3
K-6	Zombie bacteria and viruses	Solar eclipse	7/4/3
K-8	Deforestation	Biogas production from wastewater	6/2/0
K-9	Greenhouse gases	Fourth industrial revolution	5/1/0
K-10	Industrialization	Air conditioning refrigerants	4/1/4
K-12	Global climate change	Agricultural spraying (DDT Use)	4/0/6
K-13	Plant fossil discovered in glaciers	Conservation of water sources	2/1/4
K-17	Deforestation	Prohibition of Smoking	3/1/6
K-22	Advantages and disadvantages of nuclear energy	Establishment of nuclear power plants	2/3/4
K-24	Giant viruses and end of humanity	Solar eclipse	4/2/4
K-25	Global climate change	Solar eclipse	5/6/11
K-28	Zombie bacteria and viruses	Establishment of nuclear power plants	5/8/12

perspective. A limited number of participants created scenarios in a relatively balanced manner (K-4, K-5, K-6 and K-22). It was ascertained that balanced scenarios were created on both the familiar issues (agricultural spraying) and relatively novel issues (solar eclipse, establishment of nuclear power plants).

Table 4 shows that, as examples of scientific issues, participants of genetics group gave examples on relatively current issues like DNA fingerprint analysis, vertification, CRISPR technique and Huntington disease as well as familiar issues in SSI literature such as biological and chemical weapons, gene transfer and human cloning. It was observed that SSIs on which participants of the genetics group were interested in creating scenarios varied as in the case of environment group. Relatively new issues like bird flu vaccine, anthrax vaccine, transplantation of organs from pig to human, CRISPR technique and genetically-designed babies were among these issues besides familiar issues such as human cloning, transplantation of organs, genetically-modified organisms and gene transfer. Scientific scenarios proposed by participants and SSIs on which they created scenarios did not form a pattern based on each participant as in the case of environment group; however, incompatibility was more evident in this group than in the environment group.

Table 4 demonstrates that participants in this group used the information types in a balanced manner in contrast to environment group. It was discerned that the number of participants creating relatively more balanced scenarios in this group (K-2, K-7, K-19, K-20, K-27, K-29 and K-30) was higher than in the environment group. It was found that balanced scenarios were created on the basis of both the familiar issues (human cloning, genetically-modified organisms, gene transfer) and relatively new issues (bird flu vaccine, anthrax vaccine, genetically-designed babies, CRISPR technique).

Results in relation to the second research question

This section put forward results based on the following question: “To what extent were NOS components represented in terms of SSI scenarios?” To present a better framework for ensuring that the findings could be expressed clearly, results on each group were exhibited in separate tables. The number of NOS representation attempts, number and percentage of consistent attempts and lastly the mean NOS representation scores were successively exhibited in the following two tables.

Table 5 shows that it was discerned that participants of environment group had 54 NOS representation attempts across SSI scenarios, 25 of all these 54 attempts were consistent and this corresponded to a success rate of 46.30%. When NOS components were specifically reviewed, it was discerned that the highest percentage of consistent representation attempts was obtained from the empirical NOS component. Of the other components, the second highest percentage pertained to the socio-cultural NOS component (40%). The lowest percentage of consistent representation attempts was obtained equally from tentative, theory-laden and creative NOS

Table 4. Results in relation to participants of the genetics group.

Genetics group	Scientific issue	SSIs	Number of objective/positive/negative information/opinions on SSIs
K-2	DNA fingerprint analysis	Bird flu vaccine	7/2/3
K-7	Skin cancer	Human cloning	1/10/8
K-11	CRISPR technique	Genetically-designed babies	7/0/4
K-14	Gene transfer	Banning energy drinks	0/0/13
K-15	DNA fingerprint Analysis	Bird flu vaccine	6/2/8
K-16	Vertification	Gene transfer	2/4/5
K-18	Human cloning	Donation of organs	7/0/10
K-19	Grey cattle breeding	Genetically-designed babies	7/7/7
K-20	Biological and chemical weapons	Anthrax vaccine	8/1/2
K-21	Skin cancer	Genetically-modified organisms	7/4/6
K-23	Human cloning	Transplantation of organs from pig to human	4/12/3
K-26	Human cloning	Transplantation of organs	2/0/3
K-27	Biological and chemical weapons	CRISPR technique	8/4/4
K-29	Huntington disease	Genetically-modified organisms	16/10/10
K-30	Huntington disease	Gene transfer	14/12/12

Table 5. Results in relation to participants in the environment group.

