

Science, Technology, Society and Environment (STSE) Approach: Perceptions of Secondary School Science Students

Munir Khan	Assistant Professor in Department of Education, University of Malakand, Chakdara, KP, Pakistan.
Iqbal Amin Khan	Lecturer in Department of Education, University of Malakand, Chakdara, KP, Pakistan.
Guiana	M. Phil Scholar in Department of Education, University of Malakand, Chakdara, KP, Pakistan.

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Corresponding Author

Iqbal Amin Khan

Email: Iqbal.phd.edu@uom.edu.pk

Abstract: The major purpose of this study was to investigate the perceptions of government secondary school science students towards Science, Technology, Society and Environment (STSE) approach in district Dir Lower. The quantitative (survey) design was used. The data were collected from 737 science students through a self-developed questionnaire based on multiple scales. The respondents consisted of both boys and girls science students of secondary and higher secondary schools. The questionnaire included questions about awareness of STSE approach and the problems impeding this approach in science teaching. The reliability of the questionnaire was established through Cronbach's alpha and found 0.87. Data were analyzed by using frequency, percentage, mean, and standard deviation (Descriptive Statistics). The result of the study revealed that students were familiar with this approach and considered it helpful to enhance the critical and scientific thinking skills of students as it leads to motivate them in learning the abstract concepts of science. The study recommended that science teachers may be given proper training to implement this approach in the classroom to teach science subjects effectively.

Introduction

To make students scientific, critical and open-minded, the science teachers continuously searching for adopting creative and novel methods to teach science subjects effectively. Doing so their main goal is to develop a scientific literate society (Bybee, [2010](#)). One of such effort to achieve this great goal is introducing Science–Technology and Society movement, which started four decades ago. With the introduction of this approach, science teachers were encouraged to teach students in a socially contextualized approach. The STS approach was further developed with the addition of environment to transfer it in STSE approach. The rise of science and technology addressed the various environmental issues which are related

to ethics, education, society, and economy. In STSE approach, science students are taught to relate the science with the everyday situation. In this way students relate the scientific issues in the classroom with the real world situation and society (Rubba, [1991](#)). The major aim of STSE approach is to support science education. The same aim has also been found in the documents of National Science Education Standards (NRC, [1996](#)). In the same way, most recently the same aim of science education has also been highlighted in the Framework for K–12 Science Education (Bybee, [2011](#)) and has also been highlighted in Next Generation Science Standards (NRC, [2013](#)).

All these documents supported the teaching of scientific knowledge through interdisciplinary approach in the socially contextualized environment of classroom (NRC, [2013](#)). In the same way, these documents also emphasized on the significance of providing opportunities to science students to involve them in day to day activities, investigating science experiences, contextualized environment to develop skills like critical thinking, argumentation, rational thinking, and decision-making. STSE approach encourages and promotes skills among science students to think critically, analyze scientific issues from their own perspectives and search for various ways to acquire, understand, and assess scientific knowledge. Science students must be encouraged and provided opportunities to select topics which are very much important for them personally. STSE is such an approach which helps science students to select an issue, develop their own point of view and defend their view through the application of scientific method and questioning technique. When science students may be able to select an issue by their selves through their day to day experiences and investigate enquiry on it through the application of scientific method, make an association between scientific concept and social issues, then they would be able to develop a deep understanding of the nature of scientific enquiry. Science students require to develop such skills to apply scientific knowledge to solve social and real world problems (Slack & Stewart, [1990](#)). The nature of such problems are concerned with social, political, historical, cultural, ethical and sociological aspects of life (Pedretti, [1999](#)).

The supporters of STSE approach believed that scientific literacy is rooted in an individual's ethical and social responsibility (Kumar & Chubin, [2000](#); Pedretti, [1999](#); Solomon, [1993](#)). Other supporters of this approach also believed that STSE is an integrated approach which woven science, technology, society and environment together within the fabrics of social, political, technological, ethical and

cultural contexts (Pedretti & Nazir, [2011](#)). STSE approach provides an opportunity to science students to develop an understanding of the physical world where they are living while making connection of these with the scientific, social, technological and environmental aspects. This conversation has led to divergent point of views about the STSE curriculum, and various diverse theoretical perspectives, instructional approaches, programmes and methods.

