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Beliefs of preschool teacher candidates about the nature of science

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ABSTRACT

The aim of science education is to enable children to become “science-literate.” Science literacy is defined as taking responsibility for and making decisions about situations requiring scientific understanding and having sufficient knowledge, skills, attitudes and understanding of values to put their decisions into practice. Revealing teachers’ beliefs can help to understand the types of experiences presented by teachers in their classrooms. Inadequate understandings and misbeliefs of teachers shape the first perceptions of children about the NOS when they are formally introduced with science education in their early childhood. Most of the studies were also performed with science teachers and there have been few studies conducted with preschool teachers. Therefore, the present study was directed towards determining NOS beliefs of preschool teacher candidates. To achieve this aim, Nature of Science Beliefs Scale (NOSBS), developed by Özcan and Turgut (2014), was administered to the preschool teacher candidates studying in Preschool Education Department of Buca Education Faculty at Dokuz Eylül University in the spring semester of the 2018-2019 academic year. In the study, the NOS beliefs of the teacher candidates were found to be acceptable in general. While the findings of this study are consistent with those revealed in several relevant studies in the literature.

Keywords: Nature of science, beliefs, teacher candidates, early childhood.

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INTRODUCTION

The aim of science education is to enable children to become “science-literate.” Science literacy is defined as taking responsibility for and making decisions about situations requiring scientific understanding and having sufficient knowledge, skills, attitudes and understanding of values to put their decisions into practice. Three fundamentals of science can be scientific knowledge (scientific laws and theories), scientific process skills and the nature of science (features of scientific knowledge).

One of the most important dimensions of science and technology literacy is understanding the nature of science (NOS) (Bjønness and Knain, 2018).

There is an ongoing debate about what the NOS is. There are characteristics of scientific knowledge acquired in each stage of education especially from early childhood to university and agreed on by science educators. Lederman (1992) stated that the NOS is “values and hypotheses inherent to the development of scientific knowledge”. The NOS can be simply defined as what science is, how it functions, how scientific knowledge is created, how a scientific community comprised of scientists is organized, how the society influences science and how the society is affected by scientific developments (İrez, 2016). Among other fundamentals of the NOS are values and beliefs. In addition, the NOS is related to sociology and epistemology of science and scientific methods. McComas et al. (1998) defined the NOS as an intersection of different disciplines (history, sociology, psychology and philosophy of science).

Efforts to give an insight into the NOS started in early 1900s (Lederman, 1992) when understanding the NOS was regarded as understanding scientific processes and methods. At present, the NOS is not interpreted from the general positivist notion. It is explicated by using a postmodern approach in reference to the perspectives of philosophers like Kuhn and Hanson and the relativistic structure of science. According to this approach, science is a subjective human attempt based on theory and culture, though it also depends on experimental observations (Schwartz, 2004).

Advances in various scientific fields have enhanced the conceptualization of the NOS (Abd-El-Khalick and Lederman, 2000). The structure of Scientific Revolutions by Kuhn (1962) has created an important effect on the contemporary understanding of the nature of science. Prior to Kuhn's work, the work of logical empiricists was effective in the philosophy of science (Giere, 1988). In accordance with this view, justifications of scientific arguments were made by following several stages. Philosophers did not show interest in the description of how science operates. Universal facts were sought with the aid of logic, observations, and mathematical applications (Edmondson and Novak, 1993). This objectivist conceptualization made a great impact on education in the early twentieth century. In fact, knowing "the scientific method" was regarded as knowing the NOS (Abd-El-Khalick and Lederman, 2000).

At present, scientific knowledge is obtained through a construction relying on prior knowledge which constantly change and depends on human experiences (Kuhn, 1962). While there is not a general agreement about conceptualization of the NOS, in general it means "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Lederman, 1992). It has been underlined in the literature that students should become aware that scientific knowledge is characterized by tentativeness and subjectivity, empiricism (dependence on observation of the natural world), acquisition through inference, imagination, and creativity, sociocultural embeddedness and understanding of observation and inference. They are also expected to figure out the connection between scientific theories and laws. When they have misconceptions about the NOS, how they learn and perceive science and what further classes they choose are negatively affected (Clough, 2000).

