

Pre-service Primary School Teachers' Scientific Epistemological Beliefs and Attitudes toward Science: Is there a Relationship?

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Abstract

The purpose of this study was to examine pre-service primary school teachers' scientific epistemological beliefs and attitudes toward science. The study also investigated whether there was a relationship between epistemological beliefs and attitudes toward science. Sample of the study consisted of 90 students pursuing their third year in primary teacher education at Giresun University, which is located in northeastern part of Turkey. Data for the study were collected through the use of the Scientific Epistemological Beliefs Scale and the Attitudes toward Science Scale. Means, *t*-test, and correlation analysis were used to analyze data. Findings showed that these pre-service primary school teachers' scientific epistemological beliefs differentiated for the dimensions of the scale from relatively naive to sophisticated beliefs. There were no significant differences between male and female pre-service teachers in terms of scientific epistemological beliefs and attitudes toward science. Results also showed a positive significant correlation between the scientific epistemological beliefs and attitudes toward science.

Keywords: scientific epistemological beliefs, attitudes toward science, pre-service teachers

1. Introduction

Epistemological beliefs are an individual's beliefs about the nature of knowledge and acquisition of knowledge, which includes dimensions such as limits, criteria, source, and certainty of knowledge (Hofer, 2002). Studies on epistemological beliefs started with Perry's (1970) research with undergraduate students. Perry suggested that epistemological beliefs of college students progress through their years of education in college, from the belief that knowledge consists of simple, unchanging facts transferred from authority to the belief that knowledge consists of complex, tentative concepts constructed based on reasoning. According to Perry (1970), epistemological beliefs develop through four stages. In the first stage of epistemological development (dualism), individuals accept knowledge as right or wrong and believe that authority is needed to reach true knowledge. The second stage of development (multiplicity) involves partial acceptance of the uncertain and tentative nature of knowledge. In the third stage (relativism), individuals accept that knowledge might be true or wrong in its specific contexts and they make their own meanings without an external authority. In the highest stage (commitment), individuals believe in relativity of knowledge and flexibility of the knower in terms of changing his or her knowledge by commitment.

Departing from Perry's (1970) developmentalist view, Schommer (1993) proposed a multidimensionalist view and argued that epistemological beliefs should be considered a system of more or less independent beliefs. More-or-less independent means that each belief may or may not develop at a different rate. Individuals holding mature beliefs in certain dimensions might have immature beliefs in other dimensions (Schommer-Aikins & Duell, 2013). By synthesizing previous research, Schommer concluded that an epistemological belief system is composed of a minimum of five beliefs. Initially, she characterized each belief as a continuum. This epistemological beliefs system (Table 1) included beliefs about the structure of knowledge (ranging from simple to complex), the stability of knowledge (certain to uncertain), the source of knowledge (omniscient authority to reason and evidence), the speed of learning (quick to gradual), and the ability to learn (fixed to improvable).

Table 1. Schommer's (1993) Hypothesized Epistemological Dimensions

Schommer's Hypothesized Epistemological Dimensions	
1. Source of knowledge	From knowledge is handed down by omniscient authority to knowledge is reasoned out through objective and subjective means. (Omniscient Authority)
2. Certainty of knowledge:	From knowledge is absolute to knowledge is constantly evolving. (Certain Knowledge)
3. Organization of knowledge	From knowledge is compartmentalized to knowledge is highly integrated and interwoven. (Simple Knowledge)
4. Control of learning:	From ability to learn is genetically predetermined to ability to learn is acquired through experience. (Fixed Ability)
5. Speed of learning	From learning is quick or not-at-all to learning is a gradual process. (Quick Learning)

Hofer (2002), on the other hand, argued that the last two dimensions in Schommer's view are not related to the beliefs about knowledge and knowing, rather they are focused on the nature of learning. She proposed that epistemological beliefs have four dimensions: certainty of knowledge, simplicity of knowledge, source of knowing, and justification of knowing. The first two dimensions are related to the nature of knowledge, whereas the last two are concerned with the nature of knowing. Three dimensions are in line with those proposed by Schommer (1993). On the other hand, she added a fourth dimension, justification of knowing, concerned with the way in which knowledge is justified, which was a proposition more often articulated by researchers who hold a developmentalist view of epistemological beliefs (Conley, Pintrich, Vekiri, & Harrison, 2004; Lin, Deng, Chai, & Tsai, 2013).

Studies on epistemological beliefs suggest that they influence teaching and learning processes. Schommer (1993) investigated the development of secondary school students' epistemological beliefs and their influence on academic performance. She found that students' belief in simple knowledge, certain knowledge, and quick learning decreased from their freshman to senior year and that the less students believed in quick learning, the higher was their GPA. Similarly, Hofer (2001) reported that epistemological perspectives affect some cognitive variables such as reasoning and judgment. Öztürk and Yılmaz-Tüzün (2017) found a strong negative correlation between pre-service teachers' certain knowledge and counterargument construction as well as negative correlations between innate ability, certain knowledge, and quick learning dimensions of epistemological beliefs and their total argument construction. Liang, Lee, and Tsai (2010) found significant relations between scientific epistemological beliefs and approaches to learning science; in particular, a surface strategy for learning science was found to be negatively predicted by the maturation of beliefs about the source and certainty of scientific knowledge. There are many other studies showing that epistemological beliefs are related to certain learning variables such as academic achievement (Cano, 2005; Mohamed & El-Habbal, 2013; Topçu & Yılmaz-Tüzün, 2009; Yalçın & Aggöl-Yalçın, 2017), motivation (Lin et al., 2013; Paulsen & Feldman, 1999), self efficacy in learning (Bendixen & Rule, 2004; Heighl & Thomas, 2013; Sadi & Dağyar, 2015) and attitudes (Fulmer, 2014; Ocak & Erbasan, 2017).

In recent years, studies revealed that epistemological beliefs differ by discipline; consequently, there has been a shift from general-epistemological beliefs to domain-specific epistemological beliefs in the research trends. Buehl, Alexander, and Murphy (2002), for example, investigated differences in domain-specific epistemological beliefs and found that college students believed learning mathematics requires more effort than learning history. Hofer (2000) reported that students in her study accepted knowledge in science as more certain than knowledge in psychology. In a study of 428 high school students Tsai (2006) found that they viewed biology knowledge as more tentative than physics knowledge. Topcu (2013) reported that pre-service teachers' epistemological beliefs about chemistry and biology differed in terms of tentativeness of knowledge and source of knowledge.

Science-specific epistemological beliefs of students constitute an important place among domain-specific studies. A review of the research studies on scientific epistemological beliefs shows that they are positively related to school achievement (Greene, Cartiff, & Duke, 2018; Liang, Lee & Tsai, 2010; Madjar, Weinstock, & Kaplan, 2017; Özkal, 2007; Tsai, 1998, 2000) and some variables such as motivation, self-efficacy and interest in science (Chen, 2012; Mason et al., 2013; Fujiwara, Lualathaphol, & Phillips, 2012).

