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Elementary Teacher Candidates' Opinions about Science and Scientific Research*

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Abstract

The concept of nature of science, which deals with the structure of science and scientific research methods, has a very important place in science education. However, teachers, teacher candidates, and students have various scientific myths. In this study, elementary teacher candidates' views of nature of science were examined. This non-experimental quantitative study was designed by using a survey method with participation of 119 (63 female and 56 male) elementary teacher candidates. Student Understanding of Science and Scientific Inquiry (SUSSI) was used to determine elementary teacher candidates' views of nature of science. The survey consists of 24 items with six factors. For data analysis, descriptive and inferential statistics were performed. Results show that the teacher candidates had mostly transitional/mixed or less informed views related to the objectivity of scientists, variation in their observations, scientific laws as proven theories, social and cultural effects on science, and creativity and imagination. On the other hand, they had scientifically sufficient knowledge regarding that there is not a single scientific way in the formation of scientific knowledge and that experiments are not the only way to produce scientific knowledge. In addition, no significant gender difference was observed in terms of teacher candidates' opinions related to nature of science.

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INTRODUCTION

The main purpose of science education is to teach science concepts, the nature of science, and how to make science relevant, which results in individuals to be raised as science-literate (MEB, 2005; Uluçınar Sağır & Kılıç, 2013). With the effective use of scientific processes in learning environments, students attempt to make sense of the world through research starting from the first years in school and they experience scientific process directly (MEB; 2018). In this respect, one of the most important criteria for raising science literate individuals is to know the nature and functions of science (Lederman, 1992; Bayır, Çakıcı & Ertaş Atalay, 2016). McComas, Clough and Almazroa (2002) define the nature of science as a comprehensive field that includes what science is, the way scientists research, and their perspective towards research. In another definition, it is considered as the expression of values and beliefs in the structure of scientific knowledge, which takes into account the sociological and epistemological aspects of science (Lederman, 1992; Özden & Cavlazoğlu, 2015). Realization of the exact information related to the nature of science also provides a basis for the accurate understanding of science (Han & Bilican, 2018).

The nature of science as a concept is seen as the common intersection of four different fields including philosophy, history, psychology, and sociology, and it deals with what science is, how scientists act, and how societies react to science (McComas, Clough & Almazroa, 2002; Karaman & Apaydın, 2014). There exist properties of nature of science including the fact that scientific knowledge has changeable properties, it is subjective, scientific knowledge depends on social and cultural elements, it is a product of imagination and creativity, and scientific theory and laws form different types of scientific knowledge and they have different roles in science (Altındağ, Tunç Şahin & Saka, 2012; Karaman & Apaydın, 2014). In science education, it is observed that teachers and students have insufficient knowledge about nature of science, especially in subjects such as theory, law, and scientific knowledge (Tatar, Karakuyu & Tuysuz, 2011). Indeed, one of the biggest obstacles to the sound understanding of nature of science is non-scientific information expressed as scientific myths (Eyceyurt Türk & Tüzün, 2017). Statements such as theories are transformed into law, there is only one universal scientific method, the real way of reaching information is the experiment, hypotheses are carried out by competent people, science and scientific method provide definite proof, scientific models represent reality, and science and technology are the same things are considered as scientific myths (Peşman, Arı & Baykara, 2017; Eyceyurt Türk & Tuzun, 2017).

Bağcı Kılıç (2003) examined TIMMS-1999 results and concluded that countries ranked in the first five among other countries were also successful in terms of overall TIMMS-1999 scores. This result is critical to understand the nature of science. When the literature is examined, it is seen that the studies were generally carried out with teachers, teacher candidates or students at various levels in the field of science (Aslan, Yalçın & Taşar, 2009; Bayır, Çakıcı & Ertaş Atalay, 2016; Seyis Uğurlu, 2019). Also, some of the studies in the literature were related to teaching the nature of science (Çokadar & Demirtel, 2012; Önen, 2013; Han & Bilican, 2018) or existing textbooks, curriculums or undergraduate programs related to the nature of science (Abd-El-Khalick, Waters & Le, 2008; Erduran & Dagher, 2014; Özden & Cavlazoğlu, 2015). Specifically, there exist fewer studies on elementary teachers or elementary teacher candidates in the literature (Tatar, Karakuyu & Tuysuz, 2011; Sarac & Capellaro, 2015).

