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A Mixed Method Research Study on the Effectiveness of Socioscientific Issue-Based Instruction *

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Abstract

This study was conducted to examine the efficiency of socioscientific issues-based instruction on the development of the scientific literacy levels (scientific content knowledge, science-technology-society interactions, and the nature of science) of pre-service science teachers and their conceptual perception of socioscientific issues in science teacher education. In this mixed method research study, in which convergent parallel design (QUAN+QUAL) was utilized, both quantitative and qualitative research phases were administered concurrently. The study group included a total of 82 pre-service science teachers (40 experimental and 42 control) currently enrolled as third-year students in the Department of Elementary School Science Education. A basic science and technology literacy scale was used as the quantitative data collection tool, whereas pre-service science teachers' diaries, a focus group interview, and in-class observations were used as qualitative data collection tools. At the end of the study, it was concluded that the practices of socioscientific issues-based instruction quantitatively improved the scientific literacy level of pre-service science teachers in the experimental group. It was also found that the improvement in overall scientific literacy levels was due to an improvement in the nature of science area of scientific literacy in particular. Parallel to this finding, the pre-service science teachers made explanations in relation to the nature of science area based on the results of the qualitative phase. These explanations were made using the "changeability" sub-theme under the theme of conceptual perception of "socioscientific issues". Thus, based on both the quantitative and qualitative findings of the study, it can be argued that socioscientific issues-based instruction can influence the improvement of pre-service science teachers' perceptions of the nature of science. Finally, it was found that the pre-service science teachers in the experimental group had improved levels of conceptual perception of socioscientific issues. Therefore, it is believed that this approach, which places an emphasis on the social dimension of science, can contribute positively to the professional training of pre-service science teachers.

Keywords

Socioscientific issues

Socioscientific issues-based instruction

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Introduction

As modern living standards change and evolve, the roles and responsibilities expected from individuals change and increase as well. Undoubtedly, the education system and institutions shoulder the biggest responsibility for the education of the individual in a society. Education has no other important purpose than guiding individuals and preparing them for the real life by helping them to reach their maximum potential as individuals (Evren Yapıcıoğlu, 2016a). Thus, it is important that content and education approaches specific to scientific disciplines are structured parallel to social lives of students.

Throughout their lives, individuals face numerous dilemmas related to the influence of scientific practices and technological products on the society. Because the implications of scientific advancement and proliferation of science and their interruptions in human life result in ethical, moral and social dimensions to come out. New scientific knowledge and the processes to reach these have direct and indirect effects on the people all over the world, can be summarized as the following socioscientific issues: waste control and renewability (Kortland, 1996), genetic engineering (Sadler & Zeidler, 2004, 2005a), nuclear (Zengin Kırbağ, Keçeci, Kırılmazkaya, & Şener, 2011) and hydroelectric power plants (Öztürk & Leblebicioğlu, 2015; Yavuz Topaloğlu & Balkan Kıyıcı, 2017), gene therapy, cloning, and global warming (Topçu, 2008; Topçu, Sadler, & Yılmaz Tüzün, 2010). Socioscientific issues have been conceptualized recently, attract a great deal of interest from researchers, and are used very commonly in people's daily languages as well (Sadler, 2004a).

The concept called "socioscientific issues" are scientific topics that affect society and cover social dilemmas related to conceptual and technological dimensions of science and about which students would enter into a mutual dialogue, argumentation, informal reasoning and discussion (Sadler, 2003, 2004a; Zeidler & Nichols, 2009). While socioscientific issues are naturally controversial, decision-making process for creating solutions to these issues also covers moral reasoning by the individual and evaluation of ethical concerns (Zeidler & Nichols, 2009). Socioscientific issues includes context like sea-lion hunting (Zeidler & Nichols, 2009), or chicken slaughtering to prevent bird-flue (Lee & Grace, 2012) that are local in nature, as well as issues with global dimension such as stem cells and cloning (Concannon, Siegel, Halverson, & Freyermuth, 2010), genetic engineering and genetically modified organisms (Sadler & Donnelly, 2006; Yaman, 2011; Zohar & Nemet, 2002).

As it is the case with the rest of the world, socioscientific issues are a major national agenda item in Turkey as well. For instance, agenda items like "Igne Ada, Akkuyu, Sinop Nuclear Power Plant Projects, Green Road Project in Black Sea Region, Cerattepe Mine Project, Illegal Electricity Use", are socioscientific issues that can turn into social protests depending on the views of different sides of the issue. Before being integrated into a curriculum, a socioscientific issue should be evaluated as to whether or not it satisfies certain criteria. According to Evren and Kaptan (2014), before covering a socioscientific issue, researchers, educators, teachers and pre-service teachers should decide whether or not the issue is socioscientific in nature and should ask the following questions while making a decision.

- Is it scientific?
- Does it involve a dilemma?
- Is it within the scope of science-society-technology interaction?
- Is it open-ended and does it have multiple correct answers?
- Can the answer change be depending on an individual's ethical and moral values?

It is among the duties and goals of the science educators to ensure that members of the society develop a stance, view and idea in an informed manner about these issues they come across frequently on a daily basis (Evren Yapıcıoğlu, 2016b). The researchers indicate that the main purpose in integrating socioscientific issues into science classes is to educate citizens with a sense of responsibility (Hofstein, Eilks, & Bybee, 2011; Kolsto, 2001; Pedretti, 1999; Lee et al., 2013). It is stated that focusing on the science based daily issues in the world, would emphasize science's role, which is not isolated from society and is actually reflected on the society and that by means of interdisciplinary relations between different academic disciplines, future projections would be possible. (Driver, Newton, & Osborne, 2000; Kolsto, 2001; Sadler, 2003, 2004a). However, a robust science education may help in carrying society to the level of modern societies. One way of achieving this is to ensure that science education and curriculum are enriched with socioscientific issues. Zeidler and Nichols (2009) indicated that educational approaches that cover socioscientific issues should be developed and emphasized that while teaching of certain scientific principles requires special teaching methods, there would also be a need for pedagogic models that would cover both scientific issues and daily situations.

For teaching of the chosen socioscientific issue researchers usually utilize the argumentation method in the literature. Discussion of socioscientific issues using the argumentation method involves teaching that incorporates decision making by using arguments and proofs related to moral and ethical situations that have scientific aspects (Sadler, 2004b; Sadler & Zeidler, 2005b; Zeidler & Sadler, 2008a, 2008b). The national literature as well emphasizes frequently, a teaching method for socioscientific issues that is supported by argumentation (Deniz, 2014; Deveci, 2009; Domaç, 2011; Gülhan, 2013). In a learning setting where socioscientific issues are used, a preferred teaching tool is the use of problem scenarios (Evren & Kaptan, 2014; Sadler, 2003; Topçu, 2008). In this method, scenarios containing ethical and moral situations with scientific dimensions that might be of interest for students are selected and student may be guided to enter discussions about these scenarios (Dolan, Nichols, & Zeidler, 2009). Evren and Kaptan (2014) recommended that discussion of socioscientific issues using dilemma cards might be effective in a socioscientific issues based teaching process. Dilemma cards allow students to make judgments and evaluate decisions mutually and also encourage them to express their ideas, beliefs and actions explicitly (Oliveira, Akerson, & Oldfield, 2012). In this regard, it is a teaching tool that is appropriate for socioscientific issues based approach. Walker and Zeidler (2007) on the other hand, addressed the issue of genetically modified organisms in online chat rooms via a web-based teaching tool as part of a unit based on judgment of issues. Moreover, as part of this study, socioscientific issues were addressed using socioscientific issues based instruction approach. Because in socioscientific issues based instruction approach, learning and teaching processes are planned using numerous real or near-real situations that contain elements of socioscientific issues. For example, when you address the issue of "genetically modified organisms", it is a socioscientific issue (Gürbüzoğlu Yalmancı & Gözüm, 2016) with both social and scientific dimensions. In this regard, people may have an opposing stance against genetically modified organisms by taking into account their dangers for man, health and the environment. On the other hand, this issue can also be addressed in a situation where global food resources are depleted and humankind is faced with the risk of famine. In such a case, people may have a stance whereby they support the use of genetically modified organisms for food production.