On the other hand, studies on the epistemological beliefs of teachers demonstrated that they influence their preference of instructional approaches and acceptance of constructivist views of learning (Bahcivan, 2014; Hammer,

Elby, Scherr, & Redish, 2005; Kazempour, 2014; Taşkin-Sahin & Hacıömeroğlu, 2012; Tsai, 2007). Teachers holding underdeveloped epistemological beliefs are found to prefer to use teacher-directed approaches (Adibelli-Şahin, Deniz, & Topçu, 2016; Chrysostomou & Philippou, 2010; Olafson & Schraw, 2002; Yousefzadeh & Azam, 2015). Çetin-Dindar, Kirbulut, and Boz (2014) found that pre-service teachers' epistemological beliefs and their preference to use constructivist-based teaching strategies in their future classrooms were related. Pintrich (1990) argued that epistemological beliefs constitute a fundamental area that should be considered in teacher training since these beliefs might be a source of resistance to change and a barrier to educational innovations. Furthermore, Biçer, Er, and Özel (2013) reported that epistemological beliefs, being a complex variable affecting processes of teaching and learning, affect the development of educational philosophies of teachers as well. These findings suggest that identifying problematic areas in epistemological beliefs of pre-service teachers and employing effective strategies for them to develop more favorable epistemological beliefs are necessary for teacher educators.

Studies examining gender differences in epistemological beliefs produced contradictory results. Some studies determined that females had more sophisticated epistemological beliefs (e.g. Balantekin, 2013; Demirel & Çam, 2016; Kienhues, Bromme, & Stahl, 2008; Şeref, Yılmaz, & Varışoğlu, 2012; Topçu & Yılmaz Tüzün, 2009) whereas some others (e.g. Aydın & Ertürk Geçici, 2017; Başer-Gülsoy, Erol, & Akbay, 2015; Biçer, Er, & Özel, 2013; Burr & Hofer, 2002; Chan & Elliot, 2002; Conley et al., 2004; Law, Chan, & Sachs, 2008; Mason & Boscolo, 2004; Tümkaya, 2012) revealed that there was not a significant difference between males and females. Conflicting research findings obtained from different studies might result from the differences in sample characteristics.

Attitudes, as much as epistemological beliefs, influence teachers' instructional approaches. Attitude is commonly defined as a predisposition to respond positively or negatively toward things, people, places, events, and ideas (Koballa, 2007). Beliefs are important on the formation of attitudes and both beliefs and attitudes affect behavior (Riggs & Enochs, 1990). Fishbein and Ajzen (1974) proposed that there is a strong link between attitudes and behavior. According to this theory, a student's belief in "science is a difficult subject that s/he can not possibly be successful" results in an attitude of disliking science or fearing science. The effect of this attitude on behavior then might be avoiding science classes or not doing homework. The opposite of this example is an attitude of "enjoyment of science [which leads to] not missing a single science class or reading publications related to science" (Yılmaz, Yalvaç, & Tekkaya, 1998).

Parents and teachers play an important role in students' attitudes toward science. However, research studies have shown that many primary pre-service teachers have negative attitudes toward teaching science (Palmer, 2004; Pino-Pasternak & Volet, 2018; Sarıkaya, Töman, & Öztürk, 2018). This is an important problem because pre-service teachers who hold these attitudes are likely to avoid teaching science, or teach it poorly, when they become teachers (Harlen & Holroyd, 1997; Tosun, 2000; Plonczak, 2008). Teachers' attitudes toward science also found to have a major influence on the teaching methods they prefer in teaching science, for example it is likely that a teacher with negative attitudes toward science will not employ inquiry based teaching methods and adopt a didactic teaching style (Bahcivan, 2014; Bencze & Hodson, 1999; van Driel, Beijaard & Verloop, 2001), finally, it is possible that negative attitudes in their students are formed because of their attitudes and teaching behavior (Czerniak & Chiarelott, 1990; Ulug, Ozden, & Eryılmaz, 2011). Therefore, it is necessary to identify pre-service primary teachers who hold negative attitudes toward science and then to find ways to help them develop more positive attitudes before they become teachers.

Some studies reveal genderwise differences in attitudes toward science indicating that males showing more interest in science and holding more positive attitudes than females (e.g. Jones, Howe, & Rua, 2000; Simpson & Oliver, 1990, Özyürek & Eryılmaz, 2001). Studies also report that males prefer science related careers more than females (Cavas et al., 2011). However, there are other studies reported different findings. Many studies done in Turkey for example reported no significant gender differences in attitudes toward science among elementary and secondary school students (Turhan et al., 2008; Yılmaz & Timur, 2012) as well as pre-service teachers and in service teachers (Bayraktar, 2009; Duban & Gökçakan, 2012; Tekbıyık & İpek, 2007; Turkmen, 2013).

Since attitudes and epistemological beliefs are both influential in teaching and learning, it is possible to hypothesize that there might be a relationship between these two variables. However, only a few studies have examined the relationships between attitudes toward science and scientific epistemological beliefs. Liang and Tsai (2010) determined a significant relationship between students' epistemological beliefs and their attitudes toward learning of science. Fulmer (2014) found a statistically significant relationship between epistemological beliefs and attitudes: students have more positive attitudes toward science when they believe that knowledge can be derived from an authority and when they believe that knowledge is uncertain. On the other hand, Kapucu and Eralp (2015) found that

epistemological belief dimensions related to the nature of knowledge (certainty and development) did not have a significant impact on attitudes toward physics. However, dimensions related to nature of knowing (i.e., source and justification) were found to be significantly and positively related to attitudes toward physics. Studies on the subject are scarce and reveal contradictory results. Additional studies are needed to make a stronger conclusion about this relationship.

As indicated before, there are many studies about scientific epistemological beliefs and attitudes toward science. However, the number of studies investigating both variables together and the relationship between them with samples of pre-service teachers is very limited. By adding new findings, this study is expected to make a significant contribution to the research base on the subject. The following research questions were investigated in the present study:

1. What are the scientific epistemological beliefs of pre-service teachers?
2. What are the pre-service teachers' attitudes toward science?
3. Is there a gender difference in scientific epistemological beliefs?
4. Is there a gender difference in attitudes toward science?
5. Is there a relationship between attitudes toward science and scientific epistemological beliefs?

2. Methodology

2.1 Participants

The sample of this study consisted of 90 pre-service primary school teachers (21 males and 69 females) pursuing their third year in a faculty of education in a medium-scale university located in the northeastern part of Turkey. Turkish pre-service primary school teachers take science content courses in the first two years of their preparation: biology (3 credits), chemistry (3 credits), physics (3 credits), environmental science (2 credits), and science laboratory (2 credits); In the third year of the program they take science methods course. When pre-service teachers complete the primary education program, they are certified to teach basic science, mathematics, the properties of native language, art, music, and physical education for grades 1 through 4.

