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Does a “Science, Technology and Social Change” Course Improve Scientific Habits of Mind and Attitudes towards Socioscientific Issues?

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Does A "Science, Technology and Social Change" Course Improve Scientific Habits of Mind and Attitudes towards Socioscientific Issues?

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Abstract: The study aimed at exploring whether a "Science-Technology-Social Change" course improved pre-service social studies teachers' (PST) scientific habits of mind and attitudes towards socio-scientific issues. Within a pre- and post-course experimental design, the study was conducted with 135 second-year PST (68 males and 67 females) from two classes at Department of Social Studies Teacher Education in a large-size university, Turkey. Two different Likert type scales, Scientific Habits of Mind Scale and Attitudes towards Socioscientific Issues Scale, were employed to collect data before and after the course. The data were imported to SPSS 15™ for descriptive and inferential statistics in order to address research questions. The results indicated that the STSC course had some shortcomings in improving the PST's scientific habits of mind and attitudes towards socio-scientific issues. The current study recommends enriching the STSC course with tasks that integrate socio-scientific issues and scientific habits of mind into social studies.

Introduction

Globalized society requires citizens to use scientific knowledge when making decisions, resolving science-related issues, and rationally choosing the affairs of everyday lives. Hence, students develop a sense of character and values as global citizens (Kan'an, 2018; Lee et al., 2013). Therefore, citizen-focused objectives (or well-educated citizens) of tertiary education include scientific literacy and higher-order scientific thinking skills (e.g., analytical and critical thinking, (in)formal reasoning, decision-making, scientific habits of mind) (Pouliot, 2009; Wu & Tsai, 2010; Zeidler, 2001). Thus, students (even non-science students) are intended to grasp the complex role of science in decision making for science related discussions (e.g., socio-scientific / controversial issues -- the use of alternative medicines/health treatments and dietary supplements, climate change, health risks of modern technologies like mobile phones and overhead power lines, childhood vaccination programmes, use of fluoride in municipal water to prevent tooth decay and nuclear power plants). For instance, they may inquire the reliability of any news related to socio-scientific issues (SSI) via internet and/or related documents prior to the decision-making. Thereby, tertiary education should equip students with content knowledge of science and scientific thinking as a part of scientific literacy (e.g., Çalik & Coll, 2012; Çalik, Turan & Coll, 2014; Kara, 2012; Kilinc et al., 2013). For this reason, faculties of education generally suggest Science, Technology, and Society (STS) course and/or its derived versions (i.e., Science, Technology and Social Change course) that engage pre-service teachers with societal issues (e.g., Topçu, Muğaloğlu & Güven, 2014; Ültay & Calik, 2012) or SSI (i.e., Kolstø, 2001; Sadler, 2004; Stolz, Wittteck, Marks & Eilks, 2013; Topcu, 2010). The current paper hereby refers to Science, Technology and Social Change (STSC) course as an adapted version of the STS course into social studies.

Because SSI involves an interaction amongst science, technology and society, the STSC course is unique to handle open-ended, complex, and ill-structured problems/issues (Rubba & Harkness, 1993; Sadler, 2004; Topcu, 2010) as well as environmental and sustainability issues (e.g. Whannell, Whannell & White, 2012). Also, this course gives pre-service teachers an opportunity to stimulate their own intellectual and social growth through argumentation processes (Bağ & Çalık, 2017; Patronis, Potari, & Spiliotopoulou, 1999; Sadler, 2004). Phrased differently, the use of SSI in the STS course (or its derived versions) not only promotes pre-service teachers to explore related issues but also helps them realize that science is part of their lives (i.e., Ültay & Çalik, 2012).

Engaging pre-service teachers in 'science-in-the-making' or 'knowledge-in-the-making' procedure throughout the STSC course gives an opportunity for them to improve their scientific habits of mind, attitudes towards SSI, key facets of the nature of science (NOS), and scientific literacy (i.e., Çalik & Coll, 2012; Zeidler, Sadler, Simmons & Howes, 2005). Hence, they are able to catch a deeper understanding of how scientists think. As a matter of fact, Gauld (1982, 2005) called such a deeper understanding as scientific habits of mind containing *open-mindedness*, *scepticism*, *rationality*, *objectivity*, *mistrust of arguments from authority*, *suspension of belief*, and *curiosity*. These habits altogether make up the 'scientific attitude' depicted by Gauld (1982).

Given importance of the STS (and/or STSC) course in tertiary education, science educators have paid more attention to investigate its possible outcomes for online learning, nature of science (NOS), scientific investigation, scientific literacy, debate, constructivist teaching design, poster presentation, technological literacy and perceptions/concerns (i.e., Bagarinao, 2011; Celik & Bayrakceken, 2006, 2012; Dogan, Kaya, Kilic, Kilic & Aydogdu, 2004; Macaroğlu-Akgül, 2004; Scott, 2008; Turgut & Fer, 2006; Vey, 1992; Yiğit, 2013; Zahara & Atun, 2018). Moreover, they have addressed that the activities embedded within the STS course have resulted in changes/improvements in engagement with discussion forums, conceptions of science, target aspects of NOS, understanding of the STS interaction, debate process and critical thinking skills, curiosity, self-confidence and interest toward the STS issues, technological literacy levels, Science-Technology-Society-Environment competencies, perceptions and attitudes toward the STS issues (e.g., Amirshokoohi, 2016; Ayvacı & Özbek, 2015; Bagarinao, 2011; Celik & Bayrakceken, 2006, 2012; Dogan et al., 2004; Küçük, 2008; Scott, 2008; Vey, 1992; Yalaki, 2016; Yiğit, 2013). Furthermore, Macaroğlu-Akgül (2004) depicted that pre-service science teachers described the term 'scientific literacy' in an STS course as thinking and inquiry. Similarly, Vey (1992) implied that majority of science teachers preferred teaching the STS issues as a separate course even though they had some concerns about its implementation procedure.

