



An Analysis of Science Student Teachers' Epistemological Beliefs and Metacognitive Perceptions about the Nature of Science

Nilgün Yenice^a

Adnan Menderes University

Abstract

This study has been carried out to identify the relationship between the epistemological beliefs of student teachers and their metacognitive perceptions about the nature of science. The participants of the study totaled 336 student teachers enrolled in the elementary science education division of the department of elementary education at the faculty of educational sciences in a state university in western Turkey. The data for the study was collected through the scale of epistemological beliefs, the scale of metacognitive perceptions about the nature of science, and the personal information form. The scale of epistemological beliefs was developed by Schommer and adapted to Turkish by Deryakulu and Büyüköztürk. The scale of metacognitive perceptions about the nature of science was developed by Peters and adapted to Turkish by the author. The correlations between the participants' epistemological beliefs and metacognitive perceptions about the nature of science and the variables of grade level and gender were analyzed using the Mann-Whitney U test, Kruskal-Wallis H test, and multiple regression analysis. The findings of the study showed participants to have positive epistemological beliefs and metacognitive perceptions about the nature of science. The participants' epistemological beliefs and metacognitive perceptions about the nature of science were also found to not be significantly affected by the variables of grade or gender. In addition, epistemological beliefs were found to be a significant predictor of metacognitive perceptions about the nature of science.

Keywords: Student science teacher • Epistemological beliefs • Nature of science • Metacognition • Science education

a Correspondence

Assoc. Prof. Nilgün Yenice (PhD), Department of Elementary Education, Division of Science Education, Faculty of Education, Adnan Menderes University, Aydın Turkey

Research areas: Science education; Nature of science; Inquiry-based science education; Self-efficacy; Science literacy; Argumentation; Critical thinking; Metacognition; Problem solving

Email: nyenice@gmail.com

In recent years, the scientific paradigm has been subject to a change in which scientific positivism supporting objectivity based on experiments and mathematics has been replaced by post-positivism in science, which supports constructivism. Unlike positivism, this approach argues that scientific knowledge may include scientists' bias and change over time (Terzi, 2005). At the same time, the constructivist scientific approach emphasizes subjective factors in learning and regards individuals as an active participant of learning. Therefore, both teachers who guide the learning process and students who are active participants of this process are expected to have higher levels of awareness about how learning occurs as well as the sources and limitations of knowledge. They should also be aware of their cognitive awareness and control skills. Such expectations have given rise to two concepts, both of which have effects on learning: Epistemological beliefs and metacognition.

The major goals for science education based on the postpositivist scientific approach are learning scientific knowledge and understanding the philosophy behind science education (Çepni, 2008; Doğru & Kıyıcı, 2005). Science is also argued to not only be a collection of knowledge, but also a way of knowing; in order to comprehend science, students should understand the nature and structure of scientific knowledge, as well as how scientific knowledge develops (National Research Council [NRC], 2007). Therefore, being informed about students' views about scientific knowledge referring to epistemological beliefs has become a significant issue (Acat, Tüken, & Karadağ, 2010). In the related literature, the terms "scientific knowledge," "views about scientific knowledge," and "epistemological beliefs" have been used as synonyms (Ünal Çoban & Ergin, 2008).

Scientific epistemological beliefs refers to an individual's philosophical understandings about what science is, what reliable and valid scientific knowledge is, and how it is produced and shared (Deryakulu & Bıkmaz, 2003). Eroğlu and Güven (2006) considered epistemological beliefs to be an individual's subjective beliefs about how knowing and learning occur, as well as their views about knowledge. Individuals are classified as "Naive" or "Sophisticated" based on their epistemological beliefs. Naive individuals believe that knowledge is absolute and made up of independent parts. They also think that knowledge is produced by an expert who transfers it to students who have an innate ability to learn. A student's ability to learn is fixed and cannot be changed. Individuals with sophisticated epistemological beliefs, on the other hand, believe

that knowledge changes over time and has a complex structure in which interdependent parts exist. For them, individuals construct knowledge through reasoning or experiments. They also think an individual's ability to learn may be improved, and learning occurs through student effort (Deryakulu, 2002). Individuals with sophisticated epistemological beliefs employ their cognitive processing strategies in the process of learning, of which they are active participants, and frequently control their level of learning using metacognitive skills (Deryakulu & Büyüköztürk, 2005).

