

# Modeling the Relationship between Preservice Elementary Teachers' Scientific Habits of Mind, Attitudes towards Socio-scientific Issues and Scientific Literacy

Menşure Alkış Küçükaydın<sup>1\*</sup>

<sup>1</sup>Basic Education Department, Ereğli Faculty of Education, Necmettin Erbakan Üniversitesi, Konya, Turkey

\*Corresponding Author. [mensurealkis@hotmail.com](mailto:mensurealkis@hotmail.com)

**ABSTRACT** Socio-scientific issues (SSI), including dilemmas and problems in scientific and social terms, are directly related to individuals' daily lives. Individuals' interests and attitudes towards SSI also affect their perspective on events in their lives. For this reason, as a member of society, it is essential to research variables that are thought to be related to pre-service elementary teachers' attitudes towards SSI. Based on this point, the relationship between pre-service elementary teachers' attitudes towards SSI, their scientific habits of mind (SHOMS) for SSI, and their level of scientific literacy are studied and tried to be modeled. One hundred twenty pre-service elementary teachers studying at a university in the south-eastern Anatolia region of Turkey have participated in this study. The correlation research design from descriptive research methods is used in this study. In this context, three data collection tools are used with the personal data form. Research results have been analyzed by using Partial Least Squares Structural Equation Modelling. According to the analysis results, it is determined that pre-service elementary teachers' SHOMS for SSI affect scientific literacy, and attitudes towards SSI affect interest in scientific knowledge and publications.

**Keywords** Attitudes towards Socio-scientific Issues, Scientific Habits of Mind, Scientific Literacy, Scientific Knowledge, Preservice Elementary Teachers

## 1. INTRODUCTION

Socio-scientific issues (SSI) are a powerful field of study that includes interpreting and analyzing scientific data. These issues allow discussion of social subjects' moral, ethical, and epistemological aspects in a theoretical framework (Ritchie, Tomas, & Tones, 2011). This field of study is generally not limited and consists of many dimensions, such as economics, religion, politics, or the environment where exact solutions are unclear. Problems to this extent cannot be easily identified and answered as in traditional situations (Sadler, 2004). SSI are also associated with argumentation, critical thinking, and the nature of science (Yacoubian & Khishfe, 2018), and they affect students' decision-making strategies.

Emery, Harlow, Whitmer & Gaines (2017) state that including SSI in teaching is important for students. Because if students encounter uncertain and contradictory situations in their daily lives, teaching scientific knowledge that they can use to cope with these situations might be possible with the content of SSI. According to Tidemand & Nielsen (2017), SSI-based instruction progresses in different cognitive skills, especially critical thinking. Also,

moral evaluations concerning everybody in society are performed, and progress in scientific literacy is enhanced. Therefore, examining SSI by considering its relation to different contexts is necessary.

In recent studies carried on SSI, pre-service science teachers are generally preferred as a group of participants (Borgerding & Dagistan, 2018; Kapici & Ilhan, 2016; Topcu, Sadler, & Yilmaz-Tuzun, 2010; Topcu, Yilmaz-Tuzun, & Sadler, 2011), and the effect of SSI-based instruction on the quality of argumentation (Atabey & Topcu, 2017) or the relations of SSI with cognition skills (Alkış Küçükaydın, 2019, 2020) are tried to be revealed. Moreover, pre-service teachers' cases on moral or informal reasoning about SSI (Emery et al., 2017; Lee, Chang, Choi, Kim, & Zeidler, 2012; Sadler, 2004) and the relationship between SSI and critical thinking skills (Yacoubian & Khishfe, 2018) are discussed. In these studies, the relations of different variables are determined. But the possible

Received: 21 July 2021

Revised: 08 November 2021

Published: 27 July 2022

relationship between attitudes towards SSI, the scientific habits of mind (SHOMS) for SSI, and scientific literacy has not yet been determined. Therefore, they examine this situation, an important gap in the literature. Therefore, a study is needed to determine the relations between these specified variables. Based on this need, the related research tries to address the relationship between pre-service elementary teachers' attitudes towards SSI and SHOMS for SSI and the stories of scientific literacy. Within this goal, the following hypotheses have been formed:

H<sub>1</sub> = There is a relationship between the pre-service elementary teachers' attitudes towards SSI and SHOMS for SSI.

H<sub>2</sub> = There is a relationship between the pre-service elementary teachers' attitudes towards SSI and their levels of scientific literacy.

H<sub>3</sub> = There is a relationship between the pre-service elementary teachers' attitudes towards SSI and their scientific knowledge and publications interests.

H<sub>4</sub> = There is a relationship between the pre-service elementary teachers' SHOMS for SSI and their level of scientific literacy.

H<sub>5</sub> = There is a relationship between pre-service elementary teachers' attitudes towards SSI and their scientific knowledge and publications interests.

H<sub>6</sub> = There is a relationship between the pre-service elementary teachers' scientific literacy levels and their interest in scientific knowledge and publications.

## 1.1. Theoretical Framework

### 1.1.1. Scientific Habits of Mind for Socio-scientific Issues

According to Zeidler, Sadler, Simmons & Howes (2005), SSI allows discussion of ethical issues and moral judgments about science through social interaction and discourse. Through these discussion environments, both teachers and students develop attitudes on ethics, thus making decisions about moral-ethical assessments (Lee, Abd-El-Khalick, & Choi, 2006).