Because the STS(C) course via SSI intends to stimulate a responsible citizenship by developing proper attitudes/beliefs, relevant studies have clearly concentrated on several affective factors of SSI: awareness, teaching efficacy beliefs, interests/perceptions, attitudes and the interrelationship(s) amongst content knowledge, interest and attitudes (Kapici & Ilhan, 2016; Kara, 2012; Kılınç et al., 2013; Ottander & Ekborg, 2012; Rundgren, 2011; Stenseth, Bråten & Strømsø, 2016; Topcu et al., 2009; Topcu, 2010). They have also reported that: (a) attitudes towards SSI were not related to educational level, talent or gender, but were relevant to attributes of SSI; (b) pre-service science teachers held moderately high teaching efficacy beliefs about SSI; (c) students found SSI more interesting/appeal; (d) most SSI was equally interesting to males and females; (e) the Attitudes towards Socioscientific Issues Scale distinguished major and non-major students' attitudes towards SSI from each other; and (f) some affective categories (i.e., liking, interest and anxiety) impacted undergraduate students' decision-making (i.e., Kapici & Ilhan, 2016; Kaya, 2012; Kılınç et al., 2013; Ottander & Ekborg, 2012; Rundgren, 2011; Topcu, 2010). Further, the only one study by Kapici and Ilhan (2016), who handled nuclear power plants as an SSI, administered the Attitudes towards Socioscientific Issues Scale to pre-service social studies teachers (PST) to seek new evidence about their attitudes towards SSI. Even though some studies have concentrated on the aforementioned factors (i.e., affective factors and aspects of the NOS), how the STSC course influences the PST's scientific habits of mind and attitudes towards SSI have still been unexplored.

Since SSI plays a significant role in improving scientific habits of mind, Çalik and Coll (2012) developed a Scientific Habits of Mind Scale for educators and researchers, who wish to investigate scientific habits of mind for a variety of participants. Likewise, Çalik et al. (2014) deployed the Scientific Habits of Mind Scale to investigate pre-service elementary teachers' scientific habits of mind for a series of SSI and compared their views with programme types. They suggested that teacher education programmes needed to help pre-service teachers grasp better scientific thinking via scientific habits of mind. Similarly, Kolomuç and Çalık (2019), who compared academic staff's (from sciences and social sciences) scientific habits of mind regarding socio-scientific issues, reported significant differences in 'scepticism, rationality, and objectivity' sub-factors in favour of the academic staff in social sciences. Only one study (Çalik & Cobern, 2017) cross-culturally investigated the effect of the Common Knowledge Construction Model on pre-service elementary teachers' scientific habits of mind as an inferior outcome. However, none of the foregoing STS(C) and SSI studies has directly focused on how the STS(C) course influences the scientific habits of mind. Of these studies, only two studies employed PST as research participants; but they have not focused on scientific habits of mind (Kapici & Ilhan, 2016; Yiğit, 2013). For this reason, the current study is unique to measure the PST's scientific habits of mind and attitudes towards SSI before and after the STSC course. Given Bagarinao's (2011) and Rundgren's (2011) studies with 'gender' variable, the current study also incorporates the 'gender' variable that is probably the most significant variable for students' attitudes towards science (Çalık, Ültay, Kolomuç & Aytar, 2015; Osborne, Simon & Collins, 2003). Further, since the Turkish Ministry of National Education has undergone a positive discrimination towards females, the current study views the *gender* as an important variable. The study mainly aimed at exploring whether a STSC course improved the PST's scientific habits of mind and attitudes towards SSI.

The following research questions guided this work:

1. Is there any significant difference between pre- and post-course mean scores of the scientific habits of mind?
2. Is there any significant difference between pre- and post-course mean scores of attitudes towards SSI?
3. Does the gender affect the PST's scientific habits of mind and attitudes towards SSI?

Methodology

A pre- and post-course experimental design was employed to see changes in the PST's views of the scientific habits of mind and attitudes towards SSI. The research design is simple casual design (Bakırcı & Çalık, 2013; Çalik, Özsevgeç, Ebenezer, Artun & Küçük, 2014; Çalik, Ebenezer, Özsevgeç, Küçük & Artun, 2015) in order to find out the cause and effect relationships between two or more variables (Trochim, 2001). For this case, the STSC course acted as a cause (independent variable) whilst the scientific habits of mind and attitudes towards SSI were apparent as dependent variables. A missing control group may be viewed as a threat to the validity of the study.

Setting and Participants

The study was conducted at a large-size university located in the region of Eastern Black Sea of Turkey. The university, which was established in 1955, is one of the outstanding universities in Turkey with 12 faculties, 1 college, 6 graduate schools, 8 vocational schools, and 24 research centres. The university hosts more than 2000 academic staff and 40000 students. It was ranked 22^{nd} amongst 201 Turkish universities in regard to the University Ranking by Academic Performance in 2018 (see the link at http://tr.urapcenter.org/2018/2018_t9.php). Faculty of Education is well-known with its contribution to the Turkish Education System and Teacher Education Programmes. Also, the faculty has a pioneer role in content-based educational researches.

The participants of this study consisted of 135 second-year PST (aged 19-21 years; 68 males and 67 females) (from two classes in the Department of Social Studies Teacher Education) enrolled to the STSC course. Almost 75% of the PST had low level of science background in that they had taken only a 6-credit compulsory science course (physics, chemistry, and biology) at 9^{th} grade in an upper secondary school. Also, around 20% of the PST considered their science competency levels as moderate because they took one or two elective science course(s) after the compulsory ones in the upper secondary school. Around 5% of the PST did not provide any information regarding their science background. In case the PST's social interactions might affect their views, they were also asked whether they had any scientist relatives and/or close friends. Only 10% of the PST's relatives or close friends were reported as scientists. In terms of family income (as an indicator of socio-economic background/status), their monthly household incomes were mostly $700 or less (72%) whereas very small fraction of them (3.7%) reported that their monthly household income was over $1500. The PST was informed that the authors would like to use survey data for the course improvement and research purpose if they agreed. Also, the authors emphasized that their agreement or disagreement would not be counted for course credit nor affect their grades. Hence, the authors only reported the PST, who were volunteer to participate in the study. In other words, the authors removed the related documents of the PST, who disagreed to take part in the study.

Teaching Intervention

The second author taught a 2-hour-course once a week for 14 weeks (a total of 28 class hours) and used a traditional face to face teaching. Each lecture included class discussions, question and response sessions and debates with critical thinking/reflection regarding weekly topics. Hence, the PST might confront their own value-systems with their previously uncritically assimilated assumptions, beliefs, values, and perspectives. Hence, they might become more open, permeable, and better validated to change their habits and attitudes. They might find a solution to a problem inside their own value-systems (Cranton & Roy, 2003; Mezirow, 2000). The STSC course, which is centrally suggested by the Council of Higher Education in Turkey, purposes to afford future social studies teachers to comprehend the historical development of science and technology and their effects on social changes. Hence, the PST might find the STSC course relevant to their future teaching careers and student engagements. This course was compulsory for all the PST at the time of the intervention.