According to The National Science Teachers Association (2020) science classes should only concentrate on science combined with scientific methods, explanations, and generalizations to the exclusion of nonscientific or pseudoscientific methods, explanations, generalizations, and products.

Teachers and students should keep in mind that: (1) scientific knowledge is not only dependable but also changeable; (2) there is not a single method of science, but scientific approaches to science have features in common like scientific explanations being based on empirical evidence; (3) creativity plays part in creation of scientific knowledge; (4) a connection exists between theories and laws; (5) a connection exists between observations and inferences; (6) while the goal of science is objectivity, subjectivity in creation of scientific knowledge is inevitable; and (7) sociocultural factors are involved in creation of scientific knowledge.

Forming an appropriate basis to develop understanding of the NOS in young children can help them to conceptualize the NOS and other aspects of science (Akerson et al., 2011). Therefore, one of the most important goals of science education starting in earlier ages of children is to enable them to understand scientific phenomena and scientific explanations made to understand them, characteristics of these explanations and how they are formulated and the NOS, that is, values and hypotheses inherent to the essence of science (Erdas-Kartal and Ada, 2018)

Misconceptions on the NOS are frequently encountered in the relevant literature (Kampourakis, 2016; Lederman, 1992; Thye and Kwen, 2004). To exemplify, conceptionally the NOS is considered similar to the scientific method and different from the nature of scientific knowledge (Abd-El-Khalick and Lederman, 2000). Akerson et al. (2008) emphasized that teachers associate the NOS with some concepts related to the nature instead of associating the NOS with the essence of science.

Revealing teachers' beliefs can help to understand the types of experiences presented by teachers in their classrooms. It is stated by Pajares (1992) in a review about teachers' beliefs and in educational research that beliefs as "personal constructs" have an impact on individuals' behavior and help individuals to describe and comprehend the world.

Research on science education reveals that scientific epistemological beliefs of teachers can affect science education in several ways and therefore underlines the need for examining these beliefs (Chan, 2004; Hashweh, 1996; Luft and Roehrig, 2007). Hashweh (1996) reported that teachers with improved epistemological beliefs are likely to support acquisition of scientific concepts in students by taking account of the fact that scientific knowledge is not composed of a single truth but can evolve with the introduction of different theories over time.

It is assumed that teachers' understanding of the NOS and practices in classes affect students' views about the NOS (Mellado, 1998). Teachers with an understanding of the NOS at a favorable level can display this understanding in the classroom atmosphere and play an essential role in students' acquisition of scientific literacy (Tuan and Chin, 1999). As scientific literacy is very important in science education, a great number of studies have focused on: (a) students' conceptions of the NOS; (b) teachers' conceptions of the NOS; (c) curricula and interventions directed towards enhancing students' and teachers' conceptions of the NOS; and (d) the connection between teachers' conceptions, classroom activities, and students' conceptions (Lederman, 1992).

Studies on teachers' NOS beliefs show that science teachers mostly maintain a positivist ideology (Bryan, 2012; Lederman and Lederman, 2014). They disregard theory-based observations, perform scientific inquiries by using a rigid algorithmic method, are unsure about the status of scientific knowledge and may ignore the socio-cultural embeddedness and the role of creativity and imagination in science (Hodson, 2009). Studies conducted with teachers and teacher candidates showed that they have an insufficient understanding of the NOS, either (Abd-El-Khalick and Boujaoude, 1997; Dogan and Abd-El-Khalick, 2008; Haidar, 1999; Murcia and Schibeci, 1999; Rubba and Harkness, 1993; Tasar, 2006; Yakmacı, 1998).