The major aim of STSE education can also be said as science for all and the major instrument which is responsible for bringing this change is science content, which in turn help to build STSE relations. The purpose of STSE is to make the society aware about scientific literacy through using this approach during instruction in science classroom (Yurok, [2008](#)). The major aim of STSE is to develop students' critical, scientific and conceptual thinking abilities (Tal, Dori, & Keiny, [2001](#)). For a country, that needs to take steps towards an informational society, changes need to be done in the learning environment.

STSE approach has continued to be a major theme in science reform documents and educational methods throughout the world. Throughout the world this approach has been well documented such as "United States Benchmarks for Science Literacy"; (American Association for the Advancement of Science, [1993](#)), Science for All Americans (Rutherford & Algren, [1991](#)), Beyond 2000 in the United Kingdom (Miller & Osborne, [1998](#)), The Status and Quality of Teaching and Learning of Science in Australian Schools (Rennie, Goodrum & Hackling [2001](#)). All these documents show that science education should be more than just the learning about certain basic scientific terms and concepts. The motivation level, creative skills and positive attitude of students' increases as students gets involved in STSE-based teaching, also brief period of time can enhanced the performance of students treated with the application of STSE method (Lee, & Erdogan, [2007](#)).

Recently there have been many studies conducted on STSE approach. Most of these studies are conducted on students/teachers perceptions about science and mathematics course (Amirshokoohi, [2010](#); Cetinkaya, 2012; Ozer, Rutledge, & Ozer, 2019; Seeker, 2007; Yilmaz & Yilgit, 2011), STSE in Curriculum (Lestari, Anwar, Priscylio, Wahyuni, Oktasari, & Agustina, [2020](#)), STSE Learning approach (Primasstuti & Attun, 2018), STSE acquisition (Avci, Onal & Usak, [2014](#)), students learning experiences (Ackey & Yager, [2010](#)), observation of teacher's practices (Lestari, et al., [2020](#)) teachers education (Dass, 2005; Pedretti & Belloma, 2013), effectiveness of STSE approach (Zoller, 2013; Yurok, Morgil & Sicken, 2009), philosophical and pedagogical challenges (Abd-El-Khalick, Bell, & Lederman, [1998](#); Hodson, [1993](#); Lederman, 1992; Mansur, 2007; Pedretti, 1996; Pedretti, Bencze, Hewitt, Romkey, & Jivraj, 2008; Smith & Scharmann, [1999](#)). After reviewing the general application and viewpoints on STSE, it was found that most of these studies have been done in western context and in economically developed countries (Canada, United States, Germany, and Turkey) where the integration of this approach is easy to determine. Also, from a review of the related literature, it is clear that these studies covered the opinions of science teachers across the high and higher secondary schools in these contexts. In Pakistan research has been done in urban areas focusing on the challenges impeding the STSE-based teaching at high and higher secondary level. This research is an attempt to fill the gap pertaining to the student's perceptions about the STSE approach across the secondary schools of Lower Dir. This study sought to find the answers of the following questions:

1. How do secondary school science students perceive STSE approach in district Dir Lower?
2. What are the challenges that students face in the effective implementation of

STSE approach in science classroom at the secondary school level?

Research Methodology

A quantitative approach was used to analyze the perceptions of secondary school science students regarding STSE. As the study was concerned with the current issue, therefore, the researchers used descriptive research design for this study.

Population of the Study

The target population of the study consisted of all (28608) government secondary and higher secondary schools science students studying science in the schools of district Dir Lower during the academic year 2021-22.

Sample and Sampling of the Study

Respondents of the study were 7598 Science Students (5473 male and 2125 female) of government high and higher secondary schools of Tehsil Adenzai (EMIS 2021). From this sample, 50% (737) respondents (525 male & 212 female) were chosen for data collection using proportionate stratified sampling technique. As there are two groups or strata (Male and female, students and teachers), In order to get in the same proportion, the researcher used proportionate stratified sampling technique to choose science students.