The STSC course comprises of four main and required themes; *History of Science* (i.e., Historical changes in scientific method of investigation, Historical development of atomistic view of matter, Brief history of astronomy), *Nature of Science* (e.g., Defining science, Characteristics of science, Types of scientific knowledge, Scientific research methods, Definition and characteristics of scientific literacy), *Nature of Technology* (Definition of technology, Definition and characteristics of technological literacy), and *Science-Technology-Society* (i.e., Relationships amongst technology, nutrition, art/literature, culture, environment and work; Nuclear energy and nuclear security, Radiation and human health, Cloning, Stem cell research, Contiguous viral illnesses—Flu, Hepatitis, AIDS, SARS etc.--). This content is explicitly and/or implicitly related to the scientific habits of mind and attitudes towards SSI. For example, the themes 'history of science, nature of science, and nature of technology' directly embrace the scientific habits of mind domains (*curiosity, suspension of belief, open-mindedness, scepticism, rationality and objectivity*). Further, the theme 'STS' covers both all domains of scientific habits of mind and attitudes towards SSI. For example, 'atom and nuclear energy' and 'evolution and genetics' topics contain such scientific habits of mind domains as *mistrust of arguments from authority, open-mindedness, scepticism, rationality, objectivity, curiosity* and such attitudes towards SSI as *interest and usefulness, liking and anxiety*.

The PST were required to keep journals at the end of each class to reflect on their learning. Then, they handed in their journals for review. The lecturer overviewed, graded and gave feedback for each journal and brought them with him to the next class. At the beginning of subsequent class, the journals were randomly distributed to the PST for peer review via a four-point scale from 1 (the lowest) to 4 (the highest). Later, a few anonymous journals with the highest grade were read aloud by the PST. This process began on the fourth week of the semester and went on for successive six weeks. Thereby, such a teaching intervention intended to stimulate their active participation to the course and to facilitate their reflective learning at the end of each class. The PST were informed that their journals were graded based on quality of their arguments supported by scientific evidence rather than the position they took.

Data Collection and Analysis

Two different Likert type scales (Scientific Habits of Mind Scale and Attitudes towards Socio-scientific Issues Scale) were employed to collect data before and after the STSC course.

Scientific Habits of Mind Scale

Scientific Habits of Mind Scale developed by Çalik and Coll (2012) comprised of 32 four-point Likert items to address seven sub-factors of Scientific Habits of Mind suggested by Gauld (1982, 2005): open-mindedness (6 items); objectivity (5 items); suspension of belief (5 items); curiosity (4 items); mistrust of arguments from authority (4 items); rationality (4 items); and scepticism (4 items) (see Appendix 1). Items were scored in two ways; positive (1–4) or reverse (4–1). Positive scoring was employed for items 1–8, 10-25, and 27, whereas reverse scoring was used for items 9–26, and 28–32. The variation in responses was employed because constantly scoring the same way may lead to less valid responses (Trochim, 2001). Çalik and Coll (2012) reported that Scientific Habits of Mind Scale indicated reasonable reliability and high validity for a variety of participants. Its reliability coefficient was reported to be 0.73 by Çalik and Coll (2012). For the current study, Cronbach's α reliability coefficient of the scientific habits of mind was calculated to be 0.67 and 0.69 for pre- and post-course administrations respectively.

Attitudes Towards Socioscientific Issues Scale

The Attitudes Towards Socioscientific Issues Scale developed by Topcu (2010) consisted of 30 five-point Likert items ranging from 'Strongly disagree' to 'Strongly agree.' Items were scored from 1 (strongly disagree) to 5 (strongly agree). As stated by Topcu (2010), after explanatory and confirmatory factor analysis, the conceptual structure of the Attitudes Towards Socioscientific Issues Scale consisted of three sub-factors: interest and usefulness of SSI (17 items), liking of SSI (7 items), and anxiety about SSI (6 items) (see Appendix 2). Its Cronbach α reliability values showed satisfactory reliability (ranged from 0.70 to 0.90) (see Topcu, 2010 for further information). For the current study, Cronbach's α reliability coefficient of the scale was calculated to be 0.92 and 0.95 for pre- and post-course administrations respectively.

The data were imported to SPSS 15^{TM} for descriptive and inferential statistics in order to address research questions. For descriptive analysis, total and mean scores for the scales and sub-scales were calculated. Because the Scientific Habits of Mind Scale consisted of the four-point Likert items, its total and subscale mean scores were evaluated in regard to the following intervals: 1.00-1.75 (totally disagree), 1.76-2.50 (disagree), 2.51-3.25 (agree), and 3.26-4.00 (totally agree). Similar intervals were used for the Attitudes Towards Socioscientific Issues Scale: 1.00-1.80 (strongly disagree), 1.81-2.60 (disagree), 2.41-3.40 (undecided), 3.21-4.20 (agree), and 4.21-5.00 (strongly agree).

Results

The purpose of this study was to examine whether the STSC course improved the PST's scientific habits of mind and attitudes towards SSI. Therefore, the results including descriptive statistics are provided for both instruments. Then, inferential statistical results are presented to further investigate research questions.

Scientific Habits of Mind Scale

As seen from Table 1, there was a slight decrease in the PST's total scores of the scientific habits of mind when pre- and post-course were compared. However, there were mixed effects of the instruction on the sub-scales of the Scientific Habits of Mind Scale. That is, four out of seven sub-scales (open mindedness, scepticism, rationality, and objectivity) increased. Average scores for each sub-scale were calculated. The lowest pre- and post-course scores were determined in the 'mistrust of arguments from authority' sub-scale. In other words, the PST tended to trust the authorities in science even after the STSC course. The highest score of pre-course fell into 'scepticism' sub-scale (3.35). After taking the STSC course, the PST's mean score of 'scepticism' sub-scale increased slightly and remained the highest among other sub-scales. Overall, the item mean scores for a total of scientific habits of mind were categorized under the 'agree' category (3.01 and 3.00 for pre- and post-course respectively).

	N=135	Pre-course Scores			Post-course Scores		
		Standard Deviation	Item mean	Range	Standard Deviation	Item mean	Range
Scientific Habits of Mind	Mistrust of arguments from authority	1.96	2.48	9.0	2.15	2.33	12.0
	Open-mindedness	2.29	2.97	12.0	2.16	3.07	13.0
	Scepticism	1.97	3.35	8.0	1.86	3.40	9.0
	Rationality	1.55	3.05	8.0	1.36	3.10	9.0
	Suspension of belief	2.61	2.88	12.0	2.62	2.76	15.0
	Objectivity	1.52	3.06	8.0	1.61	3.08	10.0
	Curiosity	2.53	3.35	10.0	2.81	3.25	10.0
	Total	6.81	3.01	44.0	6.92	3.00	42.0
Attitudes towards Socioscientific Issues	Interest	9.69	3.92	55.0	12.02	3.91	64.0
	Liking	4.56	3.60	25.0	5.21	3.61	28.0
	Anxiety	3.61	3.65	18.0	4.13	3.52	23.0
	Total	15.05	3.79	90.0	18.89	3.76	110.0

Table 1. Descriptive statistics for scores of scientific habits of mind and attitudes towards SSI

Attitudes towards Socio-scientific Issues Scale

As can be seen from Table 1, the scores of the Attitudes towards Socio-scientific Issues Scale slightly decreased from pre-course (3.79) to post-course (3.76) and fell into the 'agree' category. When total scores were divided to item numbers, the lowest score in post-course was found for the 'anxiety' sub-scale (3.52). The highest score in pre-course appeared for the 'interest' sub-scale (3.92).