By examining experimental studies involving SSI, reached some themes with which SSI are associated (Sadler, 2004; Zeidler et al., 2005; Zeidler, 2014). These themes are an association of teachers' pedagogical content knowledge and current curriculum practices with SSI, socio-scientific issues as a source of epistemological development and reasoning, SSI-like science, and following current affairs about SSI as citizens. In addition to these themes, it has been proposed the necessity to examine SHOMS in the literature concerning SSI (Çalik & Coll, 2012). Gauld (2005) collected SHOMS under the titles as open-mindedness, skepticism, rationality, objectivity, mistrust of arguments from authority, suspension of belief, and curiosity. According to these titles, individuals who can think scientifically are skeptical of every topic and have a critical point of view. This perspective also influences

attitudes towards science. Therefore, having SHOMS is vital in having a scientific mindset (Kolomuç & Çalik, 2019). In addition, getting students to think about SSI and supporting them in this regard is influential in developing scientific literacy (Emery et al., 2017).

### 1.1.2. Attitudes towards Socio-scientific Issues

The term "attitude" includes cognitive, affective, and behavioral elements. According to Reid (2006), these elements are interrelated, and in the mental dimension, it provides information about an event, object, or state. The affective dimension includes the identification of emotions, and to the behavioral extent, it consists of an action trend towards an event, object, or state. Attitudes towards SSI, on the other hand, express attitudes not only towards science but also towards social, moral, or ethical issues that concern a significant part of society (Topcu, 2010). Zeidler (2014) states that student attitudes can change positively through SSI-based instruction. Because with SSI, students can take more responsibility for ethical issues, develop SHOMS, and expand their areas of responsibility by having autonomous thought. However, to expand these areas of responsibility, it is necessary to have a good level of scientific literacy (Chen & So, 2017). Because a good level of scientific literacy helps to develop a positive attitude towards SSI (Yerdelen, Cansiz, Cansiz, & Akcay, 2018), for this reason, it can be mentioned that there is a strong relationship between the attitude towards SSI and scientific literacy. Thus, Xiao & Sandoval (2017) state the necessity of conducting more research on the relationship between scientific literacy and reasoning about SSI and determining the predictors of this relation.

### 1.1.3. Scientific Literacy

Saunders & Rennie (2013) define scientific literacy as "*a vehicle that enables individuals to have sufficient awareness of science and its processes to be able to deal competently and confidently with science-related matters in today's world*" (p.254). According to Norris & Phillips (2003), scientific literacy means using necessary interpretive strategies to understand a scientific text and covers concepts, skills, understandings, values, and basic science content knowledge that can be generalized for all readings.

Roberts (2007) discusses scientific literacy terms from two aspects. The first aspect is addressed from the perspective of scientists, while in the second aspect, individuals' relating daily life events with scientific events as a member of society is discussed. Although this distinction seems dangerous to some, Coll, Taylor & Lay (2009) point out that the second aspect has a vital place today because interest in science affects belief in job opportunities that offer academic careers, educational opportunities, trust in the scientist, or even the existence of scientific knowledge. Moreover, Sadler, Barab & Scott (2007) brought the concept of scientific literacy under the same content with real-world issues of SSI and explained this content with the practice of science, argumentation,

moral development, and citizenship skills with the preparation of nature of science, argumentation, moral both global and local tasks.

#### 1.1.4. Relationship between Socio-scientific issues and Scientific Literacy

In the relevant literature, there is a reasonably close relationship between studies on SSI and scientific literacy because it is known that the use of socio-scientific issues in classroom environments strengthens scientific literacy (Bingle & Gaskell, 1994; Çalik & Coll, 2012). Also, Yacoubian (2018), who associates making democratic decisions with scientific literacy, states that it is crucial to associate the science curriculum with SSI. In the conceptual framework developed based on SSI and classroom practices, Zeidler et al. (2005) established a relationship between SSI and scientific literacy and expressed that SSI increased the level of scientific literacy. SSI is associated with scientific literacy (Çalik & Coll, 2012) as it includes components such as reasoning, formal or informal decision-making, analysis, synthesis, and evaluation.

Lederman, Antink & Bartos (2014) expressed scientific literacy as an individual's understanding of a subject and scientific inquiry. In short, an individual must have the ability to question scientific knowledge and think over counter-claims and evidence to make informed decisions about SSI. According to Yacoubian & Khishfe (2018), an individual with a level of scientific literacy should make informed decisions about both scientific knowledge and SSI.

#### 1.1.5. Relationship between Socio-scientific issues and SHOMS.

The main objectives of science education are to promote scientific literacy, teach SSI content to young students, examine what these students think about SSI, and interfere pedagogically if necessary. Moreover, Coll et al. (2009) stated that some scientists betrayed the publics' trust due to their explanations about SSI that concern society in general. For this reason, it is essential to study to what extent scientists appreciate an idea by examining individuals' SHOMS. It would be beneficial to explore the relationship between the attitudes and their SHOMS towards SSI and science literacy of teachers and prospective teachers, who are influential on society. However, Sadler et al. (2007) states that science teaching researchers are optimistic about SSI teaching in theory. They emphasize that it should be applied in schools, but it is essential to research the results of the situation in the field. Teachers, who are practitioners at schools, may sometimes disagree with researchers because of the structure and content of SSI and the limited time of the curriculum. This situation also affects teachers' time on SSI and their attitudes towards SSI. Tidemand & Nielsen (2017) state that many pre-service teachers consider SSI relatively superficial and short-lived. Teachers will educate

the students who will learn SSI for the first time in elementary school years. Therefore, studying teachers' scientific literacy levels, attitudes towards SSI, and SHOMS towards SSI will indirectly inform the SSI curriculum.