Data Collection

Keeping in mind the nature of the study, the researchers used the self-constructed questionnaire for data collection purpose. The questionnaire was translated into Urdu for better understanding of students and the translation checked. After establishing the face and content validity of the instruments were piloted with the same/identical people/individuals in the sample. The individuals were asked to fill the questionnaire and point out the ambiguity in the items or in directions. Through Cronbach alpha α , the reliability of the instrument was

established. The Cronbach alpha value for the questionnaire was found 0.84, which was found higher than that of the threshold value. The response rate of the respondents was 95% while 5% students did not return the questionnaire.

Data Analysis

The researchers analyzed the collected data by using descriptive statistics which consisted of frequency, percentage, mean and standard deviation.

Table 1. Demographic Information of Science Students

Gender	Frequency	Percentage
Male	525	71
Female	212	29
Class		
9th	408	55
10th	329	45
Total Respondents	737	100

The attitudes questionnaires were given to two groups of class 9th and class 10th students. For this stage, a total sample of 737 students was involved: (525 male students, 212 female students). Among which 408(55%) students were from class 10th and 329(45%) were from class 9th. The questionnaires were distributed among male and female students in March 2022,

with 15 minutes being found to be adequate time for the questionnaire to fill.

Overall opinion of students about STSE approach

The purpose of this question is to find out the overall opinion of students about STSE approach. Likert scale with three points was used, and mean score and standard deviation were calculated as:

Table 2. Descriptive Statistics Regarding STSE Approach for Students

Items	Yes	Not sure	No	Mean	SD
Understanding the concept of STSE in the local learning context	685	36	16	2.91	.357
My teacher has tried to teach in this way	683	32	22	2.90	.390
I want to learn in this way	688	37	12	2.92	.330
Not convincing that it is the best approach for my country	526	154	57	2.64	.622
Limited time makes this concept impracticable	280	192	265	2.02	.860
Grand total mean and standard deviation scores				2.67	.238

The above table shows the mean score and standard deviation for the overall views of students about STSE approach. Out of five

statements, maximum mean score (2.92) and standard deviation (.330) was observed where students responded to the STSE-based way of

teaching. Sufficient above average score (mean 2.91 and standard deviation .357) was observed for the statement showing understanding of students about STSE approach. Maximum mean score (2.90) and standard deviation (.390) was observed where students stated that their teacher has tried to teach this way. Below average mean score (2.02) and standard deviation (.860) was observed for the time limit that makes it difficult to teach using STSE approach. The overall score for the construct was found to be

(mean 2.67 & standard deviation .238) which is the average score of observance.

Perceptions of Students about the Aims of Sciences

The purpose of this question was to reflect on the students opinions of science teaching. Students were asked to choose any three options from the given eight statements which they preferred while learning science education. The frequencies of responses are as follows:

Table 3. Descriptive Statistics Regarding Aims of Sciences for Students

Aims of Science Teaching	Frequency	%age	Ranking
Acquiring good marks in the examinations	346	47	3
Opting career as scientist	219	30	5
Knowing something about that how this world works	400	54	2
Equipping myself to think scientifically and rationally	172	23	6
Knowing scientific facts accurately	439	59	1
Understanding of the scientific facts which changes world	296	40	4
Showing that scientific results can benefit and hurt human beings	297	40	4
Covering the burdened curriculum in allotted time	41	5	7

Highest proportion 439(59%) students aimed to learn science 'to know the facts of sciences correctly', reflect the traditional pattern of science teaching and learning. "To understand something of how the world works" is second most rated option (54%). 346(47%) students choose 'to gain good grades in examination' among the eight statements.