Effectiveness of the STSC course on Scientific Habits of Mind and Attitudes towards Socioscientific Issues

Paired samples t-test was employed to find out the effectiveness of the STSC course on the PST's scientific habits of mind and attitudes towards socioscientific issues. As seen from Table 2, significant differences between pre- and post-course mean scores of the Scientific Habits of Mind Scale appeared at the sub-scales 'mistrust of arguments from authority, open-mindedness and suspension of belief' but only the sub-scale 'open-mindedness' was in favour of the post-course ($p<0.05$). There was no significant difference between pre- and post-course mean scores of other subscales in the scientific habits of mind scale and between pre- and post-course mean scores of the attitudes towards socioscientific issues scale.

		Paired differences		t	df	Sig.
		Mean	Sd			(2-tailed)
Scientific habits of mind	Pre- and post-test of mistrust of arguments from authority	.57*	2.65	2.498	134	.014
	Pre- and post-test of open-mindedness	-.53*	2.65	-2.310	134	.022
	Pre- and post-test of scepticism	-.18	2.35	-.878	134	.382
	Pre- and post-test of rationality	-.23	1.71	-1.560	134	.121
	Pre- and post-test of suspension of belief	.58*	2.99	2.246	134	.026
	Pre- and post-test of objectivity	-.13	2.08	-.744	134	.458
	Pre- and post-test of curiosity	.43	2.85	1.753	134	.082
	Pre- and post-test of total scores	.51	7.68	.774	134	.441
Attitudes towards sociosciencientific issues	Pre-Interest –Post-Interest	.17	12.24	.162	134	.872
	Pre-Liking –Post-liking	-.10	5.69	-.212	134	.833
	Pre-Anxiety – Post-Anxiety	.78	4.81	1.878	134	.063
	Pre- and post-test of total scores	.84	19.74	.497	134	.620

*p< 0.05 (two-tailed)

Table 2. Paired samples t-test between pre- and post-mean scores of scientific habits of mind and attitudes towards sociosciencientific issues

Effect of 'Gender' Variable on Scientific Habits of Mind and Attitudes towards Socioscientific Issues

Independent samples t-test was employed to analyse whether the 'gender' variable influenced the PST's scientific habits of mind and attitudes towards socioscientific issues. As seen from Table 3, only four of all comparisons were found to be significant between the gender mean scores of the Scientific Habits of Mind scale and the Attitudes towards Socioscientific Issues scale. Scepticism scores were significantly different between pre- and post-course mean scores of females and males. There was also a significant difference in post-course mean scores of the 'rationality' sub-scale in favour of males. Even though no significant difference was found in pre-course mean scores of the scientific habits of mind, the PST's post-course mean scores of the scientific habits of mind yielded significant differences for the 'gender' variable in favour of males (t=-2.86, p<0.05) (see Table 3). Moreover, the PST's pre- and post-course mean scores of attitudes towards socioscientific issues showed no significant difference for the 'gender' variable.

	F: Females, M: Males		Mean Dif. (F-M)	t	p
Scientific Habits of Mind	Pre-course	Total	-1.40	-1.20	.233
		Mistrust of arguments from authority	-0.22	-0.66	.509
		Open-mindedness	0.19	0.48	.631
		Scepticism	-0.73	-2.19	.030
		Rationality	0.15	0.56	.574
		Suspension of belief	-0.53	-1.18	.242
		Objectivity	-0.10	-0.38	.704
		Curiosity	-0.16	-0.36	.721
	Post-course	Total	-3.32	-2.86	.005
		Mistrust of arguments from authority	-0.19	-0.51	.613
		Open-mindedness	-0.26	-0.70	.484
		Scepticism	-0.85	-2.71	.008
		Rationality	-0.51	-2.22	.028
		Suspension of belief	-0.86	-1.93	.055
		Objectivity	-0.16	-0.57	.572
		Curiosity	-0.49	-1.01	.313
Attitudes towards Socioscientific Issues	Pre-course	Total	-1.85	-0.72	.476
		Interest	-1.46	-0.87	.385
		Liking	-0.49	-0.62	.538
		Anxiety	0.09	0.14	.890
	Post-course	Total	-5.52	-1.71	.090
		Interest	-3.76	-1.83	.069
		Liking	-1.08	-1.20	.231
		Anxiety	-0.68	-.96	.341

Table 3. Comparisons of the PST's mean scores of scientific habits of mind and attitudes towards socioscientific issues in regard to the 'gender' variable (Females: 67, Males: 68; df: 133)

Discussion and Conclusions

As can be seen from Table 1, the item mean score of scientific habits of mind was around 3 out of 4, except for mistrust of arguments from authority. Further, the standard deviation value, which was narrower for pre-course than post-course, means that the group homogeneity was slightly better for pre-course than post-one even though they came from the same two classes. Also, the item mean scores of attitudes towards SSI in pre- and post-course were about 4 out of 5. This means that the STSC course had some shortcomings in improving the PST's scientific habits of mind and attitudes towards SSI. Interestingly, the fact that their pre-course scores were slightly higher than those of post-course ones may result from the content of the STSC course. That is, they may have found its content more scientific. On the other hand, the results of pre-course may be viewed as an indicator of the tertiary education, which luckily stimulates the scientific habits of mind and attitudes towards SSI. That is, overall effect of the tertiary education may have enhanced the effectiveness of the 14-week STSC course (i.e., Çalik et al., 2014). This indicates that improvements in scientific habits of mind and attitudes towards SSI require a longer period. Otherwise, such an issue may result from the implementation procedure of the STSC course. Namely, instead of developing the explicit activities-driven scientific habits of mind and attitudes towards SSI, the authors preferred to examine the effects of the regular STSC course (i.e., face to face instruction, whole-class discussion, journals) on these variables. Such a regular course seems to be ineffective in progressing and improving the scientific habits of mind and attitudes towards SSI even though the content of the STSC course includes several topics that explicitly refer to these variables. This may stem from limited challenges that the course engaged the PST. In other words, they might not have enough opportunities to reflect on their own previously uncritically assimilated assumptions, beliefs, values, and perspectives to transform them into a new level of the scientific habits of mind and attitudes towards SSI (Mezirow, 2000). Thus, the course should have been designed to facilitate challenges for the PST to critically reflect on their own value-systems.