Several studies on the NOS point out that primary school (Çelikdemir, 2006; Kang et al., 2005), secondary school (Demir and Akarsu, 2013) and high school (Bell et al., 2003; Moss et al., 2001) students have inadequate understandings and various misconceptions of the NOS. Therefore, the NOS should be taught in childhood to prevent the misconceptions and to establish the basis for learning in later years of life. In recent years, great importance has been placed on teachers' and students' understandings of science and many studies about science education have focused on their understandings and beliefs about the NOS.

Considering that teachers have the role of introducing scientific knowledge to children, it seems that teachers' NOS beliefs can affect students' perceptions about science. So that students become individuals understanding science and the NOS, teachers' understandings of science and the NOS should be improved. It has been revealed that teachers and teacher candidates do not have adequate understandings of the NOS. Inadequate understandings and misbeliefs of teachers shape the first perceptions of children about the NOS when they are formally introduced with science education in their early childhood. Most of the studies were also performed with science teachers and there have been few studies conducted with preschool teachers. Therefore, the present study was directed towards determining NOS beliefs of preschool teacher candidates. To achieve this aim, Nature of Science Beliefs Scale (NOSBS), developed by Özcan and Turgut (2014), was administered to the preschool teacher candidates studying in Preschool Education Department of Buca Education Faculty at Dokuz Eylül University in the spring semester of the 2018-2019 academic year.

Problem

What are the NOS beliefs of preschool teacher candidates?

Sub-problems

1. What are the levels of NOS beliefs in preschool teacher candidates?
2. Do NOS beliefs of preschool teacher candidates differ between genders?
3. Do NOS beliefs of preschool teacher candidates differ between the years of study?
4. Do NOS beliefs of preschool teacher candidates differ between their majors at high school?

METHODOLOGY

Research model

In this study, a descriptive survey model was utilized. Survey models are directed towards describing an ongoing or prior situation as it is (Karasar, 2002).

Study sample

The study population comprised of all the teacher candidates studying in the Department of Preschool Education in the Faculty of Education, Dokuz Eylül University, in the 2018-2019 academic year.

The sample included 252 preschool teacher candidates volunteering to participate in the study and responding to the items in the data collection tool completely and accurately. Table 1 presents information about the study sample.

Table 1. Study sample.

Gender	Grade	Major at High School
Female: 215	First-year: 52	Social: 30
Male: 37	Second-year: 52	Science: 28
	Third-year: 50	Turkish + Math: 186
	Fourth-year: 98	Other: 8

Instruments

Nature of Science Beliefs Scale (NOSBS), developed by Özcan and Turgut in 2014, was used to determine the NOS beliefs of the preschool teacher candidates. A personal characteristics form created by the researcher was utilized to collect data about demographic features of the participants.

NOSBS is composed of 37 items and seven subscales. It is a five-point Likert scale which allows measuring the extent of agreement on the items based on the choices "completely disagree", "disagree", "cannot decide", "agree" and "totally agree". Seven subscales were as follows:

Subscale 1 - Tentativeness: Scientific knowledge is not static, complete or absolute (Abd-El Khalick, 2001). It can be considered as reliable and long-standing; however, it may not have absolute accuracy or unequivocalness. It can change thanks to collection of new data, interpretation of available data and several advantages offered by technological developments (AAAS, 1993).

Items of this subscale can be exemplified as in the following (Özcan and Turgut, 2014):

- Scientific knowledge is improved only if technology develops.
- If a piece of knowledge is scientific, it has been definitely proven and no longer changes.
- If a conclusion is drawn based on scientific experiments, it is absolutely true.

Subscale 2 - Observation and inference: Science is based on both observations and inferences drawn from these observations. While observations provide data obtained through senses or various tools, inferences allow explaining and interpreting observed situations based on the obtained data (Lederman et al., 2002).

The items of this subscale can be exemplified as in the following (Özcan and Turgut, 2014):

- A student who says “The object I released dropped” expresses an observation he/she made.
- A student who says the object he/she released “dropped due to gravity” expresses an observation he/she made.
- When a student discovering the compression and expansion of gases says “a gas is porous”, he/she expresses his/her observation.