Perceptions of Students about the Training Skills of their Teachers

Students were asked about their teacher's training they received during their teaching experience. They responded as:

Table 4. Descriptive Statistics Regarding Training Skills of Teachers for Students

Items	SA	A	UD	DA	SDA	Mean	SD
The training which I received did not prepare me well for teaching	82	100	37	221	297	2.25	1.39
Never been trained to teach and encourage to implement STSE	64	136	93	178	266	2.39	1.36
Need training in teaching effectively by using this approach	241	207	56	151	82	3.51	1.40

Need training to know assessment techniques by using STSE approach	196	212	76	123	130	3.30	1.46
Grand mean and standard deviation scores						2.86	1.15

The above table shows the mean score and standard deviation for the perceptions of students about the training skills of their teachers. Out of four statements, maximum score (mean 3.51 & standard deviation 1.40) was observed where students stated that their teachers need training to practice teaching using STSE approach. Statement "teachers *need trained to know how to assess using this approach*" shows mean score 3.30 & standard deviation 1.46 which is also above the average score observed. Average mean score 2.25 & standard deviation 1.39 was observed for the statement showing the teachers

training skills to teach chemistry. Overall score for this construct was found to be (mean 2.86 & standard deviation 1.15) which is above the average level of observance.

Perceptions of Students about the Challenges

The purpose of this question was to determine the factors which influenced/ restricts the successive implementation of STSE approach. Students were asked to choose as many options as they thought true. The percentage of responses is as follows:

Table 5. Descriptive Statistics Regarding the Challenges for Students

Challenges	Frequency	%age	Rank
Overloaded curriculum	353	48	3
Lack of teachers experience	77	10	7
Lack of training	195	26	5
National examinations	377	51	2
Lack of money	345	47	4
Lack of students' interest	379	51	2
Shortage of equipment	440	60	1
Inappropriate textbooks	164	22	6

'Lack of equipment' is a most popular option chosen by 440(60) students. Other options chosen by majority of students include: 'national examination' (N=377, 51%), 'lack of student's interest' (N=379, 51%), 'overcrowded curriculum' (N=353, 48%) and 'lack of money' (N=345, 47%). 'Lack of teacher's experience' was found to be low rated option chosen by 77(10%) students.

Perceptions of students about the sciences in their social and environmental context

The purpose of this question is to explore how the students see sciences in relation to the context of their societal and environmental impact. Semantic differential scale was used. The percentages of responses were calculated as follows:

Table 6. Frequency Scores Regarding the Social and Environmental Context of Sciences for Students

Items	Responses						Items
Good	681	40	8	2	3	4	Bad
Boring for me	26	12	18	6	96	579	Exciting for me

Meaningless	35	12	11	42	77	560	Challenging
Helpful to pass exams	585	45	30	4	16	57	Not helpful to pass exams
Too demanding on time	249	62	67	15	41	303	Possible with time limits
Easy	414	109	20	25	33	136	Demanding
Consistent with curriculum goals	504	73	30	20	17	93	Inconsistent with curriculum goals
A new untested approach	146	25	17	22	36	491	An approach shown to work elsewhere
Inconsistent with textbooks in use	53	15	19	23	52	574	Consistent with textbooks in use

Above table shows that a high proportion of students tend to see this way of teaching as 'good' (N=681), 'exciting' (N=579) and 'challenging' (N=560). Polarizations of views was observed where students rated this approach as 'demanding' (N=249) and 'possible with time limits' (N=303). Less polarization was observed in statement where students rated it as 'easy' (N=414) and 'demanding' (N=136). Majority of

the students (N=574) thinks it *consistent with: 'textbooks'* and (504) '*curriculum goals*'.

Perceptions of students about STSE approach in science education

The purpose of this question was to find out the attitude of teachers towards STSE approach. Likert scale was used to calculate the mean score and standard deviation

Table 7. Descriptive Statistics Regarding STSE-Based Teaching for Science Students

Items	SA	A	UD	DA	SDA	Mean	SD
This approach will not be useful for students	1	5	59	318	344	4.36	.693
Relating science with real life of students	400	299	14	14	10	4.45	.750
Appreciating how this approach works better for students	392	283	46	11	5	4.42	.735
Communicating verbally to learn science well	279	289	102	47	20	4.07	1.46
In science education issues related to environment and social are discussed	311	295	105	16	10	4.20	.858
STSE approach helps to discuss global and local issues	259	271	144	45	18	3.96	1.0
This approach needs a lot of supports for implementation	254	262	133	57	31	3.88	1.09
Pressurized curriculum do not allow me to teach through this approach	196	189	148	149	55	3.44	1.27