Significant differences between pre- and post-course mean scores of the scientific habits of mind appeared at the sub-scales *'mistrust of arguments from authority, open-mindedness, and suspension of belief'* but only the one *'open-mindedness'* was in favour of the post-course. This may stem from in-class discussions between the instructor and PST that dealt with certainty of scientific knowledge via evidence-based arguments. These arguments are generally supported by clear experimental or observational evidence (called "crucial experiment") (i.e., Lovaisier's invention of Oxygen or Galileo's discovery of moons of Jupiter), which leaves no hesitation while choosing "the right claim" between two opposite arguments. Thus, such examples may have driven the PST to develop a perception of a high-profile trustworthy scientist. On the other hand, tentative nature of science was especially discussed using similar examples from history of science during the 'atoms and nuclear energy' chapter. Thus, the PST might associate scientific progress with open mindedness. In other words, they might develop senses of criticism and scepticism, which are also necessary for change.

As seen from Table 1, there was a slight increase in the *'scepticism'* sub-scale, which might be considered as supporting evidence. A decrease in the PST's views of the *'suspension of belief'* sub-scale might stem from the same roots that cause a decrease in the sub-scale *'mistrust of arguments from authority.'* As aforementioned, the PST might see scientists as impatient to confirm their findings if there is a clear evidence. This may result from the framework of the STSC course that emphasizes the results of experiments and observations rather than time elapses between them. These results are inconsistent with previous studies referring to positive impacts of the STS course (i.e. Celik & Bayrakceken, 2006, 2012; Küçük, 2008; Turgut & Fer, 2006; Dogan et al., 2004; Yiğit, 2013). Such an inconsistent result may come from scope differences between the current study (that principally handled the scientific habits of mind and attitudes towards SSI) and earlier studies (that mainly focused on aspects of NOS, critical thinking and scientific/technological literacy). A lack of poster presentation or other instructional activities in the STSC course seems to have engendered inconsistency with Dogan et al.'s (2004) results reporting significant increases in the student teachers' curiosity, self-confidence and interest toward STS issues.

As observed in Table 3, there were significant differences between females' and males' pre- and post-course mean scores of 'scepticism and rationality' sub-scales and between their post-course mean scores of the scientific habits of mind scale in favour of males. This indicates that the STSC had more influence on males to grasp critical appraisal and logical arguments than did females. This may stem from the content of the STSC course that creates a debate environment via critical thinking rather than critical reflection, which is more deductive in nature. This might lead the female PST to have lower scores on rationality and scepticism because they may have been more relational in their thinking (Flanagan & Jackson, 1987). Such a result is in harmony with that of Scott (2008) depicting that the debates helped to understand the topic better, learn new knowledge, gain an understanding of the debate process and enhance their critical thinking skills. Moreover, this may come from gender traits. That is, females tend to be more collaborative and tentative while males are more assertive and confrontational (Young, 1996). On the other hand, this result is inconsistent with Bagarinao's (2011) one reporting that female learners' engagement with online discussion forums were better than those in male ones. However, the STSC seems to have little impact on improving the remaining sub-scales of the scientific habits of mind and attitudes towards SSI. This means that the STSC course was equally interesting to females and males. This result is consistent with Ottander and Ekborg's (2012) one reporting that lower secondary school students' experiences with SSI were equally interesting to males and females in most cases. Moreover, this study is inconsistent with the related literature addressing that the 'gender' variable is probably the most significant variable for students' attitudes towards science (Çalık et al., 2015; Osborne, Simon & Collins, 2003). On the other hand, the lack of difference between males and females may come from their career plans. That is, they had chosen a career path in social studies at upper secondary school level. Indeed, the previous researches on gender differences have mostly conducted with students, who have chosen to do science.

The STSC course, which confronted the PST with SSI and decision-making, seems to have failed to statistically arouse their affective categories such as liking of SSI, interest of SSI and anxiety towards SSI (Topcu et al., 2009). This may also come from the structure of the STSC course principally focusing on scientific literacy instead of their personal teaching efficacy beliefs about SSI. For this reason, the PST might have thought that they would not teach SSI introduced in the STSC course. In a similar vein, they might have not perceived the affective factors of SSI as a need. As a matter of fact, Kara (2012) found that pre-service biology teachers, who would integrate SSI into their courses, positively perceived a need to address SSI and possessed moderate personal teaching efficacy beliefs about SSI. Overall, the feasibility of the STSC course in their teaching careers seems to have an equal influence on females' and males' attitudes towards SSI.

Someone may ask whether the instruments are valid and reliable assessment of the constructs. In designing the study, the authors constructed a cross-table to match the content of the STSC course with the main aspects of the data collection tools in order to ensure internal validity of the study. For example; the *nature of science* topic matches with "*open-mindedness, scepticism, rationality, objectivity, and suspension of belief*" sub-scales of the scientific habits of mind scale and "*interest and usefulness*" sub-factor of the attitudes towards socioscientific issues scale. Another example would be from the "*evolution and genetics*" topic, which embraces "*open-mindedness, scepticism, rationality, objectivity, curiosity, and suspension of belief*" sub-scales of the scientific habits of mind scale and "*interest and usefulness, liking and anxiety*" sub-scales of the attitudes towards socioscientific issues scale. Thus, it is believed that there is a high consistency between the data collection tools and content of the course.

Given the structure of the social studies teacher education, the current study recommends enriching the STSC course with tasks that integrate SSI and scientific habits of mind into social studies. Further, a follow-up study could be undertaken to monitor the STSC course's long-term effects. Similarly, future studies may investigate the extent to which they deploy the scientific habits of mind and attitudes towards SSI in their practicum.

Appendices

1. Scientific Habits of Mind (SHOM) Scale (Adopted from Çalik and Coll, 2012)

Directions: Please indicate the answer you think MOST CLOSELY REPRESENTS your opinion about the following statements. **It is important to understand that there is no right or wrong answer.** We are just interested in your views. Thanks for your help.

Demographic data (for data analysis purposes only). Please tick ALL that apply to you:

❑Male ❑Female

Please indicate your age: ....