NOS Components	Number of NOS representation attempts	Number and percentage of consistent attempts	Mean of NOS representation scores
Empirical	14	12 (85.71%)	0.60
Tentative	8	2 (25%)	0
Inferential	9	3 (33.33%)	0
Theory-laden	4	1 (25%)	-0.13
Creative	4	1 (25%)	0
Socio-cultural	15	6 (40%)	0.27
Total score	54	25 (46.30%)	0.12

components.

Upon review of mean NOS representation scores which ranged at a specific interval (-3, +3), it was found that the mean of NOS representation scores obtained by participants from NOS components across SSI scenarios was 0.12. This mean of scores remained at the interval of (0, +1). Thus, it can be asserted that participants in this group did not represent NOS components in a holistic manner or did occasionally have indirect, informed and consistent representations. As in the percentage of consistent attempts, it was observed that the component with the highest mean of NOS representation scores was empirical NOS component. This component was followed by the socio-cultural NOS component. Besides, a negative mean score was obtained from the theory-laden NOS component. This situation signifies that NOS representations relevant to this component had characteristics likely to give rise to science misconceptions.

Table 6 shows that participants of genetics group had 71 NOS representation attempts across SSI scenarios, 54 of all these 71 attempts were consistent and this corresponded to a success rate of 76.06%. When NOS components were specifically reviewed, it was ascertained that the highest percentage of consistent attempts pertained to the empirical NOS component as in the case of the environment group. Contrary to the environment group where the highest percentage of consistent representation attempts was obtained solely from the empirical NOS component, high percentages were obtained in the genetics group from the tentative and creative NOS components besides empirical NOS component. In a similar vein to the environment group, the lowest percentage of consistent representation attempts was obtained from theory-laden NOS component.

From the review of mean NOS representation scores, it was found that the mean of NOS representation scores obtained by participants from NOS components across SSI scenarios was 0.41. Hence, as in the case of

Table 6. Results in relation to participants in the genetics group.

NOS components	Number of NOS representation attempts	Number and percentage of consistent attempts	Mean of NOS representation scores
Empirical	24	23 (95.53%)	1.00
Tentative	7	6 (85.71%)	0.50
Inferential	11	6 (54.55%)	0.13
Theory-laden	9	3 (33.33%)	0
Creative	8	6 (75%)	0.13
Socio-cultural	12	10 (83.33%)	0.67
Total score	71	54 (76.06%)	0.41

environment group, it can be asserted that participants in this group did not represent NOS components in a holistic manner or did occasionally have indirect, informed and consistent representations. As in the percentage of consistent representation attempts, it was observed that the component with the highest mean of NOS representation scores was again empirical NOS component. NOS components with relatively low mean NOS representation scores were consecutively theory-laden, creative and inferential NOS components.

DISCUSSION

Discussion on the first research question

Instructional materials should be arranged in light of students' interests, skills and previous knowledge base before being used in the instruction. As the practitioners employ these materials during instruction, their instruction skills are improved (Davis and Krajcik, 2005; Van Driel and Henze, 2012). SSI scenarios are among the instruction materials used in science instruction. From the studies in the relevant literature, it can be asserted that scenarios which relate to the real life, are important to the society, provide a discussion platform and pay attention to the achievements in the existing science instruction program are preferred more often. It was found that information offered by these scenarios was distributed in a balanced manner across scenarios even if scenarios generally contained a higher amount of negative information (Atabey et al., 2018).