Major financial support is required to teach in this way	326	242	84	55	30	4.07	1.13
STSE helps to understand scientific facts effectively	31	87	102	257	260	2.15	1.15
Using this approach will lost the true nature of science	230	162	115	98	132	3.35	1.48
Grand total score for mean and standard deviation						3.84	.331

Students were asked to show their opinions towards STSE approach. Out of eleven statements, maximum mean score 4.45 and standards deviation .750 was observed for the statement “*I will understand how science relates to life*” which is sufficiently above the average level of observance. Maximum mean scores observed for other statements include: “*I will appreciate how science works better*” (mean 4.42 & standard deviation .735), “*The STSE approach will not prove attractive for me*” (mean 4.36 & standard deviation .693). On the other hand minimum mean score (2.15) and standard deviation (1.15) was found for the statement “*School science*

education must focus on the scientific facts” which is below average level of observance. The grand mean and standard deviation scores for the construct was found (mean 3.84 & standard deviation .331) which is above average level of observance.

Suggestions and recommendations by students

This was an open question, aimed to find out the views of students. Here are the major opinions of respondents. Frequency and percentage is calculated as follow:

Table 8. Frequency and Percentage Scores Regarding STSE in Schools for Students

Items	Frequency	Percentage
Curriculum should be consisted of STSE approach	302	40
Provision of facilities for successful implementation of STSE approach	260	35
Appropriate training for implementation of STSE is required	107	14
Requirement of Financial Resources	82	11

The above table shows that 302(40%) students suggest to include STSE approach in science curriculum, 260(35%) students suggested to provide physical facilities for successive implementation, while 107(14%) thinks that proper training must be provided. Less proportion of students, 82(11%) suggested financial resources to implement STSE approach.

Discussion

As a result of analysis, students show positive attitudes towards this approach. Findings

indicated that students considered it exciting, meaningful and challenging as political, historical, ethical, and philosophical issues can all be addressed with STSE education. In addition, implementing STSE in the science classroom can add relevance, interest, and real-world linkages. Student's awareness can be seen as STSE can be helpful in developing communication skills, understating the social nature of science, as well as knowing the local and global issues. The aims of sciences might be seen in terms of getting an understanding about

certain facts, principles and theories and gaining good grades in examinations, which reflects the traditional nature of science. However, students highlighted major issues like lack of equipment, examinations, lack of money, overloaded curriculum and lack of student's interest. Students also express concerns about the training skills of their teachers about teaching and assessment strategies. As a result, this study emphasizes the necessity of forming links between personal experiences and learning, as suggested by researchers (Sadler, Klosterman & Topcu, 2011). Learning becomes more meaningful and relevant when students can apply their information in a real-world setting.

Pedretti and Nazir (2011) define the core tenets of STSE-based education as: environmental stewardship, decision-making abilities to assist citizens in making informed decisions, ethical issues in science, social value in science, and actions to empower people. STSE-based concerns might encourage students to use their knowledge to solve a problem with socio-cultural implications (Pedretti & Nazir, 2011; Zeidler, Sadler, Applebaum, & Callahan, 2009) that is relevant to their lives. These findings back up Kim's (2011) investigation. The study discovered that in a community of learners, the social environment of collaborative science teaching and learning offers the space and opportunity for students to discuss and develop their reflective thinking skills (Garrison, 2000). Students can better organize their thoughts and ideas concerning STSE issues by expressing their views and ideas (Luppici, 2002). Other scholars have stated similar views in this context, with evidence of STSE-based school science having an impact on multiple occasions (Osborne, Simons & Collins, 2003).