The learning environments that were planned to provide learning via socioscientific issues; are related to students' content knowledge about such issues (Lewis & Leach, 2006), helps increase level of knowledge of scientific content (Klosterman & Sadler, 2010), influences positively the numerous dimensions of nature of science (Sadler, Chambers, & Zeidler, 2004), helps improve decision making skills (Gutierez, 2015; Zo'bi, 2014), supports the development of high level cognitive skills and encourages students to have a positive attitude towards science (Sadler, 2009). In addition, socioscientific issues are also seen as a way of improving scientific literacy, which is indicated to be the ultimate goal of science education (Pouliot, 2008; Topçu, Muğaloğlu, & Güven, 2014). In the studies mentioned, while the fact that socioscientific issues contributed to the scientific literacy levels of individuals was mentioned very frequently, no concrete finding was observed in relation to description of its influence in practice. Due to socioscientific issues being conceptualized in recent past (Sadler, 2003), it can be argued that individuals have started to form conceptual perceptions of these issues only very recently. And conceptual perception encompasses all emotions, ideas, associations and information that an individual has formed in relation to a concept based on their individual life experiences (Ülgen, 2001; Vendryes, 2002). On the other hand, conceptual perception of socioscientific issue is the ideas that pre-service teachers have created and other concepts that they have developed as a result of their experiences with the teaching practices. Based on the findings of studies, teachers and pre-service teachers perceive socioscientific issues as issues or topics that are interesting, current, contain risk or possibility, offer no consensus and have ethical and moral dimensions (Özden, 2015; Ekborg, Ottander, Silfver, & Simon, 2013) and socioscientific issues are believed to have the potential to help educate individuals with high level of social awareness (Tal & Kedmi, 2006).

Improvement of scientific literacy, Holdbrook and Rannikmae (2007) emphasize the importance of placing value on nature of science, improvement of personal qualities, and gaining socioscientific skills and values. Socioscientific issues help students improve their conceptualization of nature of science, and motivate them to discover the connections between science and the society (Eastwood et al., 2012; Sadler & Zeidler, 2004, 2005b). It is believed that socioscientific issues are closely related to nature of science especially because socioscientific issues contain mutual interactions between science and society (Sadler, 2003, 2004a), have content on which scientists have not yet reached a consensus (Kolsto, 2001) and have a structure that trigger the personal value, belief and moral systems of individuals (Sadler & Zeidler, 2004). However, in the studies no clear finding was obtained as to the influence of socioscientific issues on the individuals' understanding of nature of science. On the other hand, looking at the literature it is seen that while Sadler et al. (2004) and Walker and Zeidler (2007) indicated that students have used certain expressions regarding nature of science, Bell and Lederman (2003) as well as Knishfe (2012) have reached the conclusion that individuals' understanding of nature of science does not play a major role in these individuals' decisions related to socioscientific issues. In research, a clear approach to the influence of socioscientific issues on individuals' nature of science understandings was not reached. Besides, it is argued that middle school curriculums do not emphasize the nature of science, and teachers have naive opinions on the nature of science and they do not transfer their opinions to the classes on this topic (Aslan & Taşar, 2013; Şardağ et al., 2014). The purpose of this study is to analyze the effect of socioscientific issues based instruction approach practices on the development of the scientific literacy levels of pre-service science teachers and to determine their conceptual perception of socioscientific issues. In addition, moving from Zeidler and Nichols (2009) stated that there's a need for pedagogical approaches regarding implementation of socioscientific issues. Moreover, research proves that socioscientific issues allow more argumentative teaching and the issues are evaluated as alternatives to argumentation process (Bağ & Çalık, 2017). Due to these reasons, it is considered that socioscientific issues-based approach can contribute to both teachers, pre-service teachers, and related literature in science education. In fact, Genç and Genç (2007) evaluated socioscientific issues studies carried out in Turkey through content analysis and found out that these studies mostly searched for content knowledge and attitude. Furthermore, they argued that the least research area was teaching socioscientific issues. Contribution to scientific literacy of socioscientific issues was evaluated more theoretically in the past researches. Findings of this study indicate that demonstrating both qualitatively and quantitatively, the influence, in practice, of socioscientific issues based instruction approach on the nature of science, scientific content knowledge and science-technology-society interactions dimensions of scientific literacy and comparison of students' conceptual perceptions of socioscientific issues would contribute to the literature. The problem statement examined by the current study was: What is the influence of utilizing the SIBI approach for the Special Teaching Methods course, or utilizing existing routine practices for the teaching of the same course, on the science and technology literacy levels and socioscientific conceptual perceptions of pre-service science teachers? The sub-problems of focus based on the above problem statement were:

1- Is there a significant difference between basic science and technology literacy post-test scores?

2- When the basic science and technology literacy (BSTL) pretest scores are controlled, is there a significant difference between the areas of Nature of Science (NOS), Scientific Content Knowledge (SCK), and Science-Technology-Society Interactions (STSI) posttest scores?

3- What are the conceptual perceptions of socioscientific issues for pre-service science teachers in the experimental and control groups where the special teaching methods course was given based on the SSIBI approach or based on routine course practices?

Method

In this study, a mixed methods research approach was used. This method combines the use of qualitative and quantitative research approaches (Johnson & Onwuegbuzie, 2004), uses both quantitative and qualitative data collection methods and analysis (Creswell, 2003), and interprets the findings collectively. An analysis of research related to mixed method research studies shows a variety of classifications that are similar in terms of study design classification (Greene & Caracelli, 1997; Leech & Onwuegbuzie, 2009; Morse, 1991; Teddlie & Tashakkori, 2015). Additionally, in this study *convergent parallel design*, which is the classification made by Creswell and Plano-Clark (2015), was taken as a basis. In convergent parallel design, qualitative and quantitative phases are administered concurrently (starting and ending almost at the same time) at one point in the study (Creswell & Plano-Clark, 2015; Teddlie & Tashakkori, 2015). Research design is summarized in Figure 1.

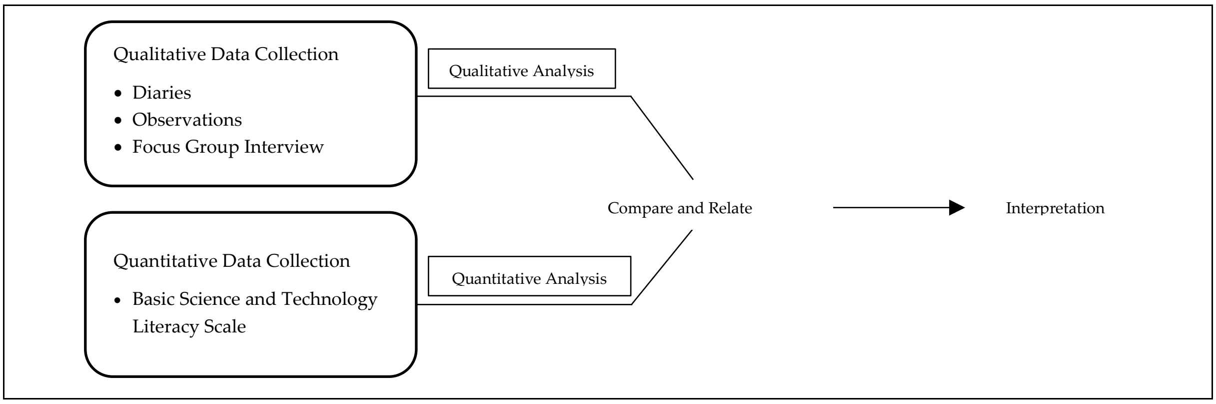

Figure 1. Concurrent Parallel Design (QUAN+QUAL)

Even though these phases are separated in the analysis phase, findings are combined in the interpretation phase. Even though the quantitative and qualitative findings were analyzed separately for the sub-problems of the study, a single conclusion and syntheses were developed in line with the study design. The reason for using converging parallel study design in the study is to bring together the different strengths as well as the non-overlapping weaknesses of quantitative methods and qualitative methods (Patton, 1990), and to triangulate the methods in order to make a direct comparison and obtain conflicts between qualitative and quantitative findings (Creswell & Plano-Clark, 2015). The other reason for using this study design is that the authors believed that this design has equal value in terms of both collection and analysis of qualitative and quantitative data in order to understand the problem as indicated by Creswell and Plano-Clark (2015).