Purpose of the study

The aim of this study is to determine elementary pre-service teachers' opinions about the nature of science. In this context, the following research question was addressed.

1. What are the elementary teacher candidates' views of the nature of science?

METHOD

This non-experimental quantitative study was designed in accordance with survey design (Johnson 2001; Johnson & Onwuegbuzie, 2004). Survey design is a research approach based on collecting data in a certain period of time, aiming to describe a situation in the past or present as it exists and to compare the relationship between the variables (Karasar, 2000).

Participants

The participants of this study was conducted on junior and senior students of Department of Elementary Education, Faculty of Education, with 119 samples (63 female and 56 male).

Data Collection Tool

In order to determine elementary teacher candidates' opinions of the nature of science, Student Understanding of Science and Scientific Inquiry (SUSSI) survey developed by Liang, Chen, Chen, Kaya, Adams, Macklin, and Ebenezer (2008). The survey was translated and adopted into Turkish by Kaya and has 24 items with six factors: observations and inferences, nature of scientific theories, theories against scientific laws, social and cultural effects on science, creativity and imagination in scientific research, and scientific research. The five-point Likert type questionnaire has a reliability coefficient value of .72. In addition to the questionnaire, a form with five questions was used to identify demographic information of the participants.

Data Analysis

Descriptive statistics, mean value and standard deviation, were used to identify the teacher candidates' views of nature of science. The following guide was used to interpret the mean values of each item in the SUSSI: Naive (1-1.80), Poor (1.81-2.60), Transitional or Mixed (2.61-3.40), Less Informed (3.41-4.20), Informed (4.21-5.00). An independent samples t-test was conducted to determine whether there is a difference between teacher candidates' opinions of nature of science in terms of gender.

FINDINGS

Table 1 shows the results about the first aspect of nature of science, observations and inferences. According to the findings, while the participants held transitional or mixed views for the item B and C, they generally had less informed views on the item A and D.

Table 1. Results related to the aspect of observations and inferences

1. Observations and Inferences	Mean	SD
A. Scientists may have different observations about the same event because their prior knowledge may affect their observations.	4.08	0.96
B. Scientists should have the same observations about the same event since they are objective people.	3.08	1.36
C. Scientists should have the same observations about the same event since observations reflect the facts.	3.11	1.22
D. Scientists may have different interpretations about the same event.	3.97	0.96

Table 2 provides average scores for the second aspect of nature of science the nature of scientific theories. The participants generally had less informed views on the item A and C, and held informed view on the item B. However, for the item D they had transitional or mixed view.

Table 2. Results related to the aspect of nature of scientific theories

2. Nature of scientific theories	Mean	SD
A. Scientific theories are subject to constant adjustments and testing.	4.07	0.81
B. Scientific theories may be completely changed by new theories in the light of new evidence.	4.31	0.69
C. Scientific theories may change since scientists always reinterpret existing observations.	4.06	0.92
D. Scientific theories developed based on accurate experiments do not change.	3.34	1.18

For the aspect of theories against scientific laws, the results are provided in Table 3. According to the findings, while the participants had transitional/mixed or partial view for the item B, they held less informed views on the item A and D. On the other hand, they had naïve views on the item C.

Table 3. Results related to the aspect of theories against scientific laws

3.	Theories against scientific laws	Mean	SD
A.	Scientific theories exist in the natural world (they are hidden in nature) and are uncovered as a result of scientific research.	4.20	0.77
B.	Unlike theories, scientific laws are not open to change.	3.05	1.19
C.	Scientific laws are proven theories.	1.79	0.64
D.	Scientific theories explain scientific laws.	3.45	1.04

The results related to the aspect of social and cultural effects on science are provided in Table 4. Overall, the participants had transitional/mixed or partial views for all items under this aspect.