2.2 Instruments

Pre-service teachers' scientific epistemological beliefs were measured by administering "Scientific Epistemological Beliefs Scale (SEBS)", which was developed by Elder (1999) and adapted into Turkish by Acat, Tüken, and Karadağ (2010). The epistemological beliefs scale includes 25 items in the form of Likert-type. It is consisted of five sub-dimensions of *authority and accuracy*, *the process of knowledge production*, *the source of knowledge*, *reasoning*, and *the changeability of knowledge*. The authority and accuracy dimension (9 items) is related to beliefs about knowledge coming from authorities as always correct and there is only one truth (e.g., everybody has to believe what scientists say). The process of knowledge production dimension (6 items) is related to the empirical nature of the scientific knowledge (e.g., correct answers are based on the evidence obtained from numerous experiments). The reasoning dimension (3 items) is related to the role of curiosity and reasoning in knowledge construction (e.g., ideas about science experiments come from being curious and thinking about how things work). The source of knowledge dimension (3 items) is related to the belief that scientific knowledge resides in external authorities such as books and teachers (e.g., we have to believe what we read in scientific books). The changeability of knowledge dimension (3 items) is related to beliefs on the evolving and changing nature of the science (e.g., new discoveries can change what scientists think is true). Cronbach Alpha reliability coefficient of the scale was found to be 0.82 for the original study and 0.77 for the present study.

The beliefs of the students are classified as follows: traditional (underdeveloped) beliefs for scores from 1.0 to 2.5, mixed (medium level) beliefs for scores from 2.6 to 3.5, and developed (contemporary) beliefs for scores from 3.6 to 5.0 (Acat et al., 2010). For the dimensions of authority and accuracy and for the source of knowledge, the classifications are reversed since all the items are negative, which means a higher result refers to traditional beliefs.

The pre-service teachers' attitudes toward science were explored by means of a 5-point Likert-type attitude scale ranging from 1 to 5 (1 = strongly disagree ... 5 = strongly agree). The attitude toward science scale was developed by using a number of items from various attitude scales (Francis & Greer, 1999; Menis, 1989; Ornstein 2006). The 34-item scale consisted of four dimensions: importance and usefulness of science, anxiety toward science, enjoyment and motivation toward science, and attitude toward science teaching. There are 22 positive statements (e.g., "Science is an enjoyable school subject.") and 12 negative statements (e.g., "Scientific discoveries do more harm than good.") in the scale. The scale was first used in another study by the researcher and proved to be a valid and reliable

instrument (Bayraktar, 2009). Cronbach alpha reliability coefficient of the scale was found to be 0.92 for the original study and 0.90 for the present study.

2.3 Data Collection

Scales of Scientific Epistemological Beliefs and Attitudes toward Science were administered to pre-service primary school teachers ($N = 90$) pursuing their third year in the Faculty of Education, who were taking a science methods course instructed by the researcher, during the class sessions at the beginning of fall semester of the 2017-2018 school year. Student teachers were given as much time as they desired to complete the scales.

2.4 Data Analyses

In analyzing the data, for both variables, the normality test was performed within each group. After establishing the normality condition, statistical techniques of means, t -test, and correlation were used to analyze the data. Means for each item and dimension of SEBS and the Attitudes toward Science Scale (ATSS) were calculated to see specifically which areas are developed and which are problematic in terms of scientific epistemological beliefs and attitudes toward science. In order to investigate whether there is a gender difference in epistemological beliefs of pre-service teachers, scores on the SEBS were compared for male and female students by utilizing the t -test. The same procedure was followed also for the ATSS results. Alpha was set at .05 level of significance for all tests. Simple correlation analysis was performed to determine whether there is a relation between attitudes and epistemological beliefs. The reliability of both scales was tested through Cronbach's alpha calculated on the data for the current study.

3. Results

Table 2. Pre-service Teachers' ($N = 90$) Scientific Epistemological Beliefs Scores in the Dimension of Authority and Accuracy

Item	<i>M</i>	<i>SD</i>
1. All questions in science have only one right answer.	2.88	1.32
5. Scientists know almost everything about science so there is not much more to know.	1.59	1.04
12. Whatever teachers say in the courses is right.	1.92	0.97
15. The findings of an experiment are the sole truth about the phenomenon at hand.	2.13	1.02
16. Everybody has to believe what scientists say.	2.25	1.07
20. Only scientists know the exact truth in science.	2.36	1.40
23. Scientists never say "maybe" because they always know the truth.	2.53	1.04
24. Scientists always agree about what is true in science.	2.21	1.03
25. Scientific views always come from scientists and teachers.	2.08	1.17
Averaged result for the dimension	2.21	0.59

The mean score for the dimension of authority and accuracy of the SEBS is 2.21 (0.59). Since all the statements are negative in this dimension, lower scores indicate more developed beliefs. Mean scores for the individual items ranged between 1.59 (1.04) to 2.88 (1.32).

Table 3. Pre-service Teachers' ($N = 90$) Scientific Epistemological Beliefs Scores in the Dimension of Knowledge Construction Process

Item	<i>M</i>	<i>SD</i>
3. The most significant role of scientific study is to reveal the truth. (-)	2.57	1.03
4. The most important role of science is to carry out experiments to obtain new ideas about the functioning of the universe or objects.	3.68	0.99
7. If scientists work hard, they can answer all questions. (-)	3.07	1.09
8. More than one experiment should be done to be sure about the discovery.	4.39	0.99
11. Experiments are good ways to know whether or not something is true.	4.04	0.95
18. Correct answers are based on the evidence obtained from numerous experiments.	4.12	1.01
Averaged result for the dimension	3.65	0.45

The mean score for the knowledge construction process dimension of the SEBS is 3.65 (0.45). This dimension highlights the role of experiments in construction of scientific knowledge and the empirical nature of the scientific

knowledge. There are two negative items in this dimension (items 3 & 7). Mean scores for individual items ranged between 2.57 (1.03) and 4.39 (0.99).

Table 4. Pre-service Teachers' (N = 90) Scientific Epistemological Beliefs Scores in the Dimension of Source of Knowledge

Item	<i>M</i>	<i>SD</i>
6. Scientific knowledge is always true.	2.63	1.12
10. We have to believe in what we read in the scientific books.	2.46	1.05
13. If you read something in a science book, you can be sure it is true.	2.80	0.95
14. We should believe in what our teacher say about science, even we cannot fully understand.	2.32	1.16
Averaged result for the dimension	2.55	0.79

The mean score for the source of knowledge dimension of the SEBS is 2.55 (0.79). Since all of the items are negatively worded for this dimension, low scores indicate more developed beliefs. Mean scores for individual items ranged between 2.32 (1.16) and 2.80 (0.95).

Table 5. Pre-service Teachers' (N = 90) Scientific Epistemological Beliefs Scores in the Dimension of Reason

Item	<i>M</i>	<i>SD</i>
2. Ideas about science experiments come from being curious and thinking about how things work.	4.00	1.08
21. It is good to have an idea before you start an experiment.	4.38	0.88
22. Curiosity over the reasons for events and facts is the best way to have an idea about a scientific phenomenon.	4.2	0.76
Averaged result for the dimension	4.19	0.69

The mean score for the reason dimension is 4.19 (0.69). Mean score for individual items ranged between 4.0 (1.08) and 4.20 (0.76).

Table 6. Pre-service Teachers' (N = 90) Scientific Epistemological Beliefs Scores in the Dimension of Change

Item	<i>M</i>	<i>SD</i>
9. Ideas in science sometimes change.	4.12	0.81
17. New discoveries can change what scientists think is true.	4.34	1.19
19. Sometimes scientists change their minds about what is true in science	3.96	0.79
Averaged result for the dimension	4.14	0.68

The mean score for the change dimension of the SEBS is 4.14 (0.68). Mean scores for individual items ranged between 3.96 (0.79) and 4.34 (1.19).