Study Group

At the beginning of the study, H.U. Ethics Committee Approval was obtained with regard to the implementation process and the data tools to be used. At the start of the implementation process, informed consent form from pre-service science teachers in the study group was obtained. The study group comprised first and second branch students in their third year of the Science Education Program, who were enrolled in the FBO 329 Special Teaching Methods course in the spring semester of the academic year 2014-2015. In the quantitative phase of the study, students were randomly assigned to the experimental and control groups. Demographic features of the students in the study group were described and groups were assembled. The study group consisted of 82 third year pre-service science teachers, 40 of which were in the experimental group and 42 of which were in the control group. The age range of the pre-service science teachers in the experimental and control groups was 19 to 25. However, the majority of the pre-service science teachers were aged 20-21 (f_e=29, f_c=34). In addition, an independent samples t-test was administered to analyze the equivalence of the groups in terms of Basic Science and Technology (BSTL) pretest scores, which were among the dependent variables of the study.

Based on the findings of the independent samples t-test, there was no statistically significant difference between the pretest results of the experimental and control groups [$t_{(80)}$=-0.265, p>0.05]. This finding showed that the groups were equal before the implementation process based on BSTL pretest score means.

Data collection methods used in the qualitative phase of the study included in-class observations, pre-service science teachers' diaries, and the focus group interview. The entire class participated in the in-class observations. Additionally, the pre-service science teachers were asked to continue keeping diaries that had already been a routine task in the special teaching methods course prior to the study. In every course, the students were reminded to incorporate into their diaries their feelings, thoughts, views, and experiences in addition to what was lectured on or completed during class. The pre-service science teachers who did not carry out diary tasks appropriately and the ones who didn't resign the diaries were excluded from the research group on the basis of volunteerism principle (Gravetter & Forzano, 2009) of research ethics. The diaries of 56 pre-service science teachers (28 experimental and 28 control group participants) were analyzed. At the end of the implementation process, pre-service science teachers volunteered for participation in the focus group. In the focus group, there were four pre-service science teachers (three female and one male) aged 21-22 from the experimental group. There were also four pre-service science teachers (two females and two male) aged 22-25 from the control group. In terms of academic performance, the participants of both groups were above average (academic success average >2.40).

Quantitative Data Collection Tools

Basic Science and Technology Literacy (BSTL) Scale: The BSTL scale used in the study was the scale developed by Laugksch and Spargo (1996). The scale, which was translated into Turkish by Yetişir (2007), comprises three sub-scales, namely: Nature of Science (NOS), Scientific Content Knowledge (SCK), and Science-Technology-Society Interactions (STSI). To determine the internal consistency reliability of the test, it was administered to 252 pre-service science teachers enrolled in their third (n: 127) and fourth (n: 125) year in the Department of Science Education of one of the major universities in Ankara. Data obtained from the sample was used to calculate the KR20 reliability coefficient for the three sub-scales and the general scale in Microsoft Office Excel.

Table 1. BSTL Scale KR20 Values

Test /Sub-Test		α20	Number of Items
1	*Scientific content knowledge*	0,831	72
2	*Nature of Science*	0,630	22
3	*Influence of science and technology on society and the environment*	0,545	16
Basic Science and Technology Literacy Test		0,881	110

As is demonsrated in Table 1, the KR20 reliability coefficient of the BSTL scale was calculated as 0.88 and it varied between 0.545 and 0.831 for individual tests. Altunışık, Coşkun, Bayraktaroğlu, and Yıldırım (2010) indicated that the desired alpha value for determining the internal consistency of the scale was 0.7, but that a value of 0.5 for research studies was acceptable. On the other hand, Salvucci, Walter, Conley, Fink, and Saba (1997) have indicated that the reliability coefficient between 0,5 and 0,8 is moderate and acceptable and that reliability coefficient of 0,8 and above is highly reliable. Thus, in order not to disrupt the original structure of an adapted scale as mentioned by Ergin (1995) as well, factor analysis was not needed.

Qualitative Data Collection Tools

Focus Group Interview: In this study, a focus group interview was conducted with participants from the experimental and control groups to obtain pre-service science teachers' views and experiences of socioscientific issues and their instruction. Moreover, SIBI, which is the main subject of this study, is not a personal or sensitive topic so the participants easily shared and discussed their views in the group setting. One of the advantages of using a focus group interview was the opportunity to obtain more in-depth information from the pre-service science teachers, as they engaged in peer discussion and responded to the researchers' questions (Yıldırım & Şimşek, 2008). For the focus group interview, a semi-structured questionnaire was used, which consisted of opened-ended questions. This format allowed the researcher to set the direction of the interview (Merriam, 2009). As part of the study, the conceptual perception of pre-service science teachers about socioscientific issues was obtained using the semi-structured questionnaire, beginning with ten open-ended questions. After the interview questions were prepared, three field experts were consulted and the questionnaire was administered after adjustments were made based on their feedback. *For instance, the question of "which socioscientific issues do you take into consideration in science education?"* was answered as part of the question of *"How would you take into consideration the socioscientific issues when you become a teacher?"*. Thus, it was given as a sub-question in the final interview form developed as a result of the focus group interview. The revised questionnaire comprised six questions and sub-questions and one additional example. The focus group interview lasted 50 minutes in total. The participants were asked to write on a piece of paper, any issue that they were not able to raise during the focus group interview because they did not want other group members to learn and because of the possibility to experience a problem with the group. However, the participants did not want to write anything on the papers and during the interview, they used expressions such as "I said everything I had in my mind". In addition, pre-service teachers were told that their names would not be shared with others in anyway. Thus, eight colors (blue, purple, yellow, white, green, dark blue, red, pink) were presented to pre-service teachers and they were asked to start their speeches by saying, "I am blue" etc. in order to avoid any confusion. Thus, during the presentation of the findings from the focus group interview as part of the qualitative data analysis, the statements made by participants were presented in accordance with their respective colors.

Pre-service teacher Diaries: As a qualitative data collection tool, pre-service science teachers' diaries were used. Pre-service science teacher diaries allow teacher educators to better understand the learning experiences of the pre-service science teachers, and as such, they are one of the most basic individual and personal documents (Ekiz, 2006; Merriam, 2009). In this study, diaries are one of the qualitative documents that pre-service science teachers share their views and to decide writing time themselves. According to this, it used to determine pre-service science teachers' conceptual perception relate to socioscientific issues.

Classroom Observation: In the study, a less structured, qualitative style of observation was used. In this observation style, the researcher does not use predefined categories or codes but engages in a more natural and open-ended practice of observation. The goal is to allow the categories and concepts necessary for analyzing observation data to emerge naturally during the observation process rather than determining them in advance based on the data or findings of previous studies (Punch, 2014). The reason for using an in-class observation method was to foster understanding of the discussions and interactions of pre-service science teachers (in both the experimental and control groups) with the researcher and among themselves. During the study, in both groups, a digital camera was used and it was placed in a location that allowed a full view of the classroom. Sections related to the problem situations of the study were selected from the camera footage made for a total of 28-course hours and data reduction as indicated by Huberman and Miles (1983) was included in the qualitative analysis of 10-hour recording. A total of ten hours of recording was completed. The discussions of the pre-service science teachers in the camera recording were decoded into sentences and analyzed.