Please write your monthly family income: ………

Please depict your religion: ………

Please address whether you have any scientist relative or close friend: …………

	I believe that this is			
	almost certainly true	quite likely to be true	quite likely to be	almost certainly untrue
1. Modern medical science is dismissive of traditional Chinese approaches to curing illnesses.	❑	❑	❑	❑
2. Because the National Radiation Research Institute, reports that the radiation emitted by digital cell phones is not hazardous, we should believe this.	❑	❑	❑	❑
3. The Ministry of Health should be believed when it says that the benefits of a mass public vaccination programs outweigh individual risks of side effects.	❑	❑	❑	❑
4. The National Association of Dentists should be believed, when it says that the use of fluoride in municipal water improves dental health.	❑	❑	❑	❑
5. If scientific evidence is produced that homeopathic medicines have an effect beyond that of a placebo, it is reasonable to consider using them.	❑	❑	❑	❑
6. It is reasonable to consider using colloidal silver medicines to cure serious illnesses, if scientific evidence is produced that proves this.	❑	❑	❑	❑
7. If scientific research revealed a relationship between overheard power lines and increased rates of cancer, it is sensible to consider living away from power lines.	❑	❑	❑	❑
8. It is reasonable to consider not vacinating children, if new scientific studies produced evidence that mass vaccination programs result in harmful side effects such as autism.	❑	❑	❑	❑
9. If new scientific studies produced evidence that use of fluoride in municipal water causes defects in tooth enamel, it is reasonable to consider the use of non-fluoridated water.	❑	❑	❑	❑
10. It is reasonable to reconsider concerns about climate change, if new scientific studies reported that long-term average global temperatures have both increased and decreased at various times.	❑	❑	❑	❑
11.We need to see more scientific evidence before we should consider the use of Yoga and meditation to treat serious illness.	❑	❑	❑	❑
12. Herbal medicines are claimed to be a better way to treat illnesses because they have fewer side effects; but we need to see more scientific evidence before we consider their use.	❑	❑	❑	❑
13. We need to see more scientific evidence before being convinced the extra cost of underground power lines compared with overhead power lines can be justified on safety grounds.	❑	❑	❑	❑
14. National mass vaccination programs to prevent Swineflu seem to have reduced the effects of the pandemic, but we need more long term scientific studies to be sure such programs are worth the cost and trouble.	❑	❑	❑	❑
15. Reducing human-produced carbon dioxide is probably a good way to prevent the potential effects of global warming, but there are so many factors to be considered we need more scientific studies before we consider changing our environmental or business practices.	❑	❑	❑	❑

16. The use of colloidal silver may lead to ill-health such as kidney damage, because it contains a lot of silver ions that are deposited in our organs.	❑	❑	❑	❑
17. It is reasonable to conclude that underground power lines reduce the risk for illness like leukaemia, because radiation passes through air more easily than through soil.	❑	❑	❑	❑
18. A higher concentration of atmospheric carbon dioxide may affect the biological systems of the oceans, because oceans may become more acidic as a result of absorbing additional carbon dioxide.	❑	❑	❑	❑
19. Early studies indicate that use of cellphones may cause brain tumours, however, we don't know enough to be sure.	❑	❑	❑	❑
20. We don't know enough to be sure that greenhouse gas emissions play a key role in climate change.	❑	❑	❑	❑
21. There is insufficient evidence to think that a focus on the whole person makes any difference when treating serious human illness, compared with trying to cure a specific illness.	❑	❑	❑	❑
22. There is insufficient evidence to seriously consider the integration of herbal treatment with modern medicine.	❑	❑	❑	❑
23. There is little evidence about the effect of overheard power lines on leukaemia in children.	❑	❑	❑	❑
24. Credible research requires the use of scientific methods.	❑	❑	❑	❑
25. The only convincing medical research is that which employs double-blind, clinical trials.	❑	❑	❑	❑
26. Scientists must make sure they do not get emotionally involved with their research, if their findings are to be believed.	❑	❑	❑	❑
27. To be confident of the impact of any research, we need to make sure we control for variables as much as practically possible.	❑	❑	❑	❑
28. Good research is research that which has undergone independent peer review of the methods, findings, and interpretation of the findings.	❑	❑	❑	❑
29. Money spent on research about unusual and interesting creatures found in the deep ocean is wasted.	❑	❑	❑	❑
30. It's a waste of money doing research about ways to improve our understanding of the brain.	❑	❑	❑	❑
31. It's a waste of money doing research about other planets and star systems.	❑	❑	❑	❑
32. Research about the fundamental forces in nature is hard to justify.	❑	❑	❑	❑

2. Attitude Towards Socioscientific Issues Scale (Adopted from Topcu, 2010)

Directions: This questionnaire is designed to gain a better understanding of your views about socioscientific issues. Please read supplementary knowledge before circling the number that represents how you view about each of the statements below. Your answers are confidential.
Thanks for your help.

Supplementary Knowledge about Socioscientific Issues:
Recent innovations in the areas of genetic engineering (gene therapy, cloning, and stem cells) and ecology (global warming) provide examples of contexts in which science and society are interacting. The controversial issues that emerge from the combination of science and society have been termed "socioscientific issues". SSI represent ill-structured problems that lack clear-cut solutions. These challenging issues are likely to be confronted in people's daily lives and frequently involve disagreements or dilemmas regarding science- related claims.

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1. I would like to learn socioscientific innovations.	1	2	3	4	5
2. SSI provide me with an opportunity to understand science well.	1	2	3	4	5
3. Socioscientific developments (SSI) cause social degeneration.	1	2	3	4	5
4. Debates on SSI attract my attention.	1	2	3	4	5

5. I worry about socioscientific developments in terms of moral and ethical perspectives.	1	2	3	4	5
6. I like SSI much better than scientific issues.	1	2	3	4	5
7. I learn science well by discussing SSI.	1	2	3	4	5
8. SSI are issues that I like much.	1	2	3	4	5
9. SSI take an important place in daily life.	1	2	3	4	5
10. I would like to pursue socioscientific innovations by media.	1	2	3	4	5
11. I think that it is important to know more about SSI.	1	2	3	4	5
12. I am not approving implementations of SSI in terms of religion.	1	2	3	4	5
13. I like conducting research on SSI	1	2	3	4	5
14. I would like to know more about SSI.	1	2	3	4	5
15. Since SSI is related to daily life, I would like to learn more details about SSI.	1	2	3	4	5
16. I think implementations of SSI are abused by the people having harmful targets.	1	2	3	4	5
17. Attending debates on SSI does not appeal to me.	1	2	3	4	5
18. In media, the more emphasis should be given to SSI.	1	2	3	4	5
19. Socioscientific developments are harmful to society rather than its benefits.	1	2	3	4	5
20. I am curious about learning interesting knowledge about SSI.	1	2	3	4	5
21. I like trying to understand the actions around my environment with SSI knowledge.	1	2	3	4	5
22. I would like to have more knowledge about the effects of SSI on society.	1	2	3	4	5
23. SSI provides us with an opportunity to rethink technological developments.	1	2	3	4	5
24. I read supplementary resources related to SSI.	1	2	3	4	5
25. Debating on SSI promotes our thinking ability.	1	2	3	4	5
26. I get bored when I try to understand SSI.	1	2	3	4	5
27. In science lessons, more emphasis should be given to SSI.	1	2	3	4	5
28. I am not interested in SSI.	1	2	3	4	5
29. I think that social values suffer from the implementation of SSI.	1	2	3	4	5
30. I am interested in the effects of SSI on society.	1	2	3	4	5

References

Amirshokoohi, A. (2016). Impact of STS issue-oriented instruction on pre-service elementary teachers' views and perceptions of science, technology, and society. *International Journal of Environmental and Science Education*, *11*(4): 359-387.