3.1 Epistemological Beliefs by Gender

The result of the study showed that there was not a gender difference in the scientific epistemological beliefs of these pre-service teachers ($t = 0.91, p = 0.37$).

3.2 Attitudes toward Science

Table 7. Pre-service Teachers' (N = 90) Attitudes toward Science Scores

Dimension	<i>M</i>	<i>SD</i>
Importance and usefulness of science	4.10	0.44
Anxiety toward science	3.02	0.77
Enjoyment of science	3.30	0.64
Attitude toward science teaching	2.73	0.67

Higher scores on these dimensions indicate positive attitudes. The mean score for the usefulness and importance of science dimension is 4.10 (0.44) and for enjoyment of science is 3.30 (0.64). Comparatively lower scores were found for anxiety toward science, 3.02 (0.77), and attitudes toward science teaching, 2.73 (0.67).

3.3 Attitudes toward Science by Gender

T-test was utilized to determine whether there was a gender difference in attitudes toward science. Results showed that there was not a statistically significant difference ($t = 0.74, p = 0.46$).

3.4 Relationship between Attitudes and Efficacy Beliefs

This study detected a significant positive weak relationship between scientific epistemological beliefs and attitudes toward science ($r = 0.210, p = 0.047$).

4. Discussion

The purpose of this study was to examine pre-service primary school teachers' scientific epistemological beliefs and their attitudes toward science. Regarding the epistemological beliefs, results of the study revealed that these pre-service primary school teachers' epistemological beliefs varied in different dimensions. Their beliefs in the dimensions of change, reason, and knowledge construction process were found to be more sophisticated than the dimensions of authority and accuracy and source of knowledge. Studies on this subject have generally revealed similar results. Most of the research showed that students have comparatively less sophisticated beliefs about the source of knowledge and certainty of knowledge (Başer-Gülsoy, Erol, & Akbay, 2015; Chai, Khine, & Teo, 2007; Yenice & Ozden, 2013).

Pre-service teachers' epistemological beliefs in the dimension of authority and truth were found somewhat developed in this study. The authority and truth dimension of the scale investigates whether respondents consider scientific knowledge coming from authority figures, including teachers and books, is always correct and there is only one truth in science (Elder, 1999). Acceptance of a certain knowledge coming from sources that are regarded as authority without questioning is completely contrary to contemporary scientific understandings and indicates an immature epistemological belief. Since lower scores indicate more sophisticated beliefs in this dimension of the scale, comparatively low scores could be interpreted as (a) these pre-service teachers have a relatively desirable understanding on this dimension of scientific knowledge and (b) that they would not accept a piece of information without questioning its accuracy even if it comes from an authoritative source. However, the results also showed that these student teachers mostly agreed on the item *there is only one truth in science*, which is considered as an underdeveloped belief.

Pre-service teachers' holding relatively developed epistemological beliefs in the authority and truth dimension might be as a result of their university education. Courses taken in the first two years might have contributed to development of their scientific epistemological beliefs. Although relatively developed beliefs were detected in the study, it seems that there is still room for improvement on the authority and truth dimension of the beliefs especially in regard to the ideas of *there is only one truth in science*. Previous research shows that students at younger ages generally have naive epistemological beliefs (Boz et al., 2011) and often accept scientific knowledge without reasoning and questioning (Edmondson & Novak, 1993). They accept knowledge coming from textbooks and from teachers even if the knowledge conflicts with their everyday experiences. In many cases they learn the facts without understanding and interpreting underlying principles (Posner, Strike, Hewson, & Gertzog, 1982). However, research also shows that students' beliefs about scientific knowledge progress by age and education (Conley et al., 2004; Karabulut & Ulucan, 2012; Kurt, 2009; Mason, Boldrin, & Zurlo, 2006; Muis & Duffy, 2012; Valanides & Angeli, 2005). These studies suggest that by employing appropriate teaching strategies it might be possible to improve the epistemological beliefs of pre-service teachers.

The pre-service teachers in this study seem to be ambivalent about the source of scientific knowledge since the mean score on this dimension falls in the undecided category. This dimension refers to the belief that teachers, scientists, and books are the only sources of knowledge. Such a belief is attributed to the naive believers who view knowledge as something handed down by external entities in Schommer's (1993) model, which is in contrast to the sophisticated believers who view empirical evidence as a knowledge-seeking tool, such that knowledge is subject to re-evaluation and can be self-constructed. Some of the student teachers in the present study were in this category. This finding is consistent with many studies revealing that students perceive knowledge acquisition as a process of transferring information from authority figures to learners (Chan, 2003; Ku, Lai, & Hau, 2014; Tanase & Wang, 2010).

The knowledge construction process dimension of the SEBS highlights the role of experiments in the construction of

scientific knowledge and the empirical nature of the scientific knowledge. Results of the current study show that these pre-service teachers' views about the empirical nature of scientific knowledge can be considered as developed. Participants had taken science courses (physics, chemistry, and biology) and a laboratory course during their first two years at university. This might have contributed to their understanding of the empirical nature of the science. Science courses contain information about how scientific knowledge developed/changed based on the evidence supplied through the experimentation process.

The pre-service teachers' beliefs on the reason dimension of the scientific knowledge could be considered as sophisticated. The reason dimension of the epistemological beliefs reflects the views on the role of scientists' curiosity and prior knowledge in the construction of new knowledge. The student teachers in this study were aware of the fact that science is a human endeavor as emphasized by McComas (2004, 2015); this result is consistent with other research on the subject (Terzi & Uyangör, 2017; Yenice, 2013).

The pre-service teachers in this study hold sophisticated beliefs about the change dimension of the scientific knowledge. The tentativeness of scientific knowledge is an important dimension of the understanding of nature of science, which refers to openness-to-revision of scientific knowledge in light of new evidence. This result is in line with other studies on the subject. Liu, Lin, and Tsai's (2011) study of college students revealed that the most sophisticated dimension of scientific epistemological beliefs is the tentative feature of knowledge. Kampa et al. (2016) also reported comparatively developed beliefs on the dimension of development of scientific knowledge.

The second aim of the present study was to examine whether there is a gender difference in scientific epistemological beliefs and attitudes toward science. Regarding the scientific epistemological beliefs, the present study did not detect a gender difference in these pre-service teachers. Although studies examining gender differences in scientific epistemological beliefs have shown that there is a significant difference at elementary school levels (Conley et al., 2004; Özkal, 2007; Yeşilyurt, 2013), other studies conducted with participants attending to higher education reported contradictory findings. For example, Terzi (2005) found that female students have more positivist beliefs. Karabenick and Moosa (2005) found that beliefs about authority in scientific knowledge were differentiated for male and female Omani students in favor of females. Şeref, Yılmaz, and Varışoğlu (2012) determined a significant gender difference in terms of scientific epistemological beliefs in pre-service Turkish Language teachers in favor of female students. Similarly, a study conducted by Terzi and Uyangör (2017), with a sample of 379 formation candidate teachers coming from several different disciplines, detected a significant difference in favor of male candidates with regard to the authority and accuracy dimension of scientific epistemological beliefs and a significant difference in favor of female candidates in the reasoning dimension. However, studies by Karabulut and Ulucan (2012) with physical education teachers and by Er (2013) with pre-service teachers from different majors concluded that scientific epistemological beliefs did not vary based on gender. It might be hypothesized that the gender differences occur for undergraduates from certain disciplines. Because there are relatively few studies on this subject at the higher education level, more studies should be performed to reach more confident conclusions.