## 2. METHOD

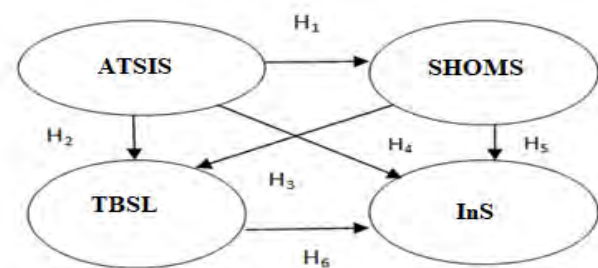
A correlational survey model which tries to examine the relations between variables is used for this study. Since the relationship between pre-service elementary teachers' attitudes towards SSI, SHOMS for SSI, and scientific literacy cases is examined, the correlational survey model is appropriate for the study.

### 2.1. Research Model and Hypotheses

The research model formed based on relevant literature is summarized in Figure 1. There are two points in the research model for the assumptions that attitudes towards SSI and scientific literacy variables are related. As stated in the relevant literature, the relationship between attitudes towards SSI and scientific literacy (Emery et al., 2017; Kapici & Ilhan, 2016; Topcu, 2010; Zeidler et al., 2005) is related to the relationship between SHOMS for SSI and scientific literacy (Çalik & Coll, 2012; Gauld, 2005; Yacoubian & Khishfe, 2018). This argument is also in line with the view that scientific literacy level is about people's getting into the SHOMS for SSI. The relationship between interest in scientific knowledge and scientific publications with other variables is also researched.

### 2.2. Participants and Data Collection

This study collected data from pre-service elementary teachers studying at a large state university in the south-eastern Anatolia region of Turkey in the 2019-2020



**Figure 1** Default research model (ATISIS= Attitudes towards socioscientific issues scale, SHOMS= Scientific habits of mind survey, TBSL= Test of basic scientific literacy, InS= Interest in Science)

academic year using an appropriate sampling method. During data collection, pre-service elementary teachers were reported that participation was based on voluntariness, and all scales were gathered and applied in a single form. The application was carried out in the spring



**Table 1** Demographic variables

		Grade Level				
		Grade 1	Grade2	Grade3	Grade4	Total
Gender	Female	22	25	16	14	77
	Male	8	7	12	16	43
	Total	30	32	28	30	120

**Table 2** Sample items each dimension of data collection instruments

Instrument	Dimensions	Sample Item
SHOMS	Mistrust of arguments from authority	Because the National Radiation Research Institute, reports that the radiation emitted by digital cell phones is not hazardous, we should believe this.
	Open-mindedness	If scientific evidence is produced that homeopathic medicines have an effect beyond that of a placebo, it is reasonable to consider using them.
	Scepticism	We need to see more scientific evidence before we should consider the use of Yoga and meditation to treat serious illness.
	Rationality	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.
	Objectivity	We don't know enough to be sure that greenhouse gas emissions play a key role in climate change.
	Suspension of belief	Credible research requires the use of scientific methods.
	Curiosity	Research about the fundamental forces in nature is hard to justify.
ATSIS	Interest and usefulness of SSI	I would like to know more about SSI. Since SSI is related to daily life, I would like to learn more details about SSI.
	Liking of SSI	I would like to pursue socioscientific innovations by media.
	Anxiety towards SSI	I think that social values suffer from the implementation of SSI.
TBSL	Nature of science	Scientists can interpret the evidence differently based on their personal beliefs, values and backgrounds.
	Science- technology-society	In decisions about any technology (e.g. installing a nuclear power station near a city), only the facts about that technology are not decisive.

semester. Pre-service teachers were given about 40 minutes to complete the form. For the approval of the study, written was obtained from pre-service teachers. The research conforms to the declaration of Helsinki (as revised in Brazil 2013). That means all the pre-service teachers took part in the study voluntarily. Demographics of the pre-service teachers participating in the study are presented in Table 1. According to this table, 77 of teachers are women, and 43 are men. 30 pre-service elementary teachers are in their first year, 32 of them are in their second year, 28 of them are in their third year, and 30 of them are in their fourth year.

### 2.3. Instruments

The data collection instruments used in this study are described below. In addition, sample items of relevant scale factors are presented in Table 2.

#### 2.3.1. Personal Information Form

It is developed by the researcher to collect demographic data of participants. In the relevant survey, participants are asked about their gender, class level, interest in SSI, and following scientific journals or other publications. Questions are gathered under the title as interest in science consist of subheadings as (1) frequently followed scientific publications, (2) frequency of follow-up publications, (3) level of interest in science.

#### 2.3.2. Scientific Habits of Mind Survey

Developed by Çalik & Coll (2012), the Scientific Habits of Mind Survey (SHOMS) consists of 32 items and is seven-dimensional as mistrust of arguments from authority, open-mindedness, skepticism, rationality, objectivity, suspension of belief, curiosity is used in the study. The seven-dimensional that make up the survey explains 50% of the total variance. The survey is a 4-point Likert type (4=always true, 1=always false). In the relevant study, positive scoring (4-1) is used for 1-8. and 27. items, negative scoring is used for (4-1) 9-26. and 28-32. items. Cronbach alpha values calculated by Çalik & Coll (2012) are between .64 and .83.