In fact, in the writing of SSI scenarios, attention should be paid to the balanced presentation of positive and negative opinions and information on the issue (Bosser and Lindahl, 2019). This is because information offered by these scenarios is not supposed to guide the student towards making a specific decision (Tsai, 2018), but to encourage him/her to make decision in light of his/her own informal reasoning (Lindahl and Folkesson, 2016; Nielsen, 2012). However, in the writing of SSI scenarios, there is no consensus on how often and in what order the objective, positive and negative information on the selected issue should be used (Atabey et al., 2018). Therefore, in this part, the discussion took place in terms of findings based on quantitative data about the use of objective/positive/negative information by participants.

In this study, it was discerned that participants in different groups referred to objective, positive and negative information at varying levels across scenarios. It was ascertained that scenarios in the environment group were presented with negative information, whereas information in the genetics groups was provided in a relatively balanced manner. In a similar vein to the findings on the genetics group, Atabey et al. (2018) analyzed fifteen scenarios in seven articles selected from among a number of articles and found that scenarios contained information types in a relatively balanced manner. Including negative information more often across scenarios in the environment group can be explained with the influence of media since participants were frequently exposed to negative news in recent years, especially news about the nuclear power plants which were planned to be established. Including information types in a more balanced manner in scenarios on genetics can be associated with the perception that health issues evoke recovery and all genetic efforts mean progress in healthcare. Similar findings exist in studies in the area of pseudoscience. Metin et al. (2017) reported that even the health practices in the area of pseudoscience were perceived as activities which were good and ameliorating for health.

It was discerned that the participants focused on SSI achievements which were in the science instruction program and were perceived indirectly, and in this respect they selected issues which were relevant to daily life and valuable for society. Likewise, studies in the relevant literature also placed the focus on the same issue (Dawson and Carson, 2017). Moreover, it was ascertained that several issues which were out of the scope of issues in SSI-based instruction and were not familiar to the society were transformed by participants of both groups into SSI scenarios (that is, solar eclipse, genetically-designed babies, CRISPR technique, Huntington disease) and participants endeavored to ensure a balanced distribution of information in this respect. This finding can be related to the fact that SSI-based instruction is a systematic practice lasting one semester, both intra-group and inter-group argumentation activities were performed in each week of the SSI-based instruction practice, and lastly participants made research each week on SSIs to be used the following week and attended the class ready with explanations, which would justify their claims. However, it was discerned that participants had difficulty in differentiating whether scenarios prepared by them were a scientific or SSI scenario and had misconception about understanding the properties which differentiated SSIs from scientific issues. It was observed that this situation gradually improved towards the last weeks in association with the SSI-based instruction practice. Gradual recognition of differentiation criteria by participants can be associated with the fact that participants did not previously have SSI-based instruction and thus did not prepare SSI scenarios in the past. On the other hand, another factor affecting the distribution of information can be whether participants were familiar with the issues on which they prepared scenarios. Findings obtained from studies in the literature indicate that, for familiar issues, better arguments were developed and a higher number of consistent NOS representations were in place (Khishfe, 2014, 2017).

Discussion on the second research question

The representation of NOS components in written instructional materials is likely to affect the development of students' NOS understanding (Chua et al., 2019). SSIs serve as an effective context for the representation of NOS components (Sadler et al., 2004). Thus, as in other materials used frequently in science teaching (that is, course books, instruction programs), it is important to identify to what extent NOS components are represented across SSI scenarios and whether these components are consistently represented. Accordingly, the present study assessed NOS representations in SSI scenarios prepared by participants and to what extent these representations were undertaken by each group (Abd-El-Khalick et al., 2008).

First, it was found that the total NOS representation attempts of participants of the environment group remained lower than those of genetics group. Beyond this quantitative difference, there was a difference of approximately 30% between two groups again in favor of genetics group, and also in terms of the percentages of consistent attempts. In other words, in terms of both representation attempts and consistency of these attempts, NOS components were used more heavily across scenarios prepared by the genetics group than those prepared by the environment group. Interestingly, this finding was confirmed with mean scores obtained through NOS representation scoring rubric. It was ascertained that there was a difference of approximately 30% also in terms of this scoring. Likewise, in a number of course book analyses, it is viewed that the mean representation scores were low (Abd-El-Khalick et al., 2008; Ramnarain and Chanetsa, 2016; Wei et al., 2013).