Findings regarding the attitudes toward science revealed that although student teachers have positive attitudes on the importance of science, attitudes are not as positive in other dimensions, especially in anxiety toward science teaching. The fact that pre-service primary school teachers generally come from a high school track in which they are not required to take any science classes might have an effect on their attitudes. Attitudes toward science of these particular pre-service teachers are similar to that of pre-service primary school teachers in other universities in Turkey (Bayraktar, 2009; Duban & Gökçakan, 2012). Results also showed that there is not a statistically significant difference between male and female pre-service teachers. This finding is consistent with many other studies done in Turkey on the subject (Denizoğlu, 2008); however, studies in other countries show contradictory results (Haciminoglu, 2016). A reason for these differing results might be related to cultural differences among the countries.

This study detected a significant positive relationship between scientific epistemological beliefs and attitudes toward science. This finding is consistent with a few other studies on the subject. Ocağ and Erbasan's (2017) study with fourth grade students revealed that attitudes toward science and general epistemological beliefs are correlated. Kapucu and Bahçivan (2015) found a significant positive correlation between the nature of knowing dimension of scientific epistemological beliefs of Turkish high-school students and attitudes toward physics. Fulmer (2014) found that individuals holding the belief that scientific knowledge is uncertain have more positive attitudes toward science. The results of the current study contribute to the studies providing evidence on the relation of scientific epistemological beliefs and attitudes toward science.

5. Conclusion

The purposes of this study were to explore pre-service primary school teachers' scientific epistemological beliefs and attitudes toward science and to determine whether there are gender-based differences in the beliefs and the attitudes. Furthermore, the research examined whether there is a relationship between scientific epistemological beliefs and attitudes toward science. The pre-service primary school teachers participating in this study had considerably developed scientific epistemological beliefs in two dimensions (i.e., reason and changeability) and moderately developed beliefs in three dimensions of the scientific epistemological beliefs (i.e., process, authority and accuracy, and source of knowledge). However, their attitudes toward science were not found to be positive at a desired level. The results of the study showed no significant differences between male and female pre-service teachers in terms of scientific epistemological beliefs and attitudes toward science. Finally, the study detected a significant positive weak relationship between scientific epistemological beliefs and attitudes toward science.

Considering that epistemological beliefs and attitudes have a crucial effect on student learning, more detailed research on the sources of the beliefs and attitudes could be beneficial for finding ways to improve students' beliefs and attitudes. Research supports the idea that students' epistemological beliefs change over time (Conley et al., 2004) and may be influenced by the type of science instruction students are exposed to in the classroom (e.g., Cotabish et al., 2013; Valanides & Angeli, 2005; Diaz, 2019) or extra-curricular activities (Schiefer et al., 2019). As Conley et al. (2004) suggested more effective instructional approaches such as hands-on and inquiry-oriented science instruction might be a source of such a change. Hammer and Elby (2002) demonstrated that teaching strategies can implicitly encourage students to use epistemological resources that will aid learning; examples given included encouraging student debate, using design and construction activities, and using bridging analogies. Students' engagement with argumentation was also found to be influential on development of epistemological beliefs toward science (Kuhn et al., 2007). Curriculum for all levels of education in Turkey emphasizes employment of such constructivist strategies; however, it seems that there is still room for improvement on the practical side.

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References

- Acat, M. B., Tüken, G., & Karadağ, E. (2010). Bilimsel epistemolojik inançlar ölçeği: Türk kültürüne uyarlama, dil geçerliği ve faktör yapısının incelenmesi. *Türk Fen Eğitimi Dergisi*, 7(4), 67-89.
- Adibelli Sahin, E., Deniz, H., & Topçu, M. (2016). Predicting Turkish pre-service elementary teachers' orientations to teaching science with epistemological beliefs, learning conceptions, and learning approaches in science. *International Journal of Environmental and Science Education*, 11(5), 515-534. <https://doi.org/10.12973/ijese.2016.333a>
- Appleton, K., & Kindt, I. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education*, 21, 155-168. <https://doi.org/10.1080/095006999290769>
- Aydın, M., & Ertürk Geçici, M. (2017). Sınıf öğrencilerinin epistemolojik inançlarının bazı değişkenler açısından incelenmesi. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi (KEFAD)*, 18(1), 213-229.
- Bahcivan, E. (2014). Examining relationships among Turkish pre-service science teachers' conceptions of teaching and learning, scientific epistemological beliefs and science teaching efficacy beliefs. *Journal of Baltic Science Education*, 13(6), 870-882.
- Balantekin, Y. (2013). İlköğretim öğrencilerinin bilimsel bilgiye yönelik epistemolojik inançları. *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, 2(2), 312-328.
- Başer-Gülsoy, V. G., Erol, O., & Akbay, T. (2015). The investigation of middle school students' epistemological belief based upon varied factors. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, 35, 1-28.
- Bayraktar, S. (2009). Turkish preservice primary school teachers' science teaching efficacy beliefs and attitudes toward science: The effect of a primary teacher education program. *School Science & Mathematics*, 111(3), 83-92. <https://doi.org/10.1111/j.1949-8594.2010.00065.x>
- Benceze, L., & Hodson, D. (1999). Changing practice by changing practice: Toward more authentic science and science curriculum development. *Journal of Research in Science Teaching*, 36, 521-539.