#### 2.3.3. Attitude Scale towards Socio-scientific Issues

Attitudes towards SSI Scale (ATSIS) developed by Topcu (2010) is used to measure pre-service elementary teachers' attitudes towards SSI. It consists of 30 items formed on a 5-point Likert scale (1=strongly disagree, 5=strongly agree). The scale consists of three-dimensional as "anxiety towards SSI," "liking of SSI," and "interest and usefulness of SSI." The dimensions that make up the scale explain 51% of the total variance. Nine items in the hierarchy are semantically negative, and the relevant items are coded reversely. For example, the scale of Cronbach alpha internal reliability coefficients reported by Topcu

(2010) is grouped in three dimensions ranging from .70-.90.

#### 2.3.4. Scientific Literacy Scale

Test of Basic Scientific Literacy (TBSL) developed by Turgut (2005) is used in this study to measure the scientific literacy levels of pre-service elementary teachers. The scale developed initially by Laugksch & Spargo (1996) includes 110 items and “right-wrong-I don't know” options. This scale has three dimensions of scientific literacy as “nature of science,” “science-technology-society relationship,” and “knowledge of scientific content.”

The dimensions of the scale explain 22% of the total variance. The related scale is adapted to Turkish culture by Turgut (2005) and turned into a 5-Likert-type scale with a total of 38 items, including 22 items on the “nature of science” dimension and 16 items on the “science-technology-society” dimension. Cronbach alpha internal reliability coefficient of the scale calculated by Turgut (2005) is .88 for the size of “nature of science” and .92 for the dimension of “science-technology-society.”

#### 2.4. Data Analysis

Partial Least Squares Structural Equation Modeling (PLS-SEM) is used for the study to test the research model. As an estimation method, PLS-SEM analysis methods use the Ordinary Least Squares/ OLS method like regression. It is based on the estimation of the correlation coefficient, which maximizes the R<sup>2</sup> value of the dependent variable. In other words, it works to maximize the explained variance of a dependent variable, which is the main focus, and to minimize the error variances (Hair, Hult, Ringle, & Sarstedt, 2014). Failure to achieve multiple normalities in

the study does not allow structural equating modeling. In addition, the complexity of the model intended to be tested and the inability to use advanced analysis such as logistic regression and the algorithm of a limited number of participants necessitates the use of PLS-SEM, which is suitable for this study (Wong, 2013). SmartPLS 3.0 is used in the study, enabling PLS-SEM to be applied. SmartPLS, free software and offers a graphical interface, is considered suitable for this study.

KMO (Kaiser-Meyer-Olkin) coefficient and Barlett Sphericity tests are performed for factor analysis suitability before the relevant analyses are carried out in the study. The KMO value is calculated as .61, which exceeds the recommended .60 value (Kaiser, 1974). In addition, the Barlett test is found to be significant, and this shows that the correlation matrix can be factorized (Tabachnick & Fidell, 2013). In each hypothesis test and reliability analysis calculated for the model, internal consistency would be provided if the Cronbach alpha value was .70 and above (Fornell & Larcker, 1981).

### 3. RESULT AND DISCUSSION

The descriptive statistical analysis results of the variables used in the study are presented in Table 3.

According to Table 3, the average score of participants on ATSSIS is 3.57. When dimensions of the scale are examined, it is seen that participants believe in the benefit and significance of SSI (Mean/ k = 3.81), although their level of liking for SSI is low (Mean/ k= 3.37). Furthermore, when the scientific literacy levels of the participants are examined, it is seen that the knowledge level of the science-technology-society dimension (Mean/ k= 3.41) is higher

**Table 3** Descriptive statistics

Scale	Number of items	Min score	Max score	Mean	Mean/k	Sd
<b>ATSSIS</b>	30	51.00	141.9	107.1	3.57	.54
liking of SSI (ATSSIS1)	7	10.99	34.02	23.59	3.37	.67
anxiety towards SSI (ATSSIS2)	6	7.020	30.00	21.24	3.54	.75
interest and usefulness of SSI (ATSSIS3)	17	29.92	83.98	67.77	3.81	.63
<b>SHOMS</b>	32	51.20	94.08	71.36	2.23	.26
mistrust of arguments from authority (SMOMS1)	4	4.00	16.00	10.28	2.57	.92
open-mindedness (SHOMS2)	6	6.00	19.20	14.64	2.44	.49
Skepticism (SHOMS3)	4	4.00	12.00	6.96	1.74	.40
Rationality (SHOMS4)	4	4.00	12.00	7.72	1.93	.35
Objectivity (SHOMS5)	5	5.00	15.00	10.1	2.02	.51
suspension of belief (SHOMS6)	5	7.50	18.35	12.60	2.52	.36
Curiosity (SHOMS7)	4	5.00	14.00	9.56	2.39	.43
<b>TBSL</b>	38	97.28	155.80	128.06	3.37	.29
nature of science (TBSL1)	22	51.92	91.96	73.26	3.33	.35
science- technology-society (TBSL2)	16	43.04	70.08	54.56	3.41	.32
<b>InS</b>	-	2.00	18.00	9.00	-	.92
interest in scientific knowledge (InS1)	-	1.00	11.00	17.74	-	.62
interest in scientific publications (InS2)	-	1.00	4.00	7.01	-	.57

than the knowledge level of the nature of science dimension (Mean/  $K = 3.33$ ). Finally, when the responses given to SHOMS of the 4-Likert type are examined, the “mistrust of arguments from authority” dimension is higher than all other SHOMS dimensions (Mean/  $k = 2.57$ ).