Recommendations

Following recommendations are offered to government, policymakers, curriculum developers and science teachers to ensure the implementation of STSE approach:

1. STSE relationships may enable students to perceive their surroundings and technological conditions, as well as their contributions to society and potential harm. As a result, research should be carried out in order to prepare teachers and equipment that will allow students to develop STSE connections.
2. Students' opinions about STSE ideas could be examined more fully during STSE-related teaching sessions utilizing the interviewing method.
3. Students who do not want to pursue science-related training could be used as a sample, with observations performed on them to determine the effectiveness of STSE-related instruction.

References

- Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education*, 82(4), 417-436.
- Akcay, H., & Yager, R. E. (2010). The impact of a science/technology/society teaching approach on student learning in five domains. *Journal of Science Education and Technology*, 19(6), 602-611. <https://doi.org/10.1007/s10956-010-9226-7>
- American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: A Project 2061 report*. New York: Oxford University Press.
- Amirshokoohi, A. (2010). Elementary Pre-Service Teachers' Environmental Literacy and Views toward Science, Technology, and Society (STS) Issues. *Science Educator*, 19(1), 56-63.
- Avci, D. E., Onal, N. S., & Usak, M. (2014). Turkish teachers' opinions about science-technology-society-environment acquisitions in science and technology course curriculum. *Journal of Baltic Science*

- Education, 13(2), 216–225.
<https://doi.org/10.33225/jbse/14.13.213>
- Bybee, R. W. (2010). *The teaching of science: 21st century perspectives*. NSTA press.
- Bybee, R. W. (2011). Scientific and engineering practices in K-12 classrooms: Understanding a framework for K-12 science education. *Science and Children*, 49(4), 10–18.
- Çetinkaya, G. (2012). *Investigation of the relationship between pre-service science teachers' understandings of the nature of science and their personal characteristics* (Unpublished Master's thesis, Middle East Technical University).
- Dass, P. M. (2005). Using a Science/Technology/Society Approach to Prepare Reform-Oriented Science Teachers: The Case of a Secondary Science Methods Course. *Issues in Teacher Education*, 14(1), 95–108.
- Garrison, R. (2000). Theoretical challenges for distance education in the 21st century: A shift from structural to transactional issues. *International Review of Research in Open and Distributed Learning*, 1(1), 1–17.
- Hodson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in school science. *Studies in Science Education*, 22(1), 85–142.
- Kim, M. (2011). Science, technology and the environment: the views of urban children and implications for science and environmental education in Korea. *Environmental Education Research*, 17(2), 261–280.
- Kumar, D. D., & Chubin, D. E. (Eds.). (2000). *Science, technology, and society: A sourcebook on research and practice* (Vol. 6). Springer Science & Business Media.
- Lederman, N. G. (1992). Students' and teachers' conceptions about the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29, 331–359.
- Lee, M. K., & Erdogan, I. (2007). The effect of science–technology–society teaching on students' attitudes toward science and certain aspects of creativity. *International Journal of Science Education*, 29(11), 1315–1327.
- Lestari, O., Anwar, S., Priscylio, G., Wahyuni, W. S., Oktasari, C., & Agustina, N. R. (2020, February). How to develop SETS-based electronic book to improve student's science literacy with 4S TMD models? *Journal of Physics: Conference Series*, 1469(1), 12067–80.
- Luppici, R. (2002). Toward a conversation system modeling research methodology for studying computer-mediated learning communities. *International Journal of E-Learning & Distance Education/Revue internationale du e-learning et la formation à distance*, 17(2), 87–101.
- Mansour, N. (2007). Challenges to STS education: Implications for Science Teacher Education. *Bulletin of Science, Technology & Society*, 27(6), 482–497.
- Millar, R., Osborne, J., & Nott, M. (1998). Science education for the future. *School Science Review*, 80(291), 19–24.
- National Research Council (1996). *National science education standards*. Washington, DC: National Academic Press.
- National Research Council. (2013). *Next generation science standards: For states, by states*. Washington, DC: National Academic Press.
- 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.
- Ozer, M. A., Rutledge, D., & Ozer, M. (2019, March). A Mixed Method Analysis of Student Achievement Dilemma: How Do Ethnicity and Socio-Economic Status Affect STEM Academy Students' Achievement Levels in Algebra. In *Society for Information Technology & Teacher Education International Conference* (pp. 2214–2218). Association for the