- Bendixen, L., & Rule, D. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, 39(1), 69-80. https://doi.org/10.1207/s15326985ep3901_7
- Bıçer, B., Er, H., & Özel, A. (2013). Öğretmen adaylarının epistemolojik inançları ve benimsedikleri eğitim felsefeleri arasındaki ilişki. *Kuram ve Uygulamada Eğitim Bilimleri*, 9(3), 229-242.
- Boz, Y., Aydemir, M., & Aydemir, N. (2011). 4th, 6th, an 8th grade Turkish elementary students epistemological beliefs. *Elementary Education Online*, 10(3), 1191-1201.
- Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, 27, 415-449. <https://doi.org/10.1006/ceps.2001.1103>
- Burr, J. E., & Hofer, B. K. (2002). Personal epistemology and theory of mind: Deciphering young children's beliefs about knowledge and knowing. *New Ideas in Psychology*, 20(2), 199-224. [https://doi.org/10.1016/S0732-118X\(02\)00010-7](https://doi.org/10.1016/S0732-118X(02)00010-7)
- Cano, F. (2005). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology*, 75(2), 203-221. <https://doi.org/10.1348/000709904X22683>
- Cavas, B., Cakiroglu, J., Cavas, P., & Ertepinar, H. (2011). Turkish students' career choices in engineering: Experiences from Turkey. *Science Education International*, 22(4), 274-281.
- Cotabish, A., Robinson, A., Dailey, D., & Hughes, G. (2013). The effects of a STEM intervention on elementary students' science knowledge and skills. *School Science and Mathematics*, 113, 215-226. <https://doi.org/10.1111/ssm.12023>
- Chai, C. S., Khine, M. S., & Teo, T. (2006). Epistemological beliefs on teaching and learning: A survey among pre-service teachers in Singapore. *Educational Media International*, 43(4), 285-298. <https://doi.org/10.1080/09523980600926242>
- Chan, K. (2003). Hong Kong teacher education students' epistemological beliefs and approaches to learning. *Research in Education*, 69, 36-50. <https://doi.org/10.7227/RIE.69.4>
- Chan, K. W., & Elliott, R. G. (2002). Exploratory study of Hong Kong teacher education students' epistemological beliefs: Cultural perspectives and implications on beliefs research. *Contemporary Educational Psychology*, 27(3), 392-414. <https://doi.org/10.7227/RIE.69.4>
- Chen, J. A. (2012). Implicit theories, epistemic beliefs, and science motivation: A person-centered approach. *Learning and Individual Differences*, 22, 724-735. <https://doi.org/10.1016/j.lindif.2012.07.013>
- Chrysostomou, M., & Philippou, G. N. (2010). Teachers' epistemological beliefs and efficacy beliefs about mathematics. *Procedia-Social and Behavioral Sciences*, 9, 1509-1515. <https://doi.org/10.1016/j.sbspro.2010.12.357>
- Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, 29, 186-204. <https://doi.org/10.1016/j.cedpsych.2004.01.004>
- Czerniak, C. M., & Chiarelott, L. (1990). Teacher education for effective science instruction: A social cognitive perspective. *Journal of Teacher Education*, 41, 49-58. <https://doi.org/10.1177/0022487190004100107>
- Çetin-Dindar, A., Kırbulut, Z. D., & Boz, Y. (2014). Modelling between epistemological beliefs and constructivist learning environment. *European Journal of Teacher Education*, 37(4), 479-496. <https://doi.org/10.1080/02619768.2014.944614>
- Demirel, A., & Çam, A. (2016). Fen bilgisi öğretmen adaylarının epistemolojik inançlarının çeşitli değişkenler açısından incelenmesi. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 24, 873-905.
- Denizoğlu, P. (2008). *Fen bilgisi öğretmen adaylarının fen bilgisi öğretimi öz-yeterlik inanç düzeyleri, öğrenme stilleri ve fen bilgisi öğretimine yönelik tutumları arasındaki ilişkinin değerlendirilmesi*. (Yayımlanmamış yüksek lisans tezi). Çukurova Üniversitesi, Adana, Türkiye.
- Diaz, M. E. (2019). Exploring Latino preservice teachers' attitudes and beliefs about learning and teaching science: What are the critical factors? *International Journal of Research in Education and Science (IJRES)*, 5(2), 574-586.
- Duban, N. Y., & Gökçakan, Y. (2012). Sınıf öğretmeni adaylarının fen öğretimi özyeterlik inançları ve fen

- öğretimine yönelik tutumları. *Sosyal Bilimler Enstitüsü Dergisi*, 21(1), 267-280.
- Edmondson, K. M., & Novak, J. D. (1993). The interplay of scientific epistemological views, learning strategies, and attitudes of college students. *Journal of Research in Science Teaching*, 32, 547-559. <https://doi.org/10.1002/tea.3660300604>
- Elder, A. D. (1999). *An exploration of fifth grade students' epistemological beliefs in science and an investigation of their relation to science learning* (Unpublished doctoral dissertation). University of Michigan, Ann Arbor, Michigan.
- Er, K. O. (2013). A study of the epistemological beliefs of teacher candidates in terms of various variables. *Eurasian Journal of Educational Research*, 50, 207-226.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
- Francis, L. J., & Greer, J. E. (1999). Measuring attitude toward science among secondary school students: The affective domain. *Science and Technological Education*, 17, 219-226. <https://doi.org/10.1080/0263514990170207>
- Fujiwara, T., Lualathapol, P., & Phillips, B. J. (2012). Thai university students' scientific epistemic beliefs: Relationships with past learning experiences. *Procedia - Social and Behavioral Sciences*, 69, 187-196. <https://doi.org/10.1016/j.sbspro.2012.11.398>.
- Fulmer, G. W. (2014). Undergraduates' attitudes toward science and their epistemological beliefs: Positive effects of certainty and authority beliefs. *Journal of Science Education and Technology*, 23(1), 198-206.
- Greene, J. A., Cartiff, B. M., & Duke, R. F. (2018). A meta-analytic review of the relationship between epistemic cognition and academic achievement. *Journal of Educational Psychology*, 110(8), 1084-1111. <https://doi.org/10.1037/edu0000263>
- Hacieminoglu, E. (2016). Elementary school students' attitude toward science and related variables. *International Journal of Environmental and Science Education*, 11(2), 35-52.
- Hammer, D. M., Elby, A., Scherr, R. E., & Redish, E. F. (2005). Resources, framing, and transfer. In J. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (pp. 89-120). Greenwich, CT: Information Age.
- Harlen, W., & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: Impact on confidence and teaching. *International Journal of Science Education*, 19(1), 93-105. <https://doi.org/10.1080/0950069970190107>
- Heighl, N. R., & Thomas, J. (2013). The effectiveness of epistemic beliefs and the role of self-efficacy in the solving of cross-curricular problems. *Psychology Learning and Teaching*, 12(2), 126-137. <https://doi.org/10.2304/plat.2013.12.2.126>
- Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378-405. <https://doi.org/10.1006/ceps.1999.1026>
- Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Journal of Educational Psychology Review*, 13, 353-383. <https://doi.org/10.1023/A:1011965830686>
- Hofer, B. K. (2002). *Personal epistemology as a psychological and educational construct: An introduction*. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 3-14). Mahwah, NJ: Lawrence Erlbaum.
- Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, attitudes toward science and scientists. *Science Education*, 84(2), 180-192. [https://doi.org/10.1002/\(SICI\)1098-237X\(200003\)84:2%3C180::AID-SCE3%3E3.0.CO;2-X](https://doi.org/10.1002/(SICI)1098-237X(200003)84:2%3C180::AID-SCE3%3E3.0.CO;2-X)
- Kampa, N., Neumann, I., Heitmann, P., & Kremer, K. (2016). Epistemological beliefs in science—a person-centered approach to investigate high school students' profiles. *Contemporary Educational Psychology*, 46, 81-93. <https://doi.org/10.1016/j.cedpsych.2016.04.007>
- Kapucu, S., & Bahçivan, E. (2015). High school students' scientific epistemological beliefs, self-efficacy in learning physics and attitudes toward physics: A structural equation model. *Research in Science & Technological Education*, 33(2), 252-267. <https://doi.org/10.1080/02635143.2015.1039976>