Analysis Process of Quantitative Data

As a result of the decision process for choosing analysis techniques in the study, skewness, and kurtosis coefficient values for BSTL pretest-posttest distributions were found to be within normal distribution (+1, -1). Additionally, based on the results of the Shapiro Wilks Test, it was observed that the pretest-posttest score distributions for both study and control groups had a normal distribution. Taking into account the fact that the sample size was greater than 30 (Büyüköztürk, Çokluk, & Köklü, 2010; Kalaycı, 2010), parametrical testing techniques were found to be appropriate for this study.

For the first sub-problem of the study, an independent samples t-test was used to determine the BSTL posttest means difference between the experimental and control groups. For the second sub-problem of the study, a MANCOVA test was used to analyze the sub-scales of NOS, SCK, and STSI. In the experimental and control groups, in order to rule out the effect of the pretest, BSTL pretest scores were appointed as a covariate. Prior to analyses, assumptions for the MANCOVA were tested. To test the homogeneity of the dependent variables, the Levene Test was used. For the homogeneity of variances, based on the results of the Levene Test, p values based on NOS (p=0,103) and SCK (p=0,076) p values were greater than the statistical significance value of 0,05. Accordingly, it can be argued that NOS and SCK posttest scores satisfied the assumption of homogeneity of variances (p> 0.05). Because the STSI p-value (p=0,010) was found to be smaller than 0,05 based on the posttest results, the assumption of homogeneity of variances was not satisfied. Moreover, it was found that the result of Box's M Test (p=0,078) was not statistically significant. The insignificance of Box's M Test results means that variance-covariance matrixes are homogenous. As the second assumption, one needs to determine whether or not the curve for dependent variables (NOS, SCK, and STSI posttest results) and the code variable of the BSTL pretest scores is reasonable. Based on the homogeneity of regression assumption test results, because the statistical relation between BSTL pretest results and dependent variables (NOS: p=0,372, SCK: p=0,893, STSI: p=0,919) had a significance greater than 0,05, it was observed that their relation was not statistically significant. This finding means that the slopes of the regression lines for both groups being equal. As a result of the analysis, the assumptions for the MANCOVA analysis were valid. In addition, the effect size of the study was calculated using the G*Power statistical analysis program using sample size, error percentage, and effect size. With the preliminary calculations made, when the effect size of 0,25 (moderate effect), alpha (α) value of 0,05, and research strength of 0,95 were used and an F-test was used for analysis, the minimum sample size to be attained was calculated as 79. Based on these analyses, a study group comprising a total of 82 students in the experimental and control groups was formed. Based on the effect analysis made at the end of the study, the effect size of the study was calculated to be 0,60. Cohen (1988) defined an effect size as small for values up to 0,10, moderate for values up to 0,25, and large for values of 0,40 and above. From this perspective, one can argue that the study had a large effect size.

Analysis Process of Qualitative Data

Qualitative data analysis was carried out based on the framework developed by Miles and Huberman (1994) considering the major phases of data analysis: data reduction, data display, and conclusion drawing and verification. First, the mass of data has to be organized and somehow meaningfully reduced or reconfigured. Miles and Huberman (1994) describe this first of their three elements of qualitative data analysis as data reduction. Not only do the data need to be condensed for the sake of manageability, they also have to be transformed so they can be made intelligible in terms of the issues being addressed. Thus, 28-hour video record was meaningfully reduced to 10-hour record which is related to research questions of the study. Besides, though a consent form was approved by pre-service science teachers, inappropriate diaries were excluded from the data analysis. In total, 10-hour observation record, 50-mins focus group interview records, and 56 diaries were included in content analysis. According to Strauss and Corbin (1990), content analysis allows the researchers to expose themes and dimensions that were not noticeable before an in-depth analysis of the data collected.

With content analysis, similar data is grouped according to certain concepts and themes and is interpreted in a manner that the reader can comprehend (Yıldırım & Şimşek, 2008). No pre-coding was done because the previous research on socioscientific issues did not correspond to this study in terms of its implementation process and the sub-problems of the research. Thus, coding based on concepts emerging from the collected data was used (Strauss & Corbin, 1990). With the raw data collected, the constant comparative method (Merriam, 2009), which is widely used in qualitative research, was used. Raw qualitative data obtained using each of the data collection tools were compiled into a single document and the below phases were used for analysis.

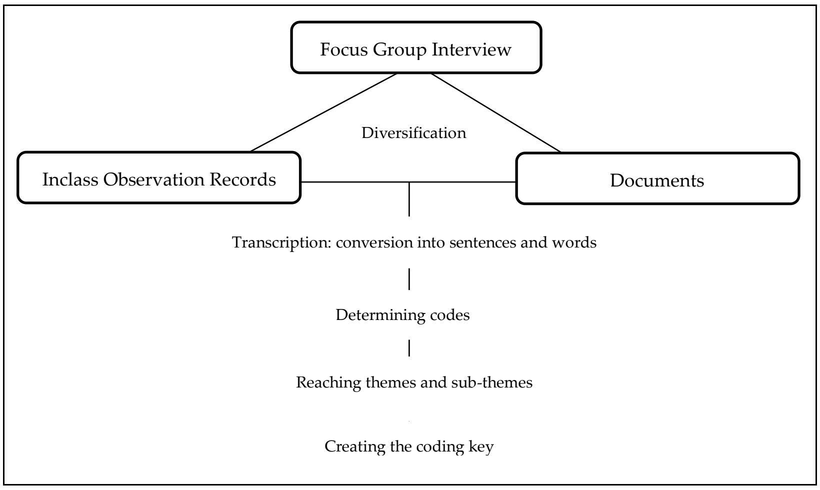

Figure 2. Analysis of Qualitative Data

The coding key and the sectional code that represents 20% of the qualitative data were sent to two experts experienced in qualitative research to ensure inter-coder reliability. Because of the calculations made [Agree / (Agree + Disagree) x 100], the coder reliability was found to be 92%. Because this value is about 80%, which is the threshold level determined by Miles and Huberman (1994), the coding was found to be reliable.

Implementation Process

The implementation process started in March and lasted seven weeks, finishing at the end of May (excluding the pretest and posttest administration times). The study was completed in a total of 28 course hours with four-hour blocks.

Special Teaching Methods Course with SIBI in the Experimental Group: A Special Teaching Methods course was given to the pre-service science teachers comprising the experimental group (n=40) based on the SIBI approach. In the planning stage of the course implementation, first the special teaching methods and techniques in science education were determined. After this step, socioscientific issues to be integrated into course content using these methods were determined and added to activity folders. Emphasis was placed on ensuring that the issues covered by the activities had a socioscientific issue dimension. During the teaching process, a total of 13 activities based on the SIBI approach was used. The first step in course administration involved an introduction to the special teaching method for science education, which was followed by implementation of activities that required active participation by the class. The activities were completed using the special teaching methods outlined in Table 2. The activities prepared based on the special teaching methods were as follows:

Table 2. Special Teaching Methods and Techniques Based on SIBI and Activities

Argumentation-Based Science Education	Activity 1: Is a dolphin a fish or a mammal? Activity 2: Dolphinariums: From the man on land to the dolphin in the sea
Scientific Process Skills Approach	Activity 3: I was ice, and got bigger; I was water and got smaller! Activity 4: News bulletin: Kyoto Protocol
Concept Teaching: Concept Cartoons and Word Association Tests	Activity 5: Search your mind and remember what you know: GMOs Activity 6: Genetic tests
Collaborative Learning Approach	Activity 7: Dilemma cards: Donation of organs and the waste problem
Problem-based Learning Approach	Activity 8: Stolen electricity, lost money Activity 9: Recyclable black bags and their purpose
View Development Technique	Activity 10: Teacher training problems Activity 11: Alternative energy sources
Outdoor Learning Approach	Activity 12: Opinion polls: GMOs
Project-Based Learning Approach	Activity 13: The Turkish education system

As part of the implementation phase, for instance, the “Genetic Tests” activity was implemented using concept cartoons. At the start of the activity, a short briefing was made regarding the use of concept cartoons in science education. After this, activity flyers related to socioscientific issues based instruction approach were given out. At the start of the activity, the question of “If someone wanted to create your genetic map, would you allow it? Why do you think so?”. At the heart of the event are also different situations related to genetic tests expressed as follows “Should a person undergo genetic testing for cancer or not?” With concept cartoons, these issues were shared via characters (Appendix 1). Pre-service teachers were asked which of the characters they agreed with and why they thought so. After obtaining individual views, a collective class discussion was started. The stance of the Instructor in every activity was Neutral as indicated by Kelly (1986). The neutral instructor supports in-class discussions without revealing his/her opinion and encourages students to share their own views. Moreover, at the end of the activity, the participants were asked their opinions about the activity and which socioscientific issues that could cover via concept cartoons.