The examination based on NOS components demonstrated that, in scenarios prepared by both groups, empirical NOS component had the highest percentage of consistent representation attempts whilst theory-laden NOS component had the lowest percentage of consistent representation attempts. Empirical NOS component was followed by the socio-scientific NOS component in both groups. These findings are consistent with the findings in the relevant literature (Abd-El-Khalick et al., 2008; Aydin and Tortumlu, 2015; Upahi et al., 2018).

A number of justifications can be offered for this situation. Firstly, participants of both groups had socio-scientific argumentation each week during SSI-based instruction, and thus they had awareness about the need to justify their claims. It can be stated that it is an expected situation if participants who created their justifications on the basis of evidence-based reasoning turned especially toward empirical NOS representation and made more representation attempts for this component. Secondly, it can be suggested that the instruction context with content similar to the scenarios prepared by participants raised the awareness of participants about these issues and thus participants were encouraged to make more attempts, and the representation percentage of socio-cultural NOS component went up indirectly. Another justification is that there was argumentation through pseudoscientific issues in the last two weeks of SSI-based instruction, and the argumentation took place primarily over pseudoscientific issues in the context of the difference between scientific and pseudoscientific issues with emphasis placed on empirical NOS component (Afonso and Gilbert, 2010; Metin et al., 2017). Arguments stressing the importance of evidence to the differentiation of science from other research disciplines might have raised the number of empirical NOS representation attempts and representation scores of participants, especially through these scenarios.

Lastly, the state of NOS understandings of participants can be addressed. Science teachers were often found to have certain naive NOS understandings (Abd-El-Khalick, 2005). This situation might have caused participants to focus on components in which they felt competent (i.e. empirical NOS component) rather than components in which they felt less competent (i.e. theory-laden NOS component, inferential NOS component) since it is well-established that participants needed comfort while preparing NOS materials (Demirdogen et al., 2016).

CONCLUSION AND RECOMMENDATIONS

At the end of the study, certain conclusions were reached leaving a clearer impression such as:

1. Prospective science teachers preparing SSIs under different contexts (environment, genetics) included

objective, positive and negative information at varying levels in these SSI scenarios. This situation can be explained with the effect of context prevailing in SSI literature.

2. The fact that prospective science teachers refer to negative information in scenarios about issues of environment and both positive and negative information in a balanced manner in scenarios about issues of genetics can be explained with the effect of news in the media and their discursive messages.

3. It was deduced that there was a general trend of compatibility between the percentage of consistent NOS representation attempts and mean NOS representation scores. This result can be explained with the fact that NOS representation analysis is conducted on the basis of similar properties also in NOS representation scoring rubric.

4. It was discerned that, while selecting SSIs, prospective science teachers did not limit themselves solely to issues which they got familiar with during SSI-based instruction and also wrote scenarios about different and current issues by activating their research and inquiry skills. This situation can be explained with the fact that socio-scientific argumentation raised the willingness of participants to find more evidence and to use the evidence as justification.

5. Even in several studies in which explicit-reflective NOS instruction was in place, it is often discerned that certain NOS components did not develop at desired level. In this study, it was concluded that the general trend as per research findings was the use of empirical NOS and theory-laden NOS components. This situation can be explained, especially with the positivist science view dominating the science instruction in national context and repercussions of this dominant perception on instructional practices.

The above conclusions are valid under certain limitations:

1. Besides the number and balance of information types across scenarios in relation to SSIs, the order of presentation of these information types is also of importance (Atabey et al., 2018). In this study, focus was placed on the number of information types rather than the order of information types. This can be considered as a limitation.

2. In the relevant literature, it is stated that the quality of socio-scientific argumentation was affected by NOS understandings. As this study did not identify NOS understandings, participants were assumed to have adequate NOS understandings at minimum level in terms of each NOS component throughout practices and to write SSI scenarios with this level of NOS understandings at the end of the semester.