Subscale 3 - Scientific method/methods: There is not a method compatible with the complex nature of science (Abd-El-Khalick, 2001) or a single, universal method scientists follow step by step during their research (AAAS, 1990; McComas, 1998). Different methods and methodologies are used in different fields of science and they may change over time (Chalmers, 1999).

To exemplify the items of this scale:

- To obtain accurate results in scientific studies, the steps determination of the problem, collection of data, formulation of hypotheses and doing experiments should be followed.
- Different methods are used in different fields of science.
- There is one single method, the steps of which are followed by scientists.

Subscale 4 - Creativity and imagination: Scientific products are directed towards reflecting a reality they are concerned with by using creativity and imagination in addition to observations, experiments and inferences rather than completely and appropriately representing the reality (Lederman et al., 2002). Creating and improving scientific knowledge involves creativity and imagination as well as observation of the nature, and creativity plays a crucial role in science (Abd-el Khalick, 2001).

To exemplify the items (Özcan and Turgut, 2014):

- Scientists use their creativity and imagination only when they design their experiments.
- Different scientists reach the same conclusions if they have the same data.
- Scientists use their creativity and imagination while they draw conclusions based on the data they obtain.

Subscale 5 - Socio-cultural embeddedness: The factors including scientists’ commitment to theories and their field of study, beliefs, priori knowledge, education, experiences, expectations, nationalities, genders and ages shape the studies they conduct (AAAS, 1990; McComas, 1998; Lederman, 1998; Chalmers, 1999). Therefore, scientists are affected by the society and culture in which they grow up, the discipline they are interested in and understandings they have acquired through their education and transmit these effects to their scientific activities (Özcan and Turgut, 2014).

To exemplify the items of this subscale:

- To be successful, scientists do not have prejudices and work independently of religious, cultural and philosophical values.
- Scientific studies are affected by cultures and value judgements of the societies.
- Personal opinions and emotions have no effect on conclusions scientists reach in their studies.

Subscale 6 - Theories and laws: Theories and laws are different kinds of knowledge (McComas, 1998). Theories are the tools used to explain and define phenomena and foresee things about them and are generally based on some assumptions and unobservable entities. Therefore, they cannot be directly tested, but they maintain their validity thanks to evidence collected indirectly; Scientists derive testable predictions from theories and test them. Laws are descriptive expressions of the observable relations between natural beings and events (Palmquist and Finley, 1997; Brown et al., 2006). Theories and laws do not evolve into each other.

To exemplify the items (Özcan and Turgut, 2014):

- Scientific theories are explanations based to certain hypotheses about directly unobservable entities.
- After proven and accepted by the scientific communities, scientific theories change into scientific laws.
- Scientific laws are definitely proven scientific assumptions.

Subscale 7 - Assumptions and boundaries: Science is not an activity whose boundaries and assumptions are indisputably determined in terms of its scope and method/methods and in some situations its boundaries are uncertain and complex. Therefore, to understand how science is the action or type of knowing and to have an idea about it, both epistemologically and ontologically, scientific hypotheses and assumptions on which science is built should be closely examined (Özcan and Turgut, 2014).

To exemplify the items of the subscale:

- Scientific explanations only involve natural factors, but never include supernatural powers (e.g. God and angels).
- Science can answer all questions which may come to your mind.
- The subject of science is directly observable events only.

The subscales of NOSBS and Cronbach' alpha for each subscale reported by Özcan and Turgut (2014) are presented in Table 2.

Table 2. Cronbach's alpha for NOSBS and its subscales reported by Özcan and Turgut (2014).