Special Teaching Methods Course with Routine Practices in the Control Group: The Special Teaching Methods course was instructed for the control group (n=42) based on routine practices. The routine practices of the course involved the use of special teaching methods and a techniques direct instruction method for science education. Special teaching methods and techniques presented in the control group in the context of routine practices as below.

- Argumentation Based Science Education
- Socioscientific Issues-Based Instruction Approach
- Scientific Process Skills Approach
- Concept Teaching: Concept Cartoons and Word Association Tests
- Collaborative Learning Approach
- Problem-based Learning Approach
- View Development Technique
- Outdoor Learning Approach
- Project-Based Learning Approach

For example the week during which the "Science Education based on Argumentation" approach was covered, the following sub-topics were covered using the direct instruction technique via power point presentation: "1-What is argumentation?, 2- Benefits of using argumentation in science classes?, 3- The relationship between skills given in science education and argumentation, 4-Toulmin's argumentation model, 5- The role of the teacher in argumentation practices, 5-Argumentation examples, 6- Examples of argumentation activities used in science classes". Socioscientific issues-based instruction approach (1-What are socioscientific issues?, 2- Examples of socioscientific issues, 3-Socioscientific issues-based instruction approach, 4- Methods, techniques and strategies that can be used with Socioscientific issues-based instruction approach, 5-The stance of an instructor in Socioscientific issues-based instruction approach in science classes, 6- Examples of Socioscientific issues-based instruction activities) and example activities were presented via direct instruction method during a one week period (four hours) as one of the special teaching methods and techniques indicated. However, the activities were not implemented and no interactive discussions were made about them. In terms of ensuring the continuity of the current routine practices in the control group, the teaching process was mostly under the control of the instructor and was more of a teacher-centered nature.

Results

Quantitative Findings of the Study

The first dependent variable examined in the study was Basic Science and Technology Literacy (BSTL). For this purpose, independent samples t-test was done in order to be able to examine differences in the BSTL levels among the groups at the end of the implementation process. The results are demonsrated Table 3.

Table 3. Independent Samples t-test Results for BSTL Posttest Score Averages for the Experimental and Control Groups

Measurement	Groups	n	$\bar{x}$	sd	df	t	p
BSTL Posttest	Experimental Group	40	83,10	5,86	80	-0,250	0,014
	Control Group	42	79,57	6,84			

Table 3 shows a statistically significant difference between the average posttest scores of the experimental and control groups [$t_{(80)}$=-0.250, p<0.05]. This finding shows that the course implementation in the experimental group had a statistically significant influence on the improvement of the basic science and technology literacy levels of the pre-service science teachers. For the MANCOVA test applied to determine from which sub-dimensions of basic science and technology literacy the statistical difference stems from, BSTL pretest scores were used as a covariant. Descriptive statistics results for the sub-dimensions are given in Table 4.

Table 4. Descriptive Statistics NOS, PCK, STSI Posttest Scores

Sub-dimensions	Groups	N	Average	Corrected Average
NOS	Experimental	40	14,77	14,75
	Control	42	13,50	13,51
SCK	Experimental	40	56,52	56,45
	Control	42	54,57	54,63
STSI	Experimental	40	11,80	11,77
	Control	42	11,50	11,52

Table 4 shows differences in NOS, SCK, and STSI posttest scores when the pretest scores were controlled. It was observed that the differences between the averages of NOS, SCK, and STSI posttest scores in the group decreased. Results of the MANCOVA test administered to measure the effect of the method used are given in Table 5.

Table 5. MANCOVA Test Applied to Measure the Effects of the Method Used

Source of Variance	Wilks' Lambda	Hypothesis sd	Error sd	F	p	Eta-Squared
Intercept	0,720			9,96	0,00	0,28
BSTL pretest	0,676	3	77,0	12,30	0,00	0,32
Group	0,870			3,83	0,01	0,13

Table 5 shows a statistically significant difference between NOS, SCK, and STSI posttest scores. In the study, partial eta squared (ηp2) value was determined to be 0,13. Eta Squared value indicates the amount of variance in the dependent variable that can be attributed to the independent variable. (Büyüköztürk et al., 2010). This value can vary between 0 and 1. Partial eta squared values are interpreted as little effect for ηp2 ≤ 0.01, moderate effect for ηp2 = 0.06 and big effect for ηp2 = 0.14. (Green & Salkind, 2005). Analysis of the partial eta-squared value ($\eta_p 2$=0,13) shows that the effect of the approach in practice was moderate independent from the BSTL pretest score. The results related to the difference of the NOS, SCK, and STSI posttest scores that occurred when the STSI pretest scores were controlled are given in Table 6.

Table 6. ANCOVA Test Results for NOS, SCK, and STSI Posttest Scores Adjusted for BSTL Pretest Scores

Source of Variance	Dependent Variables	Sum of Squares	Sd	Average of Squares	F	p	Eta-Squared
	NOS posttest	31,28		31,28	6,26	0,014*	0,073
Group	STSI posttest	1,38	1	1,38	0,53	0,468	0,007
	SCK posttest	68,07		68,07	3,20	0,077	0,039
	NOS posttest	34,88		34,88	6,98	0,010	0,081
BSTL pretest	STSI posttest	37,25	1	37,25	14,31	0,000	0,153
	SCK posttest	392,70		392,70	18,47	0,000	0,190
	NOS posttest	394,59		4,99			
Errors	STSI posttest	205,64	79	2,60			
	NOS posttest	1679,55		21,26			
	NOS posttest	16816					
Total	STSI posttest	11367	82				
	SCK posttest	254953					

As demonstrated in Table 6, a statistically significant difference was observed between the posttest scores for the sub-dimension of NOS in the experimental and control groups [F (1, 79)=6.26, p=0.014] (p< 0.05). This difference favors the experimental group for which the special teaching course was implemented using the SIBI approach ($\bar{x}$=14.75). On the other hand the partial eta squared value ($\eta_p 2$) for sub-scale of NOS was calculated to be 0,07. This value shows that the effect of the approach in practice on the NOS sub-scale of pre-service science teachers was moderate independent from the BSTL pretest scores. No statistically significant diffrence was observed between the sub-scale posttest scores for scientific content knowledge [F (1, 79)=3,20, p=0,077] and science-technology-society interactions [F (1, 79)=0,53, p=0,468], which are the other sub-scales (p > 0,05). Eta-squared values ($\eta_p 2$) for scientific content knowledge and science-technology-society interactions were calculated to be 0,007 and 0,039 respectively. Moreover, these values show that the effect of the approach in practice on scientific content knowledge and science-technology-society interactions sub-scales of pre-service teachers was little independent from the TFTO pretest scores.

Qualitative Findings of the Study

The focus group interview with pre-service science teachers, the in-class observations, and the participants' diary descriptions of the concepts of socioscientific issues were analyzed. Fifteen sub-themes were generated as a result of the content analysis of the pre-service science teachers' conceptual perceptions of socioscientific issues. Findings of the content analysis are displayed in Table 7.