- Advancement of Computing in Education (AACE).
- Pedretti, E. (1996). Learning about science, technology, and society (STS) through an action research project: Co-constructing an issues-based model for STS education. *School science and mathematics*, 96(8), 432-440.
- Pedretti, E. (1999). Decision making and STS education: Exploring scientific knowledge and social responsibility in schools and science centers through an issues-based approach. *School Science and Mathematics*, 99(4), 174-181.
- Pedretti, E. G., Bencze, L., Hewitt, J., Romkey, L., & Jivraj, A. (2008). Promoting issues-based STSE perspectives in science teacher education: Problems of identity and ideology. *Science & Education*, 17(8), 941-960.
- Pedretti, E., & Bellomo, K. (2013). A time for change: Advocating for STSE education through professional learning communities. *Canadian Journal of Science, Mathematics and Technology Education*, 13(4), 415-437.
- Pedretti, E., & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science education*, 95(4), 601-626.
- Primastuti, M., & Atun, S. (2018, September). Science Technology Society (STS) learning approach: an effort to improve students' learning outcomes. In *Journal of Physics: Conference Series* (Vol. 1097, No. 1, p. 012062). IOP Publishing.
- Rennie, L. J., Goodrum, D., & Hackling, M. (2001). Science teaching and learning in Australian schools: Results of a national study. *Research in Science Education*, 31(4), 455-498.
- Rubba, P. A. (1991). Integrating STS into school science and teacher education: Beyond awareness. *Theory into Practice*, 30(4), 303-308.
- Rutherford, F. J., & Ahlgren, A. (1991). *Science for all Americans*. Oxford University Press.
- Sadler, T. D., Klosterman, M. L., & Topcu, M. S. (2011). *Learning science content and socio-scientific reasoning through classroom explorations of global climate change*. In *Socio-scientific Issues in the Classroom* (pp. 45-77). Springer, Dordrecht.
- Seeker, S. (2007). *The evaluation of the new primary curriculum 6th class science and technology lesson curriculum in the light of teacher's opinions* (Master dissertation). Retrieved from YOK Theses Center database. (Thesis No. 212105).
- Slack, S. J., & Stewart, J. (1990). High school students' problem-solving performance on realistic genetics problems. *Journal of Research in Science Teaching*, 27(1), 55-67.
- Smith, M. U., & Scharmann, L. C. (1999). Defining versus describing the nature of science: A pragmatic analysis for classroom teachers and science educators. *Science Education*, 83(4), 493-509. [https://doi.org/10.1002/\(sici\)1098-237x\(199907\)83:4](https://doi.org/10.1002/(sici)1098-237x(199907)83:4)
- Solomon, J. (1993). *Teaching science, technology and society*. Philadelphia, PA: Open University Press.
- Tal, R. T., Dori, Y. J., & Keiny, S. (2001). Assessing conceptual change of teachers involved in STES education and curriculum development-the STEMS project approach. *International Journal of Science Education*, 23(3), 247-262.
- Yilmaz, H., & Yigit, N. (2011). The views and expectations of the students towards science and technology course 6th grade curriculum. *National Education Journal*, 190, 269-291.
- Yoruk, N. (2008). *Effects of science, technology, society and environment (STSE) approach teaching chemistry with using the 5E learning model* (Doctoral dissertation,

- Doctoral dissertation). Retrieved from YOK Theses Center database.
- Yoruk, N., Morgil, İ., & Secken, N. (2009). The Effects of Science, Technology, Society and Environment (STSE) Education on Students' Career Planning. *Online Submission*, 6(8), 68-74.
- Zeidler, D. L., Sadler, T. D., Applebaum, S., & Callahan, B. E. (2009). Advancing reflective judgment through socioscientific issues. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 46(1), 74-101.
- Zoller, U. (2013). Science, technology, environment, society (STES) literacy for sustainability: what should it take in chem/science education? *Educaciónquímica*, 24(2), 207-214.