According to Table 3, participants' attitudes towards SSI are above average (Mean/  $k = 3.57$ ), while their level of scientific literacy is intermediate (Mean/  $k = 3.37$ ). Furthermore, when participants' SHOMS is examined, it is seen that the item score corresponds to the “maybe wrong” category (Mean/  $k = 2.23$ ). That has been associated by Kolomuç & Çalik (2019) have associated that individuals often use processes to question events and understand their causes. Finally, when participants' interest in scientific knowledge and publications is examined, it is seen that their interest in scientific knowledge is higher than the rate of follow-up of scientific journals. In other words, participants are interested in scientific knowledge but are not controlled in following a scientific periodical publication.

Exploratory factor analysis is used in the study following the descriptive statistical analyses to gather more information about the mutual relations between variables

group. Factor load values of analyses are noted to be greater than .45 (Tabachnick & Fidell, 2013). As well as confirming this assumption for the scales used in the study, interest in scientific information and publications developed within the scope of this study is gathered in a single dimension. The results of factor analysis applied in the study are summarized in Table 4. During the analyses, factor analysis is retested by removing three items of which factor load is below .45 within TBLS, two items within ATSSIS, and two items within SHOMS.

Convergent reality is also used in this study to evaluate the model. Indicator reliability (factor load  $\geq .70$ ), internal consistency reliability (Cronbach alpha  $\geq .70$ ) and composite reliability (factor load  $\geq .70$ , AVE  $\geq .50$ ) are examined (Sarstedt, Ringle, & Hair, 2017) to confirm convergent reality. The results obtained are summarized in Table 5. According to the information outlined, the stated assumptions have been carried out, and convergent reality has been confirmed. After reliability analysis, the composite validity values are examined. Sarstedt et al. (2017) states that Cronbach's alpha value usually sets the value for the lower limit; however composite reliability sets

**Table 4** Factor analysis

Scale Sub-factor	Dimension						
	1	2	3	4	5	6	7
ATSIS1	0.451- 0.734						
ATSIS2		0.543- 0.699					
ATSIS3			0.463- 0.717				
Explained Variance Total: %51.27 Dimension 1: %25.87 Dimension 2: %13.42 Dimension 3: %11.98							
SHOMSS1	0.641- 0.834						
SHOMSS2		0.650- 0.815					
SHOMSS3			0.637- 0.770				
SHOMSS4				0.683- 0.806			
SHOMSS5					0.670- 0.791		
SHOMSS6						0.615- 0.721	
SHOMSS7							0.531- 0.552
Explained Variance Total: %50.54 Dimension 1: %13.13 Dimension 2: %9.56 Dimension 3: %6.79 Dimension 4: 5.98 Dimension 5: 5.42 Dimension 6: 5.16 Dimension 7: 4.51							
TBSL1	0.449- 0.529						
TBSL2		0.460- 0.541					
Explained Variance Total: %22.52 Dimension 1: %14.22 Dimension 2: %8.30							
InS	0.520- 0.621						
Explained Variance Total: %52.01							

**Table 5** The measurement model

Construct	Factors	Factor loading	Cronbach' alpha	rho_A	Composite reliability	Average variance extracted (AVE)
ATSIS	ATSIS1	.790	.931	.943	.938	.510
	ATSIS2	.888				
	ATSIS3	.708				
SHOMS	SHOMS1	.780	.721	.724	.702	.510
	SHOMS2	.763				
	SHOMS3	.757				
	SHOMS4	.765				
	SHOMS5	.710				
	SHOMS6	.712				
	SHOMS7	.710				
TBSL	TBSL1	.710	.710	.839	.700	.513
	TBSL2	.746				
InS	InS1	.708	.715	.720	.701	.539
	InS2	.708				

**Table 8** Hypothesis testing results

Hypothesis	Path	Direct effect	Indirect effect	Total effect	Path coefficient	t value	Accept/Reject
H1	ATSIS→SHOMS	-.238	.000	-.238	-.23	.997	Reject
H2	ATSIS→TBSL	-.340	.089	-.251	-.34	1.494	Reject
H3	SHOMS→TBSL	.072	.000	.072	-.37	1.970	Accept
H4	ATSIS→InS	.072	.046	.118	.072	2.386	Accept
H5	SHOMS→InS	-.127	.023	-.104	-.12	.827	Reject
H6	TBSL→InS	-.062	.000	-.062	-.06	1.386	Reject

**Table 6** Discriminant and convergent validity of the constructs

Construct	ATSIS	SHOMS	InS	TBSL
ATSIS	.714*			
SHOMS	-.156	.714*	.162	
TBSL	.157	-.195	-.155	.716*
InS	-.186		.734*	

\* indicates that the discriminant validity criteria of Fornell-Larcker in this study were fulfilled

**Table 7** HTMT values

Construct	ATSIS	SHOMS	InS	TBSL
ATSIS				
SHOMS	.395		.354	
TBSL	.387	.592	.300	
InS	.200			

a value for the upper limit, on the other hand, rho\_A (>.70) recommended by Henseler, Hubona & Ray (2016) sets a value among them. They recommend that this result should also be reported in researches. After this reporting, three values are used to test the discriminant validity. One of them is cross-loading, the second is the Fornell-Larcker criterion (Table 6), and the third is the HTMT criterion (Table 7).