Table 7. Experimental and Control Group Conceptual Perception of Socioscientific Themes (T)

Sub- Theme (ST)	Sub-Theme Name	Codes	f_e	f_c
ST1	Current	K1: Agenda K2: Current issue/event/concept	19	12
ST2	Social Structure	K3: Related to society K4: Social issue/event/concept/situation K5: Societal issue/event/concept /situation	19	14
ST3	Socioscientific Issue	K6: Socioscientific issue	18	10
ST4	Controversy	K7: Controversial issue/event/concept /situation K8: Discussion K9: Discussion setting	18	16
ST5	Related to Daily Life	K10: From/related to daily life	17	9
ST6	Dilemma	K11: Involving/creating a dilemma	17	13
ST7	Different Perspectives	K12: Different thought/argument/perspective/idea	11	12
ST8	Scientific	K13: Scientific issue/event/concept /situation	11	5
ST9	With no Single Right Answer	K14: Without a single/clear right answer K15: With more than one answer K16: Open-ended	11	12
ST10*	Changeability	K17: Change from person to person K18: Unascertained among scientists K19: No absolute right	8	4
ST11	Situations	K20: Situations	6	1
ST12	Moral Dimensions	K21: Religious judgments K22: Moral Judgments K23: Ethics K24: Conscience-related dimension	6	5
ST13*	Science-Technology-Society-Environment-Interactions	K25: Science-technology-society-environment-interactions K26: Effecting humans	4	3
ST14	Two Way Structure	K27: Can be used in a good/bad way K28: Cost/benefit relation K29: Perceived positive/negative	4	3
ST15*	Scientific literacy	K30: Contributing to scientific literacy	3	1
TOTAL			170	120

* Sub-themes related to quantitative findings of scientific literacy and its dimensions.

Pre-service science teachers' conceptual perceptions of socioscientific issues were described using 15 sub-themes and 30 codes. The sub-themes included: current (f_e=19, f_c=12), social structure (f_e=19, f_c=14), socioscientific issue (f_e=18, f_c=10), controversy (fe=18, f_c=16), relation to daily life (f_e=17, f_k=9), dilemma (fe=17, f_c=13), different perspectives (f_e=11, f_c=12), scientific (f_e=11, f_c=5), without a single right answer (f_e=11, f_c=12), changeability (f_e=8, f_c=4), situations (f_e=6, f_c=1), moral dimensions (f_e=6, f_c=5), science-technology-society-environment interaction (f_e=4, f_c=3), two way structure (f_e=4, f_c=3), and scientific literacy (fe=3, f_c=1). Based on the comparison of the totals of repeating codes, it was demonstrated that the students in the experimental group had a better conceptualization of socioscientific issues (f_e>f_c). In relation to these findings, the pre-service science teachers in the experimental (E) and control group (C) provided the following statements during the in-class observations, the focus group interview, and in the diaries.

> E2: "I can describe it briefly as an issue that results in a dilemma in society or in the scientific community."
>
> E11: "It should have both positive and unrecognized dimensions by society."
>
> E15: "A lot of daily life situations which vary from person to person are described with different arguments."
>
> C4: "In my opinion, situations where scientific and technological developments have the potential to influence society and the environment are socioscientific issues."
>
> C11: "The issue should involve a dilemma, be able to change continuously, and should be related to topics from daily life and science."
>
> C23: "These are issues related to society and don't have a single, definite answer."

In the focus group interview, pre-service science teachers with the code names of White, Green, and Purple, used the following statements related to their descriptions of socioscientific issues.

> White: "Talking about a socioscientific issue, I think about obtaining different views about a social issue, and I mean you don't have to have a single right answer, you can always have different views."
>
> Green: "I think a socioscientific issue should first of all be related to science and society."
>
> Purple: "For instance recycling has economic implications. Again, a socioscientific issue is the one where there is no single absolute right answer. I mean, it should be a social issue or subject, that's it."

Pre-service science teachers in both the control and experimental groups had descriptions of their conceptual perceptions of socioscientific issues as demonstrated by their emotions and thoughts written in their diaries.

> E16: "In our life, we are faced with numerous socioscientific issues that involve dilemmas. The first thing that I thought of during the course on socioscientific issues, which are also very popular right now, are issues that cause a dilemma and make it difficult to reach a decision for me."
>
> E9: "These are positive concepts for some and negative concepts for others in terms of the benefits of the curriculum attainments. In the case of organ donation, people might be against it because of different factors, such as their social environment or religion."
>
> E15: "One special feature of these issues is that people don't agree on a single idea. Some might find cloning ethically wrong and some others might think cloning is a positive step for human health."
>
> C9: "This approach is different from the others in some ways. The most obvious feature is that it covers issues involving dilemmas. These are issues that society hasn't labeled definitively as either 'bad' or 'good.'"
>
> C15: "A socioscientific issue is one that causes a dilemma in me. For instance, organ donation is necessary and every human being should do it. However, some people think it's forbidden due to their religious views."
>
> C47: "Another concept we talked about is socioscientific issues. For an issue to be socioscientific, it should emerge as a result of the complex interaction between science and society. They should be situations involving science, technology, and society at the same time. Among the most debated socioscientific issues are cloning, global warming, animal rights, and euthanasia."

Discussion, Conclusion and Suggestions

Today, discussing socioscientific issues and making decisions about them have become a global agenda beyond national borders. These issues are described as a way of educating young people as future generations with a well-established sense of social responsibility and high level of social and environmental awareness that can make decisions for the benefit of the society (Luther, Tippins, Bilbao, Tan, & Gelvezon, 2013; Kolsto, 2001). According to many educators, instruction via socioscientific issues has become major requirement for science education programs and science classes in terms of reinforcing the science-literacy individual identity (Driver et al., 2000). On the other hand, science literacy, which is the final goal of science education, is an identity that evolves over one's life, and an identity on the description and dimensions of which scientists couldn't reach a consensus (DeBoer, 2000; Eisenhart, Finkel, & Marion, 1996; Hodson, 2003; Holdbrook & Rannikmae, 2007; Miller, 1983). The study also researched the effect of the use of socioscientific issues based instruction approach in science teacher education on the science and technology literacy levels and conceptual perceptions of pre-service science teachers. The primary dependent variable analyzed in the study was science and technology literacy level of pre-service science teachers. Science and technology literacy was analyzed in relation to nature of science, scientific content knowledge and science-technology-society interactions sub-scales as indicated by Miller (1983) and Laugksch and Spargo (1996).

As a result of the study, it was found that the science and technology literacy levels of pre-service science teachers were statistically significant in favor of the experimental group where socioscientific issues-based instruction method was applied [$t(80)=-0,250$, $p<0,05$]. The analysis to find out the sub-scale science and technology literacy from which this difference stems showed a statistically significant difference in favor of the experimental group in the sub-scale of NOS and that the implementation of the approach resulted in moderate effect in practice [(F (1, 79)=6,26, $p=0,014$, $\eta p2=0,07$]. In addition, according to the qualitative findings of the study, pre-service science teachers defined socioscientific issues with sub-scales of changeability, science-technology-society-environment interactions and scientific literacy. The changeability of socioscientific issues is related to NOS. Because it is indicated as follows; "*changeability nature of scientific knowledge: because even though scientific knowledge is long-lasting, it is still influenced by the cultural and social structure of the society*." (Doğan, Çakıroğlu, Bilican, & Çavuş, 2009, p. 49). Accordingly, the pre-service teachers used expressions like "*subjective, not clarified by scientists and not having absolute reality*" as they described this changeability nature of socioscientific issues in relation to NOS. An analysis of the repeating codes shows that such descriptions occur more frequently in the experimental group ($f_d>f_k$). In summary, both the qualitative and quantitative findings of the study support the view that socioscientific issues based instruction practices are more effective compared to current routine practices in terms of improving the NOS perception of pre-service teachers. In the literature, there are studies that support the relationship between socioscientific issues and student's perceptions of NOS (Bell & Lederman, 2003; Knishfe, 2012; Sadler et al., 2004; Walker & Zeidler, 2007; Eastwood et al., 2012). In some of these studies students have expressed views about NOS dimensions such as empiricism, tentativeness, social embeddedness (Sadler et al., 2004), creativity, subjective, tentative and social aspects (Walker & Zeidler, 2007). Parallel to the findings of these studies, according to the qualitative findings of this study, the students have made comments related to the changeability dimension of NOS sub-scale of socioscientific issues. Unlike the findings of these studies, Bell and Lederman (2003) and Knishfe (2012), individual' nature of science notions are not an effective factor in their decision-making processes regarding socioscientific issues. According to some researchers, the NOS notions of individuals are influenced by their attitude in defining and responding to scientific issues and socioscientific problems; in other words they believe that conceptualization of NOS would affect informal reasoning regarding the knowledge and the way they interpret knowledge (Sadler et al., 2004; Zeidler, Walker, Ackett, & Simmons, 2002).