- Karabenick, S. A., & Moosa, S. (2005). Culture and personal epistemology: U.S. and Middle Eastern students' beliefs about scientific knowledge and knowing. *Social Psychology of Education, 8*(4), 375-393. <https://doi.org/10.1007/s11218-005-1826-3>
- Karabulut, E. O., & Ulucan, H. (2012). Beden eğitimi öğretmenliği adaylarının bilimsel epistemolojik inançlarının farklı değişkenler açısından incelenmesi. *Spor ve Performans Araştırmaları Dergisi, 3*(2).
- Kazempour, M. (2014). I can't teach science! A case study of an elementary pre-service teacher's intersection of science experiences, beliefs, attitude, and self efficacy. *International Journal of Environmental and Science Education, 9*(1), 77-96.
- Kienhues, D., Bromme, R., & Stahl, E. (2008). Changing epistemological beliefs: The unexpected impact of a short-term intervention. *British Journal of Educational Psychology, 78*(4), 545-565. <https://doi.org/10.1348/000709907X268589>
- Koballa, T. R. (2007). *Framework for the affective domain in science education*. Retrieved from <https://serc.carleton.edu/NAGTWorkshops/affective/framework.html>
- Ku, K. Y. L., Lai, C. M., & Hau, K. T. (2014). Epistemological beliefs and the effect of authority on argument-counterargument integration: An experiment. *Thinking Skills and Creativity, 13*, 67-79. <https://doi.org/10.1016/j.tsc.2014.03.004>
- Kuhn, D., Arvidsson, T. S., Lesperance, R., & Corprew, R. (2017). Can engaging in science practices promote deep understanding of them? *Science Education, 101*(2), 232-250. <https://doi.org/10.1002/sc.21263>
- Kurt, F. (2009). *Investigating students' epistemological beliefs through gender, grade level, and fields of the study* (Unpublished master's thesis). Middle East Technical University, Ankara, Turkey.
- Law, Y. K., Chan, C. K., & Sachs, J. (2008). Beliefs about learning, self-regulated strategies and text comprehension among Chinese children. *British Journal of Educational Psychology, 78*(1), 51-73. <https://doi.org/10.1348/000709907X179812>
- Liang, J. C., Lee, M. H., & Tsai, C. C. (2010). The relations between scientific epistemological beliefs and approaches to learning science among science-major undergraduates in Taiwan. *Asia-Pacific Education Researcher, 19*(1), 43-59. <https://doi.org/10.3860/taper.v19i1.1508>
- Liang, J. C., & Tsai, C. C. (2010). Relational analysis of college science-major students' epistemological beliefs toward science and conceptions of learning science. *International Journal of Science Education, 32*(17), 2273-2289. <https://doi.org/10.1016/j.ijer.2006.08.003>
- Lin, T. J., Deng, F., Chai, C. S., & Tsai, C. C. (2013). High school students' scientific epistemological beliefs, motivation in learning science, and their relationships: A comparative study within the Chinese culture. *International Journal of Educational Development, 33*(1), 37-47. <https://doi.org/10.1016/j.ijedudev.2012.01.007>
- Liu, S-Y., Lin, C-S., & Tsai, C.-C. (2011). College students' scientific epistemological views and thinking patterns in socioscientific decision making. *Science Education, 95*(3), 477-496. <https://doi.org/10.1002/sc.20422>
- Madjar, N., Weinstock, M., & Kaplan, A. (2017). Epistemic beliefs and achievement goal orientations: Relations between constructs versus personal profiles. *Journal of Educational Research, 110*(1), 32-49. <https://doi.org/10.1080/00220671.2015.1034353>
- Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology, 29*(2), 103-128. <https://doi.org/10.1016/j.cedpsych.2004.01.001>
- Mason, N., Boldrin, A., & Zurlo, G. (2006). Epistemological understanding in different judgement domains: Relationship with gender, grade level, and curriculum. *International Journal of Educational Research, 45*, 43-56. <https://doi.org/10.1016/j.ijer.2006.08.003>
- McComas, W. F. (2004). Keys to teaching the nature of science: Focusing on the nature of science in the science classroom. *Science Teacher, 71*(9), 24-27.
- McComas, W. F. (2015). The nature of science and the next generation of biology education. *American Biology Teacher, 77*(7), 485-491. <https://doi.org/10.1525/abt.2015.77.7.2>
- Menis, J. (1989). Attitudes towards school, chemistry students and science among upper secondary chemistry students in the United States. *Research in Science and Technological Education, 1*, 183-190.

<https://doi.org/10.1080/0263514890070206>

- Mohamed, M. T., & El-Habbal, M. (2013). The relationship between epistemic beliefs and academic performance: Are better students always more mature? *Journal of Educational and Developmental Psychology*, 3(1), 158-172.
- Muis, K. R., & Duffy, M. C. (2012). Epistemic climate and epistemic change: Instruction designed to change students' beliefs and learning strategies and improve achievement. *Journal of Educational Psychology*, 105(1), 213-225. <http://dx.doi.org/10.1037/a0029690>
- Ocak, İ., & Erbasan, Ö. (2017). Sınıf Öğrencilerinin Fen Bilimleri Dersine Yönelik Tutumları ve Epistemolojik İnançları. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi*, 19(2), 187-207.
- Olafson, L. J., & Schraw, G. (2002). Some final thoughts on the epistemological melting pot. *Issues in Education*, 8(2), 233-247.
- Ornstein, A. (2006). The frequency of hands-on experimentation and student attitudes toward science: A statistically significant relation. *Journal of Science Education and Technology*, 15, 285-297. <https://doi.org/10.1007/s10956-006-9015-5>
- Özkal, K. (2007). *Scientific epistemological beliefs, perceptions of constructivist learning environment and attitude towards science as determinants of students approaches to learning* (Unpublished master's thesis). Middle East Technical University, Ankara, Turkey.
- Ozturk, N., & Yilmaz-Tuzun, O. (2017). Pre-service science teachers' epistemological beliefs and informal reasoning regarding socioscientific issues. *Research in Science Education*, 47(6), 1275-1304. <https://doi.org/10.1007/s11165-016-9548-4>
- Özyürek, A. & Eryılmaz, A. (2001). Factors effecting students' attitudes toward physics. *Education and Science*, 26(120), 21-28.
- Palmer, D. H. (2004). Situational interest and the attitudes towards science of primary teacher education students. *International Journal of Science Education*, 26, 895-908. <https://doi.org/10.1080/0950069032000177262>
- Paulsen, M. B., & Feldman, K. A. (1999). Student motivation and epistemological beliefs. *New Directions for Teaching and Learning*, 78, 17-25. <https://doi.org/10.1002/tl.7802>
- Perry, W. G. (1970). *Forms of Intellectual and Ethical Development in the College Years: A Scheme*. New York: Holt, Rinehart, and Winston.
- Pino-Pasternak, D., & Volet, S. (2018). Evolution of pre-service teachers' attitudes towards learning science during an introductory science unit. *International Journal of Science Education*. <https://doi.org/10.1080/09500693.2018.1486521>
- Pintrich, P. R. (1990). Implications of psychological research on student learning and college teaching for teacher education. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 826-857).
- Plonczak, I. (2008). Science for all: Empowering elementary school teachers. *Education, Citizenship and Social Justice*, 3, 167-181. <https://doi.org/10.1177/1746197908090081>
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 211-227. <https://doi.org/10.1002/sci.3730660207>
- Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education*, 74(6), 625-637. <https://doi.org/10.1002/sci.3730740605>
- Sadi, O., & Dağyar, M. (2015). High school students' epistemological beliefs, conceptions of Learning, and self-efficacy for learning biology: A study of their structural models. *Eurasia Journal of Mathematics Science and Technology Education*, 11, 1061-1079.
- Sarikaya, İ., Töman, U., & Öztürk, M. (2018). Examining the Variables Predicting Attitudes towards Teaching Profession of Preservice Classroom Teachers. *Acta Didactica Napocensia*, 11(1), 129-141. <https://doi.org/10.24193/adn.11.1.10>
- Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85(3), 406-411. <https://doi.org/10.1037/0022-0663.85.3.406>