Table 4. Results related to the aspect of social and cultural effects on science

4.	Social and cultural effects on science	Mean	SD
A.	Scientific research is not affected by social and cultural values since scientists are trained to conduct original and unbiased studies.	2.83	1.22
B.	Cultural values and expectations determine which science will be conducted and accepted.	3.04	1.17
C.	Cultural values and expectations determine how science is made and accepted.	2.91	1.22
D.	All cultures carry out scientific research in the same way since science is universal and independent of society and culture.	3.01	1.38

Table 5 provides results related to the aspect of creativity and imagination in scientific research. The participants held less informed views on the items A, B, and C. On the other hand, they had transitional/mixed views on the item D.

Table 5. Results related to the aspect of creativity and imagination in scientific research

5. Creativity and imagination in scientific research	Mean	SD
A. Scientists employ their creativity and imagination when they collect data.	3.55	1.10
B. Scientists employ their creativity and imagination when they analyze data and interpret findings.	3.45	1.01
C. Scientists do not employ their creativity and imagination since creativity and imagination contradict with logical reasoning.	3.70	1.13
D. Scientists do not employ their creativity and imagination since they prevent being objective.	3.39	1.34

The results related to the aspect of scientific research are provided in Table 6. According to the results, while the participants had informed view on the item A and less informed view on the item D. On the other hand, for the item B and C, they held transitional or partial views.

Table 6. Results related to the aspect of scientific research

6. Scientific research	Mean	SD
A. Scientists use a variety of methods to produce successful results.	4.49	0.66
B. Scientists follow the same scientific method step by step.	2.70	1.23
C. When scientists use the scientific method correctly, their results are accurate and precise.	2.82	1.08
D. Experiments are not the only way to develop scientific knowledge.	3.93	1.00

Overall, out of 24 items in the SUSSI, the participants had transitional/mixed views on 11 items and less informed views on 10 items. In addition, they had informed views on 2 items and naïve views on only the following item: "Scientific laws are proven theories."

In order to identify any differences in the participants' opinions about the nature of science in terms of gender, an independent samples t test was performed. The test results are provided in Table 7. According to the findings, no significant difference was observed in terms of gender.

Table 7. Independent samples t test results related to gender differences

Factors	Gender	N	X	SS	t(117)	p	η2
1. Observations and inferences	Male	56	13.85	3.64	.997	.321	0.0008
	Female	63	14.47	3.06			
2. Nature of scientific theories	Male	56	15.37	2.61	1.481	.141	0.0001
	Female	63	16.03	2.16			
3. Theories against scientific laws	Male	56	10.16	1.93	.103	.918	0.007
	Female	63	10.12	1.60			
4. Social and cultural effects on science	Male	56	12.05	3.73	.812	.419	0.001
	Female	63	11.53	3.08			
5. Creativity and imagination in scientific research	Male	56	14.48	3.51	1.243	.217	0.0004
	Female	63	13.76	2.69			
6. Scientific research	Male	56	13.71	2.55	1.039	.302	0.0007
	Female	63	14.12	1.61			

DISCUSSION & CONCLUSION

In this study, elementary teacher candidates' opinions about the nature of science were investigated. According to the results, it was found that teacher candidates had partial understandings in terms of observations and inferences. In contrast, Yenice, Özden and Balcı (2015) found that 83.4% of their teacher candidate participants had sufficient knowledge in terms of scientists' observations. In this study, also, teacher candidates had transitional or mixed views about the item "Scientific theories developed based on accurate experiments do not change" and the items related to the relation between scientific laws and scientific theories. In their study related to the nature of science, Tatar, Karakuyu and Tüysüz (2011) found that some elementary teacher candidates described scientific theory, scientific law, and hypothesis as hierarchical structure and law as unchangeable. In another study, majority of elementary teacher candidates was found to have insufficient knowledge about the relationships among scientific theory, scientific law, and hypothesis (Yenice, Özden & Balcı, 2015). Similar results were found in the other studies (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002; Abd-El-Khalick & Akerson, 2004; Saraç & Capellaro, 2015; Aydemir, Kazanç & Karakaya Cirit, 2016). Their results reveal that teachers and teacher candidates have traditional perspective about the nature of science (McComas, 2000; Yenice, Özden & Balcı, 2015). In addition, Yenice, Özden and Balcı (2015) revealed that 34.9% of the elementary teacher candidates who participated in their study believed that social and cultural values have an effect on science.