In the context of these results, firstly, SSI-based instruction practices should be expanded and the use of different SSI types should be encouraged. In this respect, it can be recommended that socio-scientific argumentation implemented during SSI-based practices are used under contexts strengthened by means of both scientific and pseudoscientific issues. Introductory information on SSIs used in NOS courses can be offered before each course, and it can be recommended that, with a view to identifying the relationship of these issues with science instruction program, aspects of each unit in the instruction program which are well-suited or ill-suited to SSI-based instruction are unveiled, balancing between positive and negative information is ensured, and a pedagogical slogan based on the idea that representations should be available in relation to each NOS component should be created. Considering that the material development skills are associated with pedagogical content knowledge (Davis and Krajcik, 2005) to eliminate confronted problems, NOS and special instruction methods courses which are offered under teacher education programs are modeled through SSI-based instruction which relies on pedagogical content knowledge.

REFERENCES

Abd-El-Khalick, F. (**2005**).Developing deeper understandings of nature of science: The impact of a philosophy of science course on preservice science teachers' views and instructional planning. International Journal of Science Education, 27(1): 15-42.

Abd-El-Khalick, F., and **Akerson**, V. L. (**2004**).Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of nature of science. Science Education, 88(5): 785-810.

Abd-El-Khalick, F., Waters, M., and Le, A. P. (**2008**). Representations of nature of science in high school chemistry textbooks over the past four decades. Journal of Research in Science Teaching, 45(7): 835-855.

Afonso, A. S., and **Gilbert**, J. K. (**2010**). Pseudo-science: A meaningful context for assessing nature of science. International Journal of Science Education, 32(3): 329-348.

Akerson, V. L., and **Hanuscin**, D. L. (**2007**). Teaching nature of science through inquiry: Results of a 3-year professional development program. Journal of Research in Science Teaching, 44(5): 653-680.

Atabey, N., Topcu, M. S., and Ciftci, A. (**2018**). The investigation of socioscientific issues scenarios: A content analysis research. OPUS International Journal of Society Researches, 9(16): 1968-1991.

Aydin, S., and **Tortumlu**, S. (**2015**). The analysis of the changes in integration of nature of science into Turkish high school chemistry textbooks: is there any development? Chemistry Education Research and Practice, 16(4): 786-796.

Bossér, U., and **Lindahl**, M. (**2019**). Students' positioning in the classroom: A study of teacher-student interactions in a socioscientific issue context. Research in Science Education, 49(2): 371-390.

Bossér, U., Lundin, M., Lindahl, M., and Linder, C. (**2015**). Challenges faced by teachers implementing socio-scientific issues as core elements in their classroom practices. European Journal of Science and Mathematics Education, 3(2): 159-176.

Burgin, S. R., and **Sadler**, T. D. (**2016**). Learning nature of science concepts through a research apprenticeship program: A comparative study of three approaches. Journal of Research in Science Teaching, 53(1): 31-59.

Carson, K., and **Dawson**, V. (**2016**). A teacher professional development model for teaching socioscientific issues. Teaching Science, 62(1): 28.

Christenson, N., Rundgren, S. N. C., and Zeidler, D. L. (**2014**). The relationship of discipline background to upper secondary students' argumentation on socioscientific issues. Research in Science Education, 44(4): 581-601.

Chua, J. X., Tan, A. L., and Ramnarain, U. (**2019**). Representation of NOS aspects across chapters in Singapore Grade 9 and 10 Biology textbooks: insights for improving NOS representation. Research in Science & Technological Education, 37(3): 259-278.

Clough, M. P. (**2006**). Learners' responses to the demands of conceptual change: Considerations for effective nature of science instruction. Science and Education, 15(5): 463-494.

Davis, E. A., and **Krajcik**, J. S. (**2005**). Designing educative curriculum materials to promote teacher learning. Educational Researcher, 34(3): 3-14.

Dawson, V. (**2015**). Western Australian high school students' understandings about the socioscientific issue of climate change. International Journal of Science Education, 37(7): 1024-1043.

Dawson, V., and **Carson**, K. (**2017**). Using climate change scenarios to assess high school students' argumentation skills. Research in Science and Technological Education, 35(1): 1-16.

Dawson, V., and **Venville**, G. J. (**2009**). High-school students' informal reasoning and argumentation about biotechnology: An indicator of scientific literacy? International Journal of Science Education, 31(11): 1421-1445.