According to the cross-loading criterion, whether factor load in the variable of each indicator used in the study is

higher than the factor load of other variables. At the Fornell-Larcker criterion, the values displayed in the diagonal are the square root of the AVE value of a related variable, and each is expected to be greater than the correlation coefficients in the same column (Hair et al., 2014). It is seen that this criterion is also confirmed in the study. HTMT refers to the ratio of indicators belonging to all variables in the model to geometric averages of correlations of indicators belonging to the same variable. Henseler et al. (2016) state that this value should be below .90. The criterion for HTMT value in this study is .90, and all values obtained from the survey are below this criterion.

Before testing path analysis, resampling is performed to test the statistical significance of factor loads. The number of subsamples is increased to 5000 for this resampling. Resampling results applied for factor analysis show that all indicators' relationships with the variables related to are statistically significant. After all these analyses mentioned in the study, the path analysis is studied, and the model is presented in Figure 2. When collinearity statistics (VIF) values are examined from the analysis results, it is observed that both the VIF values of indicators and the VIF values of variables are below the critical value of 5 (Sarstedt et al., 2017). Since collinearity statics value does not cause problem, for the second step, the correlation coefficient values, R<sup>2</sup> (.25 [little], .50 [medium], .75 [strong]) and f<sup>2</sup> (.02 [low], .15 [medium], .34 [high]), are examined. A resampling



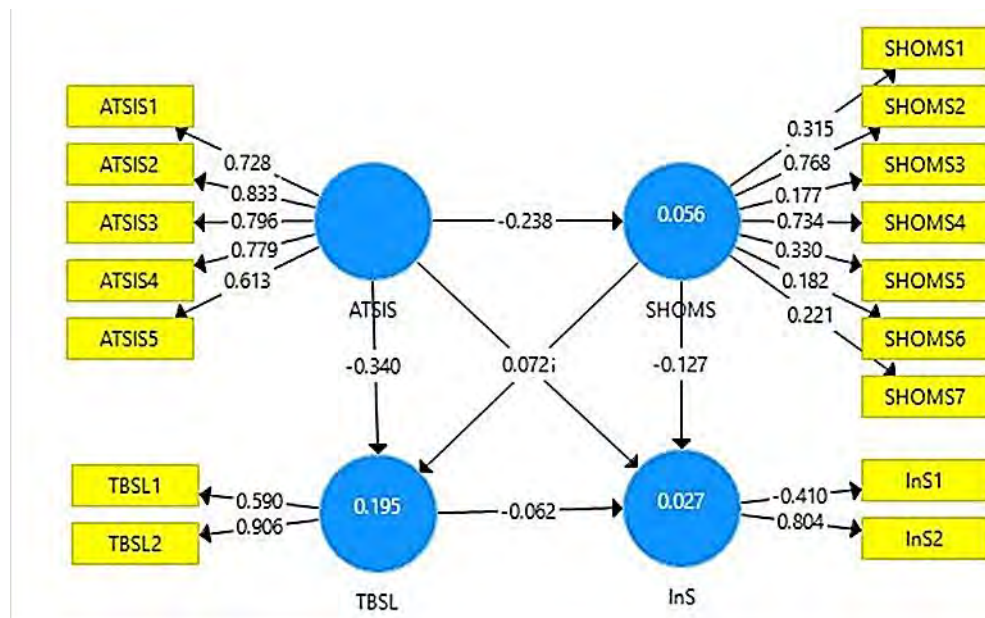


Figure 2 Path coefficients of the research model

is performed to test whether these collinearity coefficients are statistically significant. Thus, each hypothesis's direct, indirect, and total effects values are calculated. In addition, t-test results are presented, applied to test significant differences in collinearity coefficients (Table 8).

Six hypotheses are tested on the model prepared within the scope of the study (Figure 2). According to these test results, hypotheses H<sub>3</sub> and H<sub>4</sub> are supported ( $tH_3 = 1.970$ ;  $tH_4 = 2.386$ ), while the remaining hypotheses are not supported. Thus, it is possible to say that SHOMS for SSI influences scientific literacy, and attitudes towards SSI influence scientific knowledge and interest in publications.

## CONCLUSION

A relation between scientific literacy and SHOMS has been established in this study. The relationship between pre-service elementary teachers' SHOMS, attitudes towards SSI, and their scientific literacy are tried to be revealed. Moreover, it has been observed that there is a relationship between attitudes towards SSI and interest in scientific knowledge and publications. Both relationships are oriented positively at the same time. That indicates that if SHOMS is improved, scientific literacy improves (H<sub>3</sub>), and attitude towards SSI also influences the interest in scientific knowledge and publications (H<sub>4</sub>). Çalik & Karataş (2019) points out that to improve pre-service elementary teachers' SHOMS is essential to find out what the SHOMS is. SHOMS is related to SSI (Çalik & Coll, 2012) and is parallel with scientific literacy development. The limited number of studies including these variables mentioned in the literature shows that there are indeed many unknown points about SHOMS. In addition, Şahin & Ateş (2020) expressed a relationship between scientific literacy and cognitive variables in their study. Therefore, it is worth

studying the effects of these features' effects on SHOMS and their reflection on scientific literacy.

It is necessary to increase scientific literacy to understand scientific phenomena better (Yahaya, Zain, & Karpudewan, 2012). However, being scientifically literate is not enough to understand SSI. Because there is a need for teaching programs on SSI and pre-service teachers with pedagogical competence (Lewis & Leach, 2006), SSI and scientific literacy cannot be separated. That is related to the intertwined nature of SSI and science (Sadler, 2004). However, the relationship between SSI and scientific literacy has not yet been addressed with empirical studies or a holistic approach. This situation is seen as a gap for SSI studies. Considering this gap, studies to be carried out with pre-service teachers, especially in science, may contribute to a clearer view of the current situation.