In this study, it was concluded that socioscientific issues based instruction practices did not result in a statistically significant difference in terms of scientific content knowledge [F (1, 79)=3,20, $p=0,077$, $\eta_p 2=0,03$] and science-technology-society interactions [F (1, 79)=0,53, $p=0,468$, $\eta_p 2=0,00$] which were evaluated under science and technology literacy and that this approach had little effect in practice. However, unlike the quantitative findings of the study, according to the qualitative findings, pre-service science teachers made comments related to science-technology-society interactions sub-scale of socioscientific issues using expressions such as those that effect people or that influence science-society-environment. In the literature, no study that researches socioscientific issues and students' science-technology-society interactions could be found. However, conceptually the authors view socioscientific issues as a broader term that brings together all recommended science-technology-society concepts (Zeidler et al., 2002). According to Ministry of National Education of Turkey (MEB, 2013) socioscientific issues in science education helps individuals to make ethical and scientific judgments and develop solutions in the area of learning the science-technology-society-environment interactions. On the other hand, Zeidler, Sadler, Simons, and Howes (2005) indicated that understanding science, technology, society and environment interactions is an important component of scientific literacy and that it is not independent of the subjective beliefs of students. Based on the quantitative findings of the study it was concluded that socioscientific issues based instruction is not an approach that helps pre-service teachers increase their scientific content knowledge. In the literature, studies that research the effect of teaching environments planned with a focus on socioscientific issues as in this study, on students' content knowledge levels have reached different findings. For instance, Taşpınar (2011) indicated that health education activities supported with socioscientific discussions helped increase students' level of knowledge regarding health compared to the constructivist approach. On the other hand, Klosterman and Sadler (2010) indicated that a three week socioscientific issues based teaching program on global warming was effective in increasing content knowledge of students regarding this topic and that students were able to make more detailed and complicated comments. On the other hand, Zohar and Nemet (2002) indicated that an instruction program based on climates in the area of human genetics was more effective in increasing the knowledge levels of students regarding genetic concepts compared to traditional instruction methods. The reason for the above mentioned studies to reach findings different than the findings of this study may be that they covered the teaching of a single socioscientific issue such as global warming, human health or human genetics and that a measurement tool (genetic concept test or a multi-dimensional measurement tool specific for global warming) specific to the socioscientific issue that researched was used. On the other hand, in this study, numerous socioscientific issues based instruction activities were covered such as Kyoto protocol, global warming, organ donation, waste issues, and genetically modified organisms. In addition, the sub- scale of scientific content knowledge is the nature of science and technology, as well as life sciences, physics / chemistry sciences, health sciences as noted by Yetişir (2007).

On the other hand, apart from the problem situation focused on in the current study, the other studies in the literature have focused on the importance of content knowledge or its relation with content knowledge in argumentation, decision-making and informal reasoning process in socioscientific issues. Some of these studies have indicated that there was no relation between levels of content knowledge and quality of socioscientific argumentation or individuals' decision-making processes (Jho, Yoon, & Kim, 2014; Sadler & Donnelly, 2006; Kutluca, Çetin, & Doğan, 2014). On the other hand, Sadler and Zeidler (2005a) indicated that, contrary to what's been indicated, students with a higher level of conceptual understanding of genetics made fewer errors in their informal reasoning processes compared to students with a low level of conceptual understanding of genetics and that their level of knowledge in this field is related to the quality of their informal judgments. On the other hand, while Jiménez-Aleixandre and Pereiro-Muñoz (2002) indicated that students used conceptual knowledge rather than socialism while making decisions regarding socioscientific issues and during the argumentation process while Lewis and Leach (2006) indicated that students' comprehension of limited number of basic concepts which they need and would use in real life would be sufficient in discussions regarding socioscientific issues. Jho et al. (2014) did not find any relation between students' abilities to make decisions regarding socioscientific issues and their level of scientific content knowledge and indicated that individuals' decisions are based on their personal opinions and preferences.

Quantitative and qualitative findings related to the primary and secondary sub-problems of the study have been shared in the paragraph above. As the third sub-problem of the study, students' conceptual perceptions of socioscientific issues were analyzed. It can be argued that, based on the number of repeating codes, socioscientific issue conceptualizations of the pre-service teachers in the experimental group are better than those in the control group ($f_d>f_k$). For describing the concept of socioscientific issue, pre-service teachers used the following sub-themes and codes: "socioscientific issue", "current; agenda, current issue/event/concept", "related to daily life; from inside/related to daily life", "social structure; related to society, social issue/event/concept/situation", "dilemma; involving/creating dilemma", "scientific; scientific issue/event/concept/situation", "controversy; controversial issue/event/concept/situation, discussion, discussion setting", "two way structure; can be used in a good/bad way, cost/benefit relationship, can be perceived as being positive/negative", "different perspectives; different thought/argument/perspective/idea", "changeability; change from person to person, unascertained among scientist, no absolute right", "situations", "moral dimension; religious and moral judgments, conscience related and ethical dimension", "with no single right answer; without a single/clear right answer, with more than one answer, open ended", "science, technology, society and environment insteractions; science-technology-society-environment interactions, effecting humans", and "scientific literacy". These sub-themes are shared by the pre-service teachers in both the study and control group. This is in fact an expected outcome of this study. Because in the experimental group where the socioscientific issues based instruction approach was implemented, socioscientific issues based instruction activities were held for seven weeks. Socioscientific issues based instruction approach, which is a part of the routine teaching practices in the control group as well, was implemented with direct instruction method during four-hour class sessions for a total of one week. This process has resulted in the formation of a conceptual perception for socioscientific issues in both groups. However, based on the values in the frequency table (Table 7), one can argue that covering socioscientific issues using real life examples and practices brings better results.

The findings of the study related to the third sub-problem of the study have certain similarities and differences with past studies in the literature. Similar to the comments of the pre-service teachers, Sadler (2004a) and Sadler and Zeidler (2005b) have also defined socioscientific issues as topics that are related to science's conceptual and technological dimensions, cover social dilemmas, are open ended, are not structured and present varying perceptions and solutions for controversial issues. In the study conducted by Özden (2015), pre-service teachers joined discussions on nuclear energy and global warming socioscientific issues for a period of two weeks as part of the science and technology course. Study findings showed that pre-service teachers described socioscientific issues, as issues that affect humans, do not have a common decision, contain risks and possibility, contain open-ended dilemmas and multiple solution alternatives, do not have a defining answer, and offer the opportunity to evaluate ethical and moral options. Study findings also showed that pre-service teachers did not mention the religious or cultural dimensions too much. On the other hand, in this study, it was seen that as part of their conceptual perceptions of socioscientific issues, pre-service teachers expressed codes such as religious judgments, conscience, ethics and moral judgment with regard to the moral sub-dimension. This may be because, while in this study the socioscientific issues based activities covering socioscientific issues such as dolphinariums (use of dolphins for entertainment and education) or organ donation (moral, ethical and legal discussions related to organ donation have been the main focus) have underlined such features of socioscientific issues, the socioscientific issues of nuclear energy and global warming used by Özden (2015) mentioned such features of socioscientific issues to a lesser extent. Similar to the findings of this study, Ratcliffe and Grace (2003) as well have noted that the nature of socioscientific issues has features like 'having a scientific basis, being frequently on the agenda, requiring value and ethical judgment, and requiring cost and benefit analyses'. The fact that socioscientific issues inherently contain risk and possibility, which was noted by both Özden (2015), and Ratcliffe and Grace (2003) was not observed in the conceptual perceptions of pre-service teachers in the current study. However, pre-service teachers have noted that socioscientific issues have a two way structure and they have drawn attention to this aspect indirectly by mentioning features of this structure such as "requiring cost/benefit analysis, having potential to be exploited or used for a good and having the potential to be perceived as positive/negative".