Ayvacı, H.Ş. & Özbek, D. (2015). The effect of science technology society course on preservice science teachers' perceptions of nature of science. *Journal of Hasan Ali Yücel Faculty of Education*, *12*(23): 93-108

Bağ, H. & Çalık, M. (2017). A thematic review of argumentation studies at the K-8 level. *Education and Science*, *42*(190): 281-303 https://doi.org/10.15390/EB.2017.6845

Bagarinao, R.T. (2011). Learners' access patterns and performance in an online course in science, technology and society. *ASEAN Journal of Open Distance Learning*, *3*(1): 1-14.

Bakırcı, H. & Çalık, M. (2013). Effect of guide materials developed in "adaptation and natural selection" subject on remedying grade 8 students' alternative conceptions. *Education and Science*, *38*(168): 215-229

Celik, S. & Bayrakçeken, S. (2006). The effect of a 'Science, Technology and Society' course on prospective teachers' conceptions of the nature of science. *Research in Science & Technological Education*, *24*(2): 255-273 https://doi.org/10.1080/02635140600811692

Celik, S. & Bayrakceken, S. (2012). The influence of an activity-based explicit approach on the Turkish prospective science teachers' conceptions of the nature of science," *Australian Journal of Teacher Education*, *37*(4): 75-95 https://dx.doi.org/10.14221/ajte.2012v37n4.3

Cranton, P. A. & Roy, M. (2003). When the bottom falls out of the bucket: A holistic perspective on transformative learning. *Journal of Transformative Education*, 1(2): 86-98. https://doi.org/10.1177/1541344603253928

Çalik, M. & Cobern, W.M. (2017). A cross-cultural study of CKCM efficacy in an undergraduate chemistry classroom. *Chemistry Education Research and Practice,* 18(4): 691-709 https://doi.org/10.1039/C7RP00016B

Çalik, M., & Coll, R.K. (2012). Investigating socioscientific issues via scientific habits of mind: Development and validation of the scientific habits of mind survey. *International Journal of Science Education*, *34*(12): 1909-1930 http://dx.doi.org/10.1080/09500693.2012.685197

Çalik, M., Ebenezer, J., Özsevgeç, T., Küçük, Z. & Artun, H. (2015). Improving science student teachers' self-perceptions of fluency with innovative technologies and scientific inquiry abilities. *Journal of Science Education and Technology, 24*(4): 448–460 https://dx.doi.org/10.1007/s10956-014-9529-1

Çalik, M., Özsevgeç, T., Ebenezer, J., Artun, H. & Küçük, Z. (2014). Effects of 'environmental chemistry' elective course via technology embedded scientific inquiry model on some variables. *Journal of Science Education and Technology*, *23*(3): 412-430 https://dx.doi.org/10.1007/s10956-013-9473-5

Çalik, M., Turan, B. & Coll, R.K. (2014). A cross-age study of elementary student teachers' scientific habits of mind concerning socioscientific issues. *International Journal of Science and Mathematics Education*, *12*(6): 1315-1340 https://dx.doi.org/10.1007/s10763-013-9458-0

Çalık, M., Ültay, N., Kolomuç, A. & Aytar, A. (2015). A cross-age study of science student teachers' chemistry attitudes. *Chemistry Education: Research and Practice, 16:* 228-236 https://dx.doi.org/10.1039/c4rp00133h

Dogan, A., Kaya, O.N., Kilic, Z., Kilic, E. & Aydogdu, M. (2004). *Modeling the activities of scientists: Prospective science teachers' poster presentations in a STS course*. Paper presented at the18th International Conference on Chemical Education "Chemistry Education for the Modern World", Istanbul, Turkey.

Flanagan, O., & Jackson, K. (1987). Justice, care, and gender: The Kohlberg-Gilligan debate revisited. *Ethics*, *97*(3): 622-637. https://doi.org/10.1086/292870

Gauld, C.F. (1982). The scientific attitude and science education: A critical reappraisal. *Science Education*, *66*: 109–121. https://doi.org/10.1002/sce.3730660113

Gauld, C.F. (2005). Habits of mind, scholarship and decision making in science and religion. *Science & Education*, *14*: 291–308. https://doi.org/10.1007/s11191-004-1997-x

Kan'an, A. (2018). The relationship between Jordanian students' 21st century skills (Cs21) and academic achievement in science. *Journal of Turkish Science Education, 15*(2): 82-94.

Kapici, H. Ö. & Ilhan, G.O. (2016). Pre-service teachers' attitudes toward socioscientific issues and their views about nuclear power plants. *Journal of Baltic Science Education, 15*(5): 642-652.

Kara, Y. (2012). Pre-service biology teachers' perceptions on the instruction of socio-scientific issues in the curriculum. *European Journal of Teacher Education, 35*(1): 111-129. https://doi.org/10.1080/02619768.2011.633999

Kılınç, A., Kartal, T., Eroğlu, B., Demiral, Ü., Afacan, Ö., Polat, D., Demirci Guler, M.P. & Görgülü, Ö. (2013). Preservice science teachers' efficacy regarding a socioscientific issue: A belief system approach. *Research in Science Education, 43*(6): 2455-2475 https://doi.org/10.1007/s11165-013-9368-8

Kilinc, A., Yeşiltaş, N.K., Kartal, T., Demiral, Ü. & Eroğlu, B. (2013). School students' conceptions about biodiversity loss: Definitions, reasons, results and solutions. *Research in Science Education, 43*(6): 2277-2307. https://doi.org/10.1007/s11165-013-9355-0

Kolomuç, A., & Çalık, M. (2019). A comparison of academic staff's scientific habits of mind via socioscientific issues. *Yuksekogretim Dergisi, 9*(1): 67-74 https://dx.doi.org/10.2399/yod.18.039

Kolstø, S.D. (2001a). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*: 291–310. https://doi.org/10.1002/sce.1011

Küçük, M. (2008). Improving preservice elementary teachers' views of the nature of science using explicit-reflective teaching in a science, technology and society course. *Australian Journal of Teacher Education*, *33*(2): 16-40 https://dx.doi.org/10.14221/ajte.2008v33n2.1

Lee, H., Yoo, J., Choi, K., Kim, S.W., Krajcik, J., Herman, B.C. & Zeidler, D.L. (2013). Socioscientific issues as a vehicle for promoting character and values for global citizens. *International Journal of Science Education, 35*(12): 2079-2113 https://dx.doi.org/10.1080/09500693.2012.749546

Macaroğlu-Akgül, E. (2004). Teaching scientific literacy through a science technology and society course: prospective elementary science teachers' case. *The Turkish Online Journal of Educational Technology (TOJET), 3*(4): 58-61.