Demirdogen, B., Hanuscin, D. L., Uzuntiryaki-Kondakci, E., and Koseoglu, F. (**2016**). Development and nature of preservice chemistry teachers' pedagogical content knowledge for nature of science. Research in Science Education, 46(4): 575-612.

Evren-Yapıcıoğlu, A. (**2016b**). The views and reflections of preservice science teachers regarding implementations of socioscientific issue based instructions. Hacettepe University Graduate School of Educational Sciences Journal of Educational Research, 2(2): 132-151.

Evren-Yapıcıoğlu, A. (**2018**). Advantages and disadvantages of socioscientific issue-based instruction in science classrooms. International Online Journal of Education and Teaching (IOJET), 5(2): 361-374.

Fraenkel, J. R., Wallen, N. E., and Hyun, H. H. (**2012**). Internal validity. How to design and evaluate research in education. New York: McGraw-Hill, 166-83.

Genel, A., and **Topçu**, M. S. (**2016**). Turkish preservice science teachers' socioscientific issues-based teaching practices in middle school science classrooms. Research in Science and Technological Education, 34(1): 105-123.

Gul, M. D., and **Akcay**, H. (**2020**). Structuring a new socioscientific issues (SSI) based instruction model: Impacts on pre-service science teachers' (PSTs) critical thinking skills and dispositions. International Journal of Research in Education and Science, 6(1): 141-159.

Gustafsson, B., and **Öhman**, J. (**2013**). DEQUAL: A tool for investigating deliberative qualities in students' socioscientific conversations. International Journal of Environmental and Science Education, 8(2): 319-338.

Hanegan, N. L., Price, L., and Peterson, J. (**2008**). Disconnections between teacher expectations and student confidence in bioethics. Science and Education, 17(8-9): 921-940.

Hofstein, A., Eilks, I., and Bybee, R. (**2011**). Societal issues and their importance for contemporary science education—a pedagogical justification and the state-of-the-art in Israel, Germany, and the USA. International Journal of Science and Mathematics Education, 9(6): 1459-1483.

Holbrook, J., and **Rannikmae**, M. (**2009**). The meaning of scientific literacy. International Journal of Environmental and Science Education, 4(3): 275-288.

Khishfe, R. (**2014**). Explicit nature of science and argumentation instruction in the context of socioscientific issues: An effect on student learning and transfer. International Journal of Science Education, 36(6): 974-1016.

Khishfe, R. (**2017**). Consistency of nature of science views across scientific and socio-scientific contexts. International Journal of Science Education, 39(4): 403-432.

Khishfe, R., and **Abd-El-Khalick**, F. (**2002**). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. Journal of Research in Science Teaching, 39(7): 551-578.

Khishfe, R., and **Lederman**, N. (**2006**). Teaching nature of science within a controversial topic: Integrated versus nonintegrated. Journal of Research in Science Teaching, 43(4): 395-418.

Kolsto, S. D. (**2001**). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. Science Education, 85(3): 291-310.

Lederman, N. G. (**1992**). Students' and teachers' conceptions of the nature of science: A review of the research. Journal of Research in Science Teaching, 29(4): 331-359.

Lenz, L., and **Willcox**, M. K. (**2012**). Issue-oriented science: Using socioscientific issues to engage biology students. The American Biology Teacher, 74(8): 551-556.

Lin, S. S., and **Mintzes**, J. J. (**2010**). Learning argumentation skills through instruction in socioscientific issues: The effect of ability level. International Journal of Science and Mathematics Education, 8(6): 993-1017.

Lindahl, M. G., and **Folkesson**, A. M. (**2016**).Attitudes and language use in group discussions on socio-scientific issues. Eurasia Journal of Mathematics, Science and Technology Education, 12(2): 283-301.

McComas, W. F. (**2015**). The nature of science & the next generation of biology education. The American Biology Teacher, 77(7): 485-491.

Metin, D., Cakiroglu, J., and Leblebicioglu, G. (**2017**). Perceptions of eighth graders concerning the aim, effectiveness, and scientific basis of pseudoscience: the case of crystal healing. Research in Science Education, 50(1): 175-202.