Sub scale	Alpha value
1. Tentativeness	0.803
2. Observation and Inference	0.704
3. Scientific Method/Methods	0.829
4. Creativity and Imagination	0.705
5. Assumptions and Boundaries	0.764
6. Socio-cultural Embeddedness	0.732
7. Theories and Laws	0.702
Total	0.783

Data analysis

Data from the participants who did not fulfill data collection tools completely or accurately were not included into the analysis. Obtained data were analyzed with Statistical Package Program for Social Sciences 22.0. Descriptive data were presented by using mean, standard deviation and minimum and maximum scores. Shaphiro-Wilk test and skewness and kurtosis were used to determine the normality of data and the results of these did not show a normal distribution of the data. Therefore, Mann-Whitney U test and Kruskal Wallis test were utilized to compare the groups. Scheffe test was employed to determine which group caused the difference. The statistical significance was set at 0.05 for the results of all the tests performed.

RESULTS

Results about the first subproblem

The first subproblem of the study was what the levels of NOS beliefs in teacher candidates are. The mean values, standard deviations and minimum and maximum scores for the responses to scale items given by the teacher candidates are shown in Table 3.

As presented in Table 3, the preschool teacher candidates had the mean scores of over three for NOSBS and many subscales (M: 3.35). The preschool teacher candidates had acceptable NOS beliefs. However, the mean scores for theories and laws (2.98) and socio-cultural embeddedness (2.87) were slightly low.

Results about the second subproblem

The second subproblem of the study was whether NOS beliefs of the preschool teacher candidates differ between genders. The results of the analysis with Mann-Whitney U test to determine the difference between genders are given in Table 4.

The female teacher candidates had the mean score of 125.42 and the male teacher candidates had the mean score of 132.77 for NOSBS without a significant difference (p>0.05). This shows that the female and male teacher candidates had similar NOS beliefs.

Concerning the subscales, there was a significant difference in socio-cultural embeddedness (z = 2.388; p = 0.017*) and method/methods (z = 1.989; p = .047*) in favor of the male candidates. However, there was no significant difference in theories and laws (z = -.669; p = .503), observation and inference (z = -1.182; p = .237), creativity and imagination (z = 1.254; p = .210), assumptions and boundaries (z = -.859; p = .391) and tentativeness (z = -1.559; p = .119) between genders.

Results about the third subproblem

The third subproblem of the study was whether NOS beliefs of the preschool teacher candidates differ between the years of study. The results of the analysis with Kruskal Wallis test to determine the differences between the years of study are presented in Table 5.

As shown in Table 5, the total mean scores of NOS beliefs significantly differed between the years of study. Scheffe test showed a significant difference between the first-year students and the fourth-year students, between the second-year students and third-year students and between the second-year students and the fourth-year students. The third-year and the fourth-year students had the highest scores.

Regarding the subscales, Scheffe test revealed a significant difference in attentiveness between the first-year students and the fourth-year students (x^2 = 8.632; p = .035*), in theories and laws between the first-year students and the fourth-year students and between the second-year students and the fourth-year students (x^2 = 9.213; p = .027*), in observation and inference

Table 3. Descriptive results of the scores for NOSBS and its subscales.

	N	Mean	DF	Minimum	Maximum
Total	252	3.358	.2785	1.43	4.05
Tentativeness		3.757	.4849	1.00	5.00
Observation and Inference		3.354	.4862	1.00	4.75
Method/Methods		3.142	.4827	1.00	4.50
Creativity and Imagination		3.455	.6803	1.00	5.00
Assumptions and Boundaries		3.630	.3789	1.00	4.75
Socio-Cultural Embeddedness		2.878	.8106	1.00	5.00
Theories and Laws		2.984	.3636	1.83	4.00

Table 4. The results of the analysis with Mann-Whitney U test to determine the difference in NOS beliefs between genders.

Gender	N	MR	U	Z	P
Female	215	125.42			
Male	37	132.77	4.209	.567	.571
Total	252				

Table 5. The results of the analysis with Kruskal Wallis test to determine the differences in NOS beliefs between the years of study.