The teacher candidates held less informed views on the first three items in the creativity and imagination in scientific research factor. However, for the item "scientists do not use their creativity and imagination since they prevent objectivity", they had transitional or mixed view. This finding may be interpreted that the participants may have stereotypes that scientists are objective. In another study, researchers stated that 76.19% of science teachers and 57.89% of pre-service teachers expressed partially at the scientific level regarding the imagination and creativity in science (Aydemir, Kazanç & Karakaya Cirit, 2016).

In the last factor of the questionnaire, the participants had less informed and informed views for the items "Scientists use a variety of methods to produce successful results" and "Experiments are not the only way to develop scientific knowledge.", respectively. The results showed that teacher candidates' opinions for both items were compatible with the characteristics of the nature of science and their knowledge was scientifically sufficient. On the other hand, in another study, Ecevit, Yalaki and Kingir (2018) stated that only 33% of elementary school teacher candidates believed that scientific knowledge is experimental. Aydemir, Kazanç and Karakaya Cirit (2016) also found that 66.67% of science teachers and 78.95% of teacher candidates had a scientific perception that scientific knowledge is experimental based. In addition, the remaining items "Scientists follow the same scientific method step by step" and "When scientists use the scientific method correctly, their results are accurate and precise", revealed participants' transitional or mixed view. It may be interpreted that teacher candidates are a little bit further away from stereotyped scientific myths about the nature of scientific research. In their study, Palmquist and Finle (1997) stated that teacher candidates were traditional in scientific theory, the role of the scientist, and the scientific method. When the independent samples t test results related to the views of nature of science were examined in terms of gender variable, there was no significant difference between the groups in terms of sub-dimensions. Similarly, the results of the different studies conducted by Kubilay (2014) and Gül and Erkol (2016) with prospective teachers showed that there was no difference between the views on the nature of science in terms of gender variable.

The inadequacies in teachers' knowledge about the nature of science negatively affect students' learning related to the nature of science (Lederman, 1992). More specifically, science related courses in teacher education programs and the way in which the nature of science is included in the curriculum and textbooks are among the reasons for the insufficient views of teachers and students on the nature of science (Abd-El-Khalick, Waters & Le, 2008). In this respect, it is important for teachers to have science-related competencies in order for their students to learn the nature of science (İnce & Özgelen, 2017). On the other hand, teacher candidates' insufficient knowledge in the nature of science and misconceptions may be formed in their early education and those misconceptions have effects on shaping their opinions about the nature of science (Ecevit, Yalaki & Kingir, 2018). More specifically, teachers and teacher candidates' knowledge about the nature of science has critical importance in teaching science-related concepts (Dorsah, 2020). While Murcia and Schibeci (1999) stated that elementary teacher candidates' understanding of the nature of science contributes greatly to science education, Lederman and colleagues (2001) stated that teacher candidates who do not internalize the importance of the nature of science do not teach in accordance with the nature of science. Students also reported that they did not have scientific myths, and these myths were taught by their teachers (McComas, 1996). In his study with elementary teacher candidates, Kıran (2019) attributed that sophomores in undergraduate education has the lowest level of knowledge about the nature of science and the reason for this is that there are no courses related to the nature of science at this grade level.

Along with the results of this study, the scientific insufficiencies such as transitional or mixed views in some of the sub-dimensions of the questionnaire may be because teacher candidates do not learn enough about the nature of science in their undergraduate education, which may be considered as an insufficiency in undergraduate programs. Also, this situation continues throughout their professional lives. In this respect, increasing the intensity of the nature of science in theoretical and practical courses in elementary education undergraduate programs at every grade level and providing connections to the nature of science in other courses are recommended to increase teacher candidates' understandings about the nature of science.

Suggestions

1. Future studies should consider using different data collection tools with different research models in order to determine teacher candidates' knowledge about the nature of science.
2. Future studies should be conducted with teachers as well as students in order to find out insufficiencies in their knowledge about nature of science and possible reasons for these insufficiencies.
3. Future studies should consider evaluation of elementary teacher education programs in terms of the nature of science.
4. For practice, elementary teacher candidates must participate in activities to advance their knowledge about the nature of science in order to overcome their shortcomings in science.

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