The study also found that attitudes towards SSI affect the interest in scientific knowledge and publications positively. Kapici & İlhan (2016) reports in their research that pre-service elementary teachers are willing to learn new developments involving SSI because they think they are related to daily life problems. Yerdelen et al. (2018) state that pre-service elementary teachers' attitudes towards SSI are generally positive. Their positive attitude towards SSI may also trigger the interest in scientific publications, including these topics. It is observed in this study that pre-service elementary teachers' attitudes towards SSI and scientific knowledge are above average. It is seen that in SSI literature, the interest factor (Sadler & Zeidler, 2004) influences mood. This indicates that cognitive and affective factors also influence individuals' learning of SSI. Therefore, based on the model tested in the study, it can be proposed to include attitude studies to get individuals to acquire SHOMS and develop scientific literacy.



It is seen that the other four hypotheses tested in the study are not accepted ( $H_1$ ,  $H_2$ ,  $H_3$ ,  $H_6$ ). In addition to the study's contributions to the relevant literature, it also has some limitations, as in other studies. First of all, It is the first modeling study that discusses such variables as attitudes towards SSI, SHOMS, and basic literacy skills as a whole. In addition to this, data is collected from a limited sample, and PLS-SEM analysis is used in this related modelling study. The data obtained from the research is valid only for the pre-service elementary school teachers in the sample. Therefore, the relevant study can be done with pre-service science teachers who took the SSI teaching course during their undergraduate education. It is also proposed to study cross-cultural differences by using the same variables. Thus, a contribution to the literature can be made with comparative studies.

## REFERENCES

- Alkış Küçükaydın, M. (2019). Concept teaching in science classrooms: A critical discourse analysis of teachers' talk. *Journal of Education in Science Environment and Health*, 5(2), 209-226.
- Alkış Küçükaydın, M. (2020). Eighth grade students opinions on the socioscientific issue and their argument structure. *Elementary Education Online*, 18(1), 174-174.
- Atabey, N., & Topcu, M. S. (2017). The effects of socio-scientific issues based instruction on middle school students' argumentation quality. *Journal of Education and Practice*, 8(26), 61-71.
- Bingle, W. H., & Gaskell, P. J. (1994). Scientific literacy for decision making and the social construction of scientific knowledge. *Science Education*, 78(2), 185-201.
- Borgerding, L.A., & Dagistan, M. (2018). Pre-service science teachers' concerns and approaches for teaching socio-scientific and controversial issues. *Journal of Science Teacher Education*, 29(4), 283-306.
- Çalik, M., & Coll, R.K. (2012). Investigating socio-scientific 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. DOI: 10.1080/09500693.2012.685197
- Çalik, M., & Karatas, F. Ö. (2019). Does a "science, technology and social change" course improve scientific habits of mind and attitudes towards socio-scientific issues?. *Australian Journal of Teacher Education*, 44(6), 35-52.
- Chen, Y., & So, W. W. M. (2017). An investigation of mainland china high school biology teachers' attitudes toward and ethical reasoning of three controversial bioethics issues. *Asia-Pacific Science Education*, 3(1), 1-16. DOI 10.1186/s41029-016-0012-6
- Coll, R. K., Taylor, N., & Lay, M. C. (2009). Scientists' habits of mind as evidenced by the interaction between their science training and religious beliefs. *International Journal of Science Education*, 31(6), 725-755. DOI: 10.1080/09500690701762621
- Emery, K., Harlow, D., Whitmer, A., & Gaines, S. (2017). Compelling evidence: an influence on middle school students' accounts that may impact decision-making about socio-scientific issues. *Environmental Education Research*, 23(8), 1115-1129. DOI: 10.1080/13504622.2016.1225673
- Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research*, 18, 382-388.
- Gauld, C.F. (2005). Habits of mind, scholarship and decision making in science and religion. *Science & Education*, 14, 291-308. DOI 10.1007/s11191-004-1997-x
- Hair, J.F., Hult, G.T.M., Ringle, C.M., & Sarstedt, M. (2014). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage Publications, Los Angeles.
- Henseler, J., Hubona, G.S., & Ray, P.A. (2016). Using PLS path modeling in new technology research: Updated guidelines. *Industrial Management & Data Systems*, 116, 1-19. DOI: 10.1108/IMDS-09-2015-0382
- Kaiser, H. (1974). An index of factorial simplicity. *Psychometrika*, 39, 6-31.
- Kapıcı, H. O., & İlhan, G. O. (2016). Pre-service teachers' attitudes toward socio-scientific issues and their views about nuclear power plants. *Journal of Baltic Science Education*, 15(5), 642-652.
- Kolomuç, A., & Çalik, M. (2019). A comparison of academic staff's scientific habits of mind regarding socio-scientific issues. *Journal of Higher Education (Turkey)*, 9(1), 67-74.
- Laugksch, R. C., & Spargo, P. E. (1996). Literacy goals. *Science Education*, 80(2), 121-143.
- Lederman, N.G., Antink, A., & Bartos, S. (2014). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: a pathway to developing a scientifically literate citizenry. *Science & Education*, 23, 285-302. DOI: 10.1007/s11191-012-9503-3
- Lee, H., Chang, H., Choi, K., Kim, S.-W., & Zeidler, D.L. (2012). Developing character and values for global citizens: Analysis of pre-service science teachers' moral reasoning on socio-scientific issues. *International Journal of Science Education*, 34(6), 925-953. DOI: 10.1080/09500693.2011.625505
- Lee, H., Abd-El-Khalick, F., & Choi, K. (2006). Korean science teachers' perceptions of the introduction of socio-scientific issues into the science curriculum. *Canadian Journal of Science Mathematics and Technology Education*, 6(2), 97-117.
- Lewis, J., & Leach, J. (2006). Discussion of socio-scientific issues: the role of science knowledge. *International Journal of Science Education*, 28(11), 1267-1287. DOI: 10.1080/09500690500439348
- Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education*, 87(2), 224-240.
- Reid, N. (2006). Thoughts on attitude measurement. *Research in Science and Technological Education*, 24 (1), 3-27. DOI: 10.1080/02635140500485332
- Ritchie, S.M., Tomas, L., & Tones, M. (2011). Writing stories to enhance scientific literacy. *International Journal of Science Education*, 33(5), 685-707. DOI: 10.1080/09500691003728039
- Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729-780). Mahwah, NJ: Lawrence Erlbaum.
- Sadler, T. D. (2004). Informal reasoning regarding socio-scientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41(5), 513-536. DOI: 10.1002/tea.20009
- Sadler, T. D., & Zeidler, D. L. (2004). The morality of SSI: Construal and resolution of genetic engineering dilemmas. *Science Education*, 88, 4-27. DOI: 10.1002/sci.10101
- Sadler, T. D., Barab, S. A., & Scott, B. (2007). What do students gain by engaging in socio-scientific inquiry?. *Research in Science Education*, 37(4), 371-391. DOI: 10.1007/s11165-006-9030-9
- Şahin, F., & Ateş, S. (2020). Examination of the relationship between seventh-grade students' scientific literacy among certain cognitive variables. *Education and Science*, 45(203), 63-89. DOI: 10.15390/EB.2020.8552
- Sarstedt, M., Ringle, C.M., & Hair, J.F. (2017). Partial least squares structural equation modeling. In C. Homburg, M. Klarmann, & A. Vomberg (Eds.) *Handbook of market research* (p.1-40). Heidelberg, Springer.
- Saunders, K. J., & Rennie, L. J. (2013). A pedagogical model for ethical inquiry into socio-scientific issues in science. *Research in Science Education*, 43(1), 253-274. DOI: 10.1007/s11165-011-9248-z
- Tabachnick, B.G., & Fidell, L.S. (2013). *Using multivariate statistics* (6 th edn). Boston: Person Education.
- Tidemand, S., & Nielsen, J. A. (2017). The role of socio-scientific issues in biology teaching: From the perspective of teachers. *International*