Mulvey, B. K., and **Bell**, R. L. (**2017**). Making learning last: teachers' long-term retention of improved nature of science conceptions and instructional rationales. International Journal of Science Education, 39(1): 62-85.

Nielsen, J. A. (**2012**). Science in discussions: An analysis of the use of science content in socioscientific discussions. Science Education, 96(3): 428-456.

Owens, D. C., Sadler, T. D., and Friedrichsen, P. (**2019**). Teaching practices for enactment of socio-scientific issues instruction: An instrumental case study of an experienced biology teacher. Research in Science Education, 1-24.

Patton, M. Q. (**2002**). Two decades of developments in qualitative inquiry: A personal, experiential perspective. Qualitative Social Work, 1(3): 261-283.

Ramnarain, U. D., and **Chanetsa**, T. (**2016**). An analysis of South African Grade 9 natural sciences textbooks for their representation of nature of science. International Journal of Science Education, 38(6): 922-933.

Ratcliffe, M., and **Grace**, M. (**2003**). Science education for citizenship: Teaching socio-scientific issues. McGraw-Hill Education (UK).

Reis, P., and **Galvão**, C. (**2004**). Socio-scientific controversies and students' conceptions about scientists. International Journal of Science Education, 26(13): 1621-1633.

Rudge, D. W., and **Howe**, E. M. (**2009**). An explicit and reflective approach to the use of history to promote understanding of the nature of science. Science and Education, 18(5): 561-580.

Sadler, T. D. (**2004**). Informal reasoning regarding socioscientific issues: A critical review of research. Journal of Research in Science Teaching, 41(5): 513-536.

Sadler, T. D. (**2009**). Situated learning in science education: socio-scientific issues as contexts for practice. Studies in Science Education, 45(1): 1-42.

Sadler, T. D., and **Zeidler**, D. L. (**2009**). Scientific literacy, PISA, and socioscientific discourse: Assessment for progressive aims of science education. Journal of Research in Science Teaching, 46(8): 909-921.

Sadler, T. D., Chambers, F. W., and Zeidler, D. L. (**2004**). Student conceptualizations of the nature of science in response to a socioscientific issue. International Journal of Science Education, 26(4): 387-409.

Tsai, C. Y. (**2018**). The effect of online argumentation of socio-scientific issues on students' scientific competencies and sustainability attitudes. Computers and Education, 116: 14-27.

Türkmen, H., Pekmez, E., and Saglam, M. (**2017**). Pre-service science teachers' thoughts about socio-scientific issues. Ege Journal of Education, 18(2): 448-475.

Upahi, J. E., Ramnarain, U., and Ishola, I. S. (**2018**). The nature of science as represented in chemistry textbooks used in Nigeria.

Research in Science Education, 1-19.
Van Driel, J. H., and **Henze**, I. (**2012**). Extended paper for PCK Summit, Colorado 2012. Retrieved from http://pcksummit.bscs.org.
Wei, B., Li, Y., and Chen, B. (**2013**).Representations of nature of science in selected histories of science in the integrated science textbooks in China. School Science and Mathematics, 113(4): 170-179.
Yahaya, J. M., Nurulazam, A., and Karpudewan, M. (**2016**). College students' attitudes towards sexually themed science content: a socioscientific issues approach to resolution. International Journal of Science Education, 38(7): 1174-1196.
Zeidler, D. L. (**2014**). Socioscientific issues as a curriculum emphasis. Theory, research, and practice.In NG Lederman & SK Abell (Eds.), Handbook of research on science education, 2, 697-726.
Zeidler, D. L., Applebaum, S. M., and Sadler, T. D. (**2011**). Enacting a socioscientific issues classroom: Transformative transformations. In Socio-scientific issues in the classroom (pp. 277-305).Springer, Dordrecht.
Zeidler, D. L., Sadler, T. D., Simmons, M. L., and Howes, E. V. (**2005**). Beyond STS: A research-based framework for socioscientific issues education. Science Education, 89(3): 357-377.
Zohar, A., and **Nemet**, F. (**2002**). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. Journal of Research in Science Teaching, 39(1): 35-62.

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