Mezirow, J. (2000). Learning to think like an adult: Core concepts of transformative learning theory. In Mezirow, J. and Associates (Eds.), *Learning as transformation*. San Francisco: Jossey-Bass.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9): 1049-1079 https://dx.doi.org/10.1080/0950069032000032199

Ottander, C. & Ekborg, M. (2012). Students' experience of working with socioscientific issues - a quantitative study in secondary school. *Research in Science Education, 42*: 1147–1163 https://doi.org/10.1007/s11165-011-9238-1

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision making on a socio-scientific issue: Implications for teaching. *International Journal of Science Education*, *21*(7): 745–754. https://doi.org/10.1080/095006999290408

Pouliot, C. (2009). Using the deficit model, public debate model and co-production of knowledge models to interpret points of view of students concerning citizens' participation in socio-scientific issues. *International Journal of Environmental & Science Education, 4*(1): 49-73.

Rubba, P. A. & Harkness, W. L. (1993) Examination of preservice and in-service secondary science teachers' beliefs about Science-Technology-Society interactions, *Science Education, 77*(4): 407–431. https://doi.org/10.1002/sce.3730770405

Rundgren, S.N.C. (2011). How does background affect attitudes to socioscientific issues in Taiwan? *Public Understanding of Science*, *20*(6): 722-732 https://doi.org/10.1177/0963662509359998

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, *41*(5): 513–536. https://doi.org/10.1002/tea.20009

Scott, S. (2008). Perceptions of students' learning critical thinking through debate in a technology classroom: A case study. *Journal of Technology Studies*, *38*(1) Retrieved from http://scholar.lib.vt.edu/ejournals/JOTS/v34/v34n1/scott.html https://doi.org/10.21061/jots.v34i1.a.5

Stenseth, T., Bråten, I. & Strømsø, H.I. (2016). Investigating interest and knowledge as predictors of students' attitudes towards socio-scientific issues. *Learning and Individual Differences*, *47*: 274–280 https://doi.org/10.1016/j.lindif.2016.02.005

Stolz, M., Wittteck, T., Marks, R. & Eilks, I. (2013). Reflecting socio-scientific issues for science education coming from the case of curriculum development on doping in chemistry education. *Eurasia Journal of Mathematics, Science & Technology Education*, *9*(4): 361-370 https://doi.org/10.12973/eurasia.2014.945a

Topçu, M.S., Muğaloğlu, E.Z. & Güven, D. (2014). Socioscientific issues in science education: The case of Turkey. *Educational Sciences: Theory & Practice, 14*(6): 14-22 https://dx.doi.org/10.12738/estp.2014.6.2226

Topcu, M.S., Yilmaz-Tuzun, O., & Sadler, T.D. (2009). *Preservice science teachers' informal reasoning regarding socioscientific issues and the factors influencing their informal reasoning*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Garden Grove, CA.

Topcu. M.S. (2010). Development of attitudes towards socioscientific issues scale for undergraduate students. *Evaluation & Research in Education*, *23*(1): 51-67. https://doi.org/10.1080/09500791003628187

Trochim, W.M.K. (2001). *The research methods knowledge base*, 2nd ed. Cincinnati: Atomic Dog Publishing.

Turgut, H. & Fer, S. (2006). Fen bilgisi öğretmen adaylarının bilimsel okuryazarlık yeterliklerinin geliştirilmesinde sosyal yapılandırmacı öğretim tasarımı uygulamasının etkisi (The effect of social constructivist instructional design to prospective science teachers' scientific literacy profiencies). *Eğitim Bilimleri Dergisi: Marmara Üniversitesi Atatürk Eğitim Fakültesi*, *24*: 205-229 (In Turkish).

Ültay, N., & Çalik, M. (2012). A thematic review of studies into the effectiveness of context-based chemistry curricula. *Journal of Science Education and Technology*, *21*(6): 686-701 https://doi.org/10.1007/s10956-011-9357-5

Vey, B. W. (1992). *Proposed science, technology and society course for secondary schools in Newfoundland and Labrador: teachers' perceptions and concerns.* Master thesis, Memorial University of Newfoundland, Canada.

Whannell, P., Whannell, R. & White, R. (2012). Tertiary student attitudes to bicycle commuting in a regional Australian university. *International Journal of Sustainability in Higher Education*, *13*(1): 34-45 https://doi.org/10.1108/14676371211190290

Wu, Y.T. & Tsai, C.C. (2010). High school students' informal reasoning regarding a socio-scientific issue, with relation to scientific epistemological beliefs and cognitive structures. *International Journal of Science Education, 33*(3): 371-400. https://doi.org/10.1080/09500690903505661

Yalaki, Y. (2016). Improving university students' science-technology-society-environment competencies. *International Journal of Progressive Education*, 12(1): 90-98.

Yiğit, E. Ö. (2013). Science, technology and social change course's effects on technological literacy levels of social studies pre-service teachers. *The Turkish Online Journal of Educational Technology (TOJET)*, *12*(3): 142-156.

Young, I. M. (1996). Communication and the other: Beyond deliberative democracy. In S. Benhabib (Ed.), *Democracy and difference: Contesting the boundaries of the political* (pp. 120-135). Princeton, NJ: Princeton UP.

Zahara, H.T. & Atun, S. (2018). Effect of science-technology-society approach on senior high school students' scientific literacy and social skills. *Journal of Turkish Science Education, 15*(2): 30-38.

Zeidler, D. L. (2001). Participating in program development: Standard F. In D. Siebert & W. McIntosh (Eds.), *College pathways to the science education standards* (pp. 18 – 22). Arlington, VA: National Science Teachers Press.

Zeidler, D.L., Sadler, T.D., Simmons, M.L., & Howes, E.V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education, 89*: 357–377. https://doi.org/10.1002/sce.20048