- Journal of Science Education*, 39(1), 44-61. DOI: 10.1080/09500693.2016.1264644
- Topcu, M. S. (2010). Development of attitudes towards socio-scientific issues scale for undergraduate students. *Evaluation & Research in Education*, 23(1), 51-67. DOI: 10.1080/09500791003628187
- Topcu, M. S., Sadler, T. D., & Yilmaz-Tuzun, O. (2010). Pre-service science teachers' informal reasoning about socio-scientific issues: the influence of issue context. *International Journal of Science Education*, 32(18), 2475-2495. DOI: 10.1080/09500690903524779
- Topcu, M. S., Yilmaz-Tuzun, Ö., & Sadler, T. D. (2011). Turkish pre-service science teachers' informal reasoning regarding socio-scientific issues and the factors influencing the informal reasoning. *Journal of Science Teacher Education*, 22(4), 313-332. DOI: 10.1080/09500690903524779
- Turgut, H. (2005). *The effect of constructivist design practice on the development of "nature of science" and "science-technology-society relationship" aspects of science literacy competencies of science teacher candidates*. Unpublished Doctoral Dissertation. Yildiz Technical University, Istanbul.
- Wong, K. K. K. (2013). Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Marketing Bulletin*, 24(1), 1-32.
- Xiao, S., & Sandoval, W. A. (2017). Associations between attitudes towards science and children's evaluation of information about socio-scientific issues. *Science & Education*, 26(3-4), 247-269. DOI: 10.1007/s11191-017-9888-0
- Yacoubian, H. A., & Khishfe, R. (2018). Argumentation, critical thinking, nature of science and socio-scientific issues: a dialogue between two researchers. *International Journal of Science Education*, 40(7), 796-807. DOI: 10.1080/09500693.2018.1449986
- Yacoubian, H.A. (2018). Scientific literacy for democratic decision-making. *International Journal of Science Education*, 40(3), 308-327. DOI: 10.1080/09500693.2017.1420266
- Yahaya, J. M., Zain, A. M. N., & Karpudewan, M. (2012). Understanding socio-scientific issues in a low literate society for the achievement of the millennium development goals. *World Academy of Science, Engineering and Technology*, 72, 123-126.
- Yerdelen, S., Cansiz, M., Cansiz, N., & Akcay, H. (2018). Promoting pre-service teachers' attitudes toward socio-scientific issues. *Journal of Education in Science, Environment and Health*, 4(1), 1- 11. DOI:10.21891/jeseh.387465
- Zeidler, D. (2014). Socio-scientific issues as a curriculum emphasis: Theory, research and practice .In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 697-726). New York, NY: Routledge, Taylor and Francis.
- Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: a research-based framework for socio-scientific issues education. *Science Education*, 89(3), 357-377. DOI: 10.1002/sce.2004