Based on the findings of this study, which researched the effect of socioscientific issues-based instruction approach on science pre-service science teachers' scientific literacy levels and conceptual perceptions, the following recommendations have been made.

Suggestions

Recommendations Based on Study Findings

- Based on the findings of the study, it was concluded that socioscientific issues based instruction practices in the training of science education teachers are more effective compared to current practices, in improving the scientific literacy levels of students. Thus, it is considered to be an effective approach in the development of scientific literacy identity, which is indicated to be the ultimate goal of science education in most science education reforms and programs (American Association for the Advancement of Science [AAAS], 1990; MEB, 2005, 2013). However, the authors recommend it to be used as an approach that supports scientific literacy to a great extent not only in elementary and middle school science education programs but in Science Teacher Education programs as well.

- Based on the qualitative findings of the study, socioscientific issues based instruction approach practices contributes to scientific literacy of pre-service teachers especially by improving their understanding of NOS. Moreover, based on the qualitative findings of the study, pre-service teachers explained the relationship between socioscientific issues and NOS with socioscientific issues' features like their changeble nature, people having different perspectives about them, not offering a single absolute reality and not being clarified by scientists. Thus, it can serve as a good context in practices related to in the teaching of NOS

- Qualitative findings of the study show that compared to current routine practices, socioscientific issues based instruction approach practices help improve the conceptual perceptions of pre-service teachers about these issues much better and result in pre-service teachers making more explanations that are detailed. Thus, covering socioscientific issues as part of Science Teacher education programs in short time intervals (during four course hours) mostly with the use of instruction technique with an active participation of the class rather than through a teacher-centered instruction might be a much more effective tool in ensuring the improvement of conceptual perceptions of pre-service teachers.

Recommendations for Future Research

- One recommended future research might be one which analyzes comparatively, the products of teaching practices using socioscientific issues based instruction approach with students living in an area where a socioscientific issue (such as a city where a nuclear power plant construction is planned or where illegal electricity use is common) takes place and students living in remote areas. Socioscientific issues based instruction approach's effect can be researched on the basis of different dependent variables (problem solving skills, critical thinking skills, judgment skills etc.) in individuals that differ in terms of age group, learning style, socioeconomic level, and level of social media utilization.

Recommendations for Practitioners

- Socioscientific issues (organ donation, illegal electricity use, genetic diagnosis tests, Kyoto protocol, dolphinariums, etc.) covered as part of socioscientific issues based instruction approach and the methods, techniques and teaching tools (such as dilemma cards, problem scenarios, concept cartoons and news bulletins etc.) can be utilized in science classes.
- Elective courses related to socioscientific issues based instruction practices in different disciplines can be included in the relevant curriculums, socioscientific issues based instruction approach, and its activities can be added to field training curriculum.
- For teachers currently on duty, seminars related to these socioscientific issues, which are considered important by the MEB (2013) as well and related to socioscientific issues based instruction approach, can be planned.

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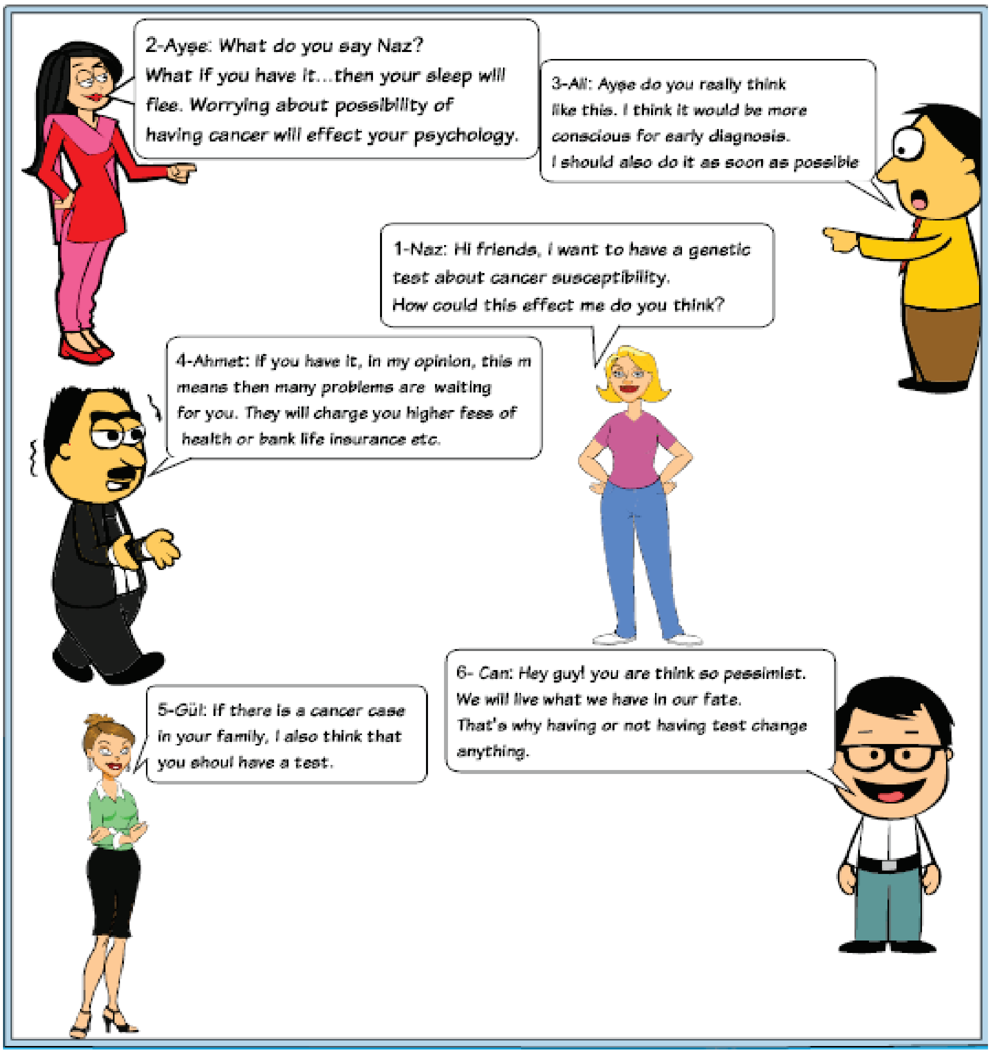
Appendix 1. Activity of Socioscientific Issue Based Instruction Approach

What Do You Think About GENETIC DIAGNOSTIC TEST?

Purpose of Activity	**To be able to evoke different views on the use of genetic diagnostic tests in the concept cartoon**	
Methods and Tecniques	SSIBI-Concept Cartoons	
Type of Activity	Classroom Activity	
Duration	50 minutes	
Activity Number	7	
Grades and Issue	Third Grade Science Pre-service science teacher	Genetic Diagnostic Test

Preliminary Questions: If they wanted to break down your genetic map, how would you decide? What are the factors that influence your decision?

Steps of Process: In the following concept cartoon, different opinions of different people are shared about genetic diagnostic tests. Please read the characters in the concept cartoons carefully. Which character would you prefer to be in this cartoon? Why?



Leading Questions: 1-Share your opinions by stating your justifications. 2- Suppose that you create a character yourself. What would the expressions of this character be?

Discussion Question: What would be its benefits or the ethical, moral, and legal problems, if the genetic diagnostic tests become compulsory when a baby is in the mother's womb in the future?

My opinions about Effectiveness of Concept Cartoons and confusions in These Subjects

References: Prepared from http://www.toondoo.com/