Scale	Group	N	Score	x^2	DF	P
Total	1st year	52	105.02	22.01	3	0.000*
	2nd year	52	97.48			
	3rd year	50	138.81			1-4, 2-3, 2-4
	4th year	98	147.04			

between the first-year students and the third-year students and between the second-year students and the third-year students (x^2 = 15.829; p = .001*), in method/methods between the first-year students and the fourth-year students and between the second-year students and the fourth-year students (x^2 = 8.721; p = .033*) and in creativity and imagination between the first-year students and the fourth-year students and between the second-year students and the fourth-year students (x^2 = 10.963; p = .012*). However, no significant difference was found in sociocultural embeddedness (x^2 = 3.575; p = .311) and assumptions and boundaries (x^2 = 3.696; p = .296).

Results about the fourth subproblem

The fourth subproblem of the study was whether NOS beliefs of the preschool teacher candidates differ between their majors at high school. The results of the analysis with Kruskal Wallis test performed to seek an answer to this problem are shown in Table 6.

Table 6. The results of the analysis with Kruskal Wallis test to determine the difference in NOS beliefs scores between the majors at high school.

	Groups	N	Scores	x^2	SD	P
Total	Social	30	98.40	7.781	3	.051
	Science	28	144.39			
	Turkish and Mathematics	186	126.36			
	Other	8	161.07			

As demonstrated in Table 6, no significant difference was detected in the total mean scores for NOSBS between the majors at high school. There was no significant difference in the mean scores for the subscales, either. This shows that NOS beliefs of the students were similar in terms of their majors at high school (social, science, Turkish and Mathematics and other) and high school education did not create a significant difference in NOS beliefs.

DISCUSSION

In the present study, the NOS beliefs of the teacher candidates were found to be acceptable in general. While the findings of this study are consistent with those revealed in several relevant studies in the literature (Doğan Bora, 2005; Önen Öztürk, 2016; Tairab, 2001), they are conflicting with those from other studies (Aslan et al., 2009; Adak and Bakır, 2017; Akerson et al., 2008; Ayvacı and Er-Nas, 2010; Erdaş-Kartal and Ada, 2018; Gücüm, 2000; Kaya, 2012).

In a study by Erdaş-Kartal and Ada (2018) on 94 preschool teacher candidates, most of the participants have naive conceptions and misconceptions about the NOS. Similarly, the NOS beliefs scores regarding sociocultural embeddedness and creativity and imagination were found to be lower in the present study. A study by Abd-El-Khalick (2006) on the opinions of university students and university graduates about science and scientific knowledge also revealed that the participants considered science as independent of social and cultural factors. However, Macaroğlu et al. (1999) reported that the participants did not regard scientific knowledge as completely independent of the social and cultural structure.

In the current study, NOS beliefs of the preschool teacher candidates generally did not differ in terms of gender, but there were differences in some subscales (method/methods and sociocultural embeddedness) in favor of the male candidates, which is not compatible with the literature. Several studies have shown that gender did not produce a difference in NOS beliefs of teacher candidates (Abd-El-Khalick and BouJaoude, 1997; Akgün, 2015; Angın and Kiremit, 2017; Arı, 2010; Doğan-Bora, 2005; Gücüm, 2000; Kaya, 2012; Yalçın and Yalçın, 2011).

In the present study, NOS beliefs of the teacher candidates differed in terms of their year of study, which is conflicting with the results of the studies by Türk et al. (2018). The differences in the present study resulted from the third-year and fourth-year students. It may be that these students received courses about the issue during their undergraduate education. This suggests that education offered at university (science education and mathematics education, etc) is effective in NOS beliefs. The science course is given in the third year of the undergraduate education. Methods and practices involved in the course content might have created a change in these beliefs.

Gücüm (2000) performed a study to reveal understandings of science teacher candidates about the NOS and their differences in terms of gender and the year of study. The researcher reported that the teacher candidates had very low scores for their understandings of the NOS and did not differ according to their gender and year of study.

In the current study, NOS beliefs of the teacher candidates were not different with respect to their majors at high school. This can be ascribed with the fact that education given at primary school and secondary school is similar and that views about scientific knowledge did not differ between majors offered at high school.