- Schommer-Aikins, M., & Duell, O. K. (2013). Domain specific and general epistemological beliefs. Their effects on mathematics. *Revista de Investigación Educativa*, 31(2), 317-330. <http://dx.doi.org/10.6018/rie.31.2.170911>
- Schiefer, J., Golle, J., Tibus, M., Herbein, E., Gindele, V., Trautein, U., & Oschatz, K. (2019). Effects of an extracurricular science intervention on elementary school children's epistemic beliefs: A randomized controlled trial. *British Journal of Educational Psychology*. <https://doi.org/10.1111/bjep.12301>
- Simpson, R. D., & Oliver, J. S. (1990) A Summary of Major Influences on Attitude Toward and Achievement in Science Among Adolescent Students. *Science Education*, 74(1), 1-18. <https://doi.org/10.1002/sce.3730740102>
- Şeref, İ., Yılmaz, İ., & Varışoğlu, B. (2012). Türkçe öğretmeni adaylarının bilimsel epistemolojik inançları üzerine bir inceleme. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 5(10), 399-418.
- Tanase, M., & Wang, J. A. (2010). Initial epistemological beliefs transformation in one teacher education classroom: Case study of four pre-service teachers. *Teaching and Teacher Education*, 26(6), 1238-1248. <https://doi.org/10.1016/j.tate.2010.02.009>
- Taşkın-Şahin, Ç., & Hacıömeroğlu, G. (2010). İlköğretim bölümü öğretmen adaylarının mesleğe yönelik tutumları: Nicel ve nitel verilere dayalı bir inceleme. *İlköğretim Online [Elementary Education Online]*, 9(2), 922-933.
- Tekbıyık, A., & İpek, Y. (2007). Sınıf öğretmeni adaylarının Fen Bilimlerine yönelik tutumları ve mantıksal düşünme becerileri. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 4(1).
- Terzi, A. R. (2005). Üniversite öğrencilerinin bilimsel epistemolojik inançları üzerine bir araştırma. *Afyon Kocatepe Üniversitesi, SBED*, 7(2), 298-311.
- Terzi, A. R., & Uyangör, N. (2017). An Analysis of the Relationship between Scientific Epistemological Beliefs and Educational Philosophies: A Research on Formation Teacher Candidates. *Universal Journal of Educational Research*, 5(12), 2171-2177. <https://doi.org/10.13189/ujer.2017.051206>
- Topçu, M. S. (2013). Pre-service teachers' epistemological beliefs in physics, chemistry and biology: A mixed study. *International Journal of Science and Mathematics Education*, 11(2), 433-458. <https://doi.org/10.1007/s10763-012-9345-0>
- Topçu, M. S., & Yılmaz-Tüzün, Ö. (2009). Elementary students' metacognition and epistemological beliefs considering science achievement, gender and socioeconomic status. *Elementary Education Online*, 8(3), 676-693.
- Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School Science and Mathematics*, 100, 374-379. <https://doi.org/10.1111/j.1949-8594.2000.tb18179.x>
- Tsai, C. C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education*, 82(4), 473-489. [https://doi.org/10.1002/\(SICI\)1098-237X\(199807\)82:4%3C473::AID-SCE4%3E3.0.CO;2-8](https://doi.org/10.1002/(SICI)1098-237X(199807)82:4%3C473::AID-SCE4%3E3.0.CO;2-8)
- Tsai, C. C. (2000). Relationships between students' scientific epistemological beliefs and perceptions of constructivist learning environment. *Educational Research*, 42(2), 193-205. <https://doi.org/10.1080/001318800363836>
- Tsai, C. C. (2006). Biological knowledge is more tentative than physics knowledge: Taiwan high school adolescents' views about the nature of biology and physics. *Adolescence*, 41(164), 691-704.
- Tsai, C. C. (2007). Teachers' scientific epistemological views: The coherence with instruction and students' views. *Science Education*, 91(2), 222-243. <https://doi.org/10.1002/sce.20175>
- Turhan, F., Aydoğdu, M., Şensoy, Ö., & Yıldırım, H. İ. (2008). Analysis of the relationship among cognitive growth, science achievement, attitudes towards science and gender of the eighth graders. *Kastamonu Journal of Education*, 16(2), 439-450.
- Tümekaya, S. (2012). The investigation of the epistemological beliefs of university students according to gender, grade, fields of study, academic success and their learning styles. *Educational Sciences: Theory & Practice*, 1(12), 88-95.
- Turkmen, L. (2013). In-service Turkish elementary and science teachers' attitudes toward science and science teaching: A sample from Usak province. *Science Education International*, 24(4), 437-459.
- Ulug, M., Ozden, M. S., & Eryılmaz, A. (2011). The effect of teachers attitudes on students' personalities and performance. *Procedia Social and Behavioral Sciences*, 20, 738-742.

<https://doi.org/10.1016/j.sbspro.2011.10.144>

- Valanides, N., & Angeli, C. (2005). Effects of instruction on changes in epistemological beliefs. *Contemporary Educational Psychology, 30*(3), 314-330.
- Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching, 38*, 137-158.
- Yalçın, M., & Aggul-Yalçın, F. (2017). The Investigation of Pre Service Science Teachers' Epistemological Beliefs According to Some Variables. *Journal of Education and Training Studies, 5*(10), 207-217. <https://doi.org/10.11114/jets.v5i10.2224>
- Yeşilyurt, E. (2013). İlköğretim okulu öğrencilerinin bilimsel epistemolojik inançları. *International Journal of Social Science, 6*(1), 1587-1609.
- Yılmaz, Ö., Yalvaç, B., & Tekkaya, C. (1998). Fen bilgisi dersine ilişkin beceri ve tutumların Ölçülmesi [The assessment of skills related to science and attitudes toward science class]. *Eğitim ve Bilim Dergisi, 22*, 45-50.
- Yılmaz, Ş., & Timur, B. (2012). Investigation of primary education 6th, 7th, and 8th grade students' attitudes toward science and technology lesson. *The Online Journal of New Horizons in Education, 2*(3), 25-41.
- Yenice, N., & Özden, B. (2013). Analysis of scientific epistemological beliefs of eighth graders. *International Journal of Education in Mathematics, Science and Technology, 1*(2).
- Yousefzadeh, M., & Azam, L. B. (2015). The effect of Iranian teachers' epistemological beliefs on their teaching practice. *Advances in Language and Literary Studies, 6*(6), 25-28. <https://doi.org/10.7575/aiac.all.v.6n.6p.25>