Adak and Bakır (2017) showed that science teacher candidates and science teachers had a traditional understanding of the sources of scientific knowledge. They explained that the participants focused on observations and experiments as the origins of scientific knowledge and did not consider creativity and imagination as important. They also reported that most of the teachers and teacher candidates defined theory as a hypothesis proven through observations and experiments and agreed on the presence of a hierarchical relationship between theories and laws. In addition, most of them commented that scientific knowledge can change.

Işık-Öner et al. (2020) in their study with primary education teacher candidates showed that the participants had subjective perceptions about the NOS and had moderate scores for the role of theories in science and technology and low scores for characteristics of science and scientists, openness to change and sociocultural aspects of science.

Akçay and Koç (2009) showed that science teachers had various opinions about experimentalism, creativity and imagination in science and theories and laws, and completely naïve views about tentativeness and observation-inference. On the other hand, the teachers had sufficient understanding of the sociocultural structure.

Turgut (2009) aimed to interpret perceptions of science teacher candidates about scientific knowledge and methods in some conceptual frameworks. The teacher candidates had a realistic approach to scientific knowledge and believed in a scientific method including certain steps to access accurate knowledge.

Aslan et al. (2009) in their study with science and technology teachers found out that the teachers had some naïve views and misconceptions about the definition of science, the nature of observations, tentativeness of scientific knowledge, the nature of hypotheses, theories and laws and scientific methods. Similarly, Ayvacı and Er-Nas (2010) conducted a study with science and technology teachers and found that most of them had naïve views about the NOS and did not have a realistic view about many aspects of the NOS.

Önen-Öztürk (2016) performed a study with teacher candidates in Abu Dhabi to determine their scientific epistemological beliefs, views about the NOS and scientific attitudes and discovered that the teacher candidates had favorable opinions about the NOS. In Tairab's study (2001), the teacher candidates were also found to have an adequate understanding of the NOS.

Köseoğlu et al. (2010) created an occupational improvement program and examined its effects on the NOS in 27 chemistry teachers. They found out that it is difficult and takes a long time to change misconceptions about the NOS.

Yenice and Atmaca (2017) in their study with science teacher candidates found that the candidates had incomplete knowledge and mistaken beliefs about the NOS and concluded that their views and knowledge can be considered partly acceptable. Murcia and Schibeci's study (1999) with 73 pre-service primary teachers, conceptions of the participants on the NOS were also reported to conflict with modern views.

In a study by Abd-El-Khalick (2005), science teachers were found to be unable to differentiate between observations and inferences and believed that scientific knowledge could be obtained through observations.

Gürses et al. (2005) carried out a study with chemistry teacher candidates and primary school teacher candidates to evaluate their views on science and the NOS. The researchers revealed that the students could not distinguish between theoretical and experimental concepts and had incomplete knowledge and misconceptions about theory, law and proof. The students also thought that theories can be changed but that laws are unchangeable and offer absolute knowledge.

RECOMMENDATIONS

- Undergraduate education curricula could incorporate a course involving history of science, the NOS and philosophy of science to improve NOS beliefs.
- The teacher candidates were observed to have more acceptable NOS beliefs over time, which shows the impact of university education. Appropriate practices could be implemented during courses of undergraduate education (e.g. science education, mathematics education, philosophy of education and special education methods) to improve NOS beliefs.
- NOS beliefs of teacher candidates could be determined and improved through various activities (direct teaching).
- This study was conducted in students in Preschool Education Department of Dokuz Eylül University. Further studies with larger samples including students from several institutions could be conducted to increase the external validity of the results.
- Data were obtained with only one data collection tool. Data triangulation could be achieved by using various tools such as observations, interviews and open ended questions. Therefore, it can be recommended that beliefs and skills of teacher candidates about the NOS be determined by using different data collection tools.
- The present study had a cross-sectional design and was performed with students with different years of study in a short time. It can be suggested that longitudinal studies be conducted to reveal changes in NOS beliefs of teacher candidates across time.

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