Epistemological beliefs help us understand the control strategies used by individuals to see whether or not their knowledge is correct, to evaluate new learning, and to make significant decisions over their own life or others' lives (King & Kitchener, 1994; Kuhn, 1991; Sapanç, 2012). Perry (1981) argues that epistemological beliefs reflect the decision-making criteria used by individuals in regard to the limitations, acquisition, and absoluteness degree of knowledge, and that epistemological beliefs develop based on an individual's beliefs about "learning, teaching, and intelligence." Schommer-Aikins and Hutter (2002) found that epistemological beliefs have significant effects on an individual's comprehension skills, control skills about this comprehension, skills related to the interpretation of learning, and the skill for maintaining academically difficult tasks. In order to have developed epistemological beliefs, individuals should have metacognitive skills which make it possible to have higher levels of awareness about their cognitive processes, as well as to plan, follow, and evaluate the learning process (Sapanç, 2012).

Bendixen and Rule (2004) stated that metacognition plays a significant role in the development of epistemological beliefs. Research (Belet & Güven, 2011; Dahl, Bals, & Turi, 2005; Deryakulu, 2004; Özgelen, Yılmaz-Tüzün, & Hanuscin, 2010; Wachsmuth & Leibham, 2007) suggests that there is a relationship between metacognition and epistemological beliefs (Başbay, 2013). Schommer (1994) argued that epistemological beliefs significantly affect an individual's cognitive and metacognitive processes. Metacognition refers to the awareness of individuals about mental activities involved in perception, thought, and recall, as well as control of these mental activities (Desoete & Özsoy, 2009; Hacker & Dunlosky, 2003; Huit, 1997; Schraw & Moshman, 1995). Metacognition is made up of two sub-systems: Metacognitive knowledge and metacognitive control (Özsoy, 2008; Schraw, 2001). Metacognitive knowledge refers to an individual's awareness about one's mental

resources such as knowledge and beliefs, and what they may do with these resources (Coutinho, 2007; Özsoy, 2008). However, metacognitive knowledge does not necessarily lead to the realization of proper task behavior. For instance, a student may know that it is necessary to follow a path of learning, but cannot actualize this for several reasons. It is also possible that the task of learning may be boring or hard, or the student may lack the necessary skills to achieve this task (Çakıroğlu, 2007). The other sub-system, metacognitive control, consists of major mental procedures and refers to the use of metacognitive knowledge for strategically achieving cognitive goals (Özsoy & Günindi, 2011). Sapanıcı (2012) argues that if an individual is aware of their ability and views on the process of knowledge production, and then they employ this awareness in the process of learning, they may develop a positive epistemological belief about the process of knowledge production. Therefore, these mutually affect each other during the learning process.

One of the major goals of the science education program is to make students informed about science and its nature (Milli Eğitim Bakanlığı [MONE], 2013). Because in order to produce science literate individuals, students should comprehend both science and its nature (Çepni, Ayvacı, & Bacanak, 2004; MONE, 2006, 2013). On the other hand, comprehension about the nature of science is also related to the epistemological beliefs of students. The nature of science should not be taught to students as a structure, but as epistemological knowledge. In order to teach epistemology to students, there are certain methods. One such method involves making students ponder how to verify knowledge and to develop their metacognition concerning these thought processes (Peters, 2007). Schraw and Sperling-Dennison (1994) argue that learners with higher levels of metacognitive awareness use better strategies and perform much better. They added that this advantage is due to the fact that metacognitive awareness provides students with an opportunity to plan, arrange, and follow up on their learning. Therefore, metacognition about the nature of science is significant in that epistemological beliefs cover the nature of science, and epistemological beliefs and metacognition are closely related to each other.

Although there are numerous studies on the theoretical structure, dimensions, and levels of epistemological beliefs, the relationship between epistemological beliefs and some variables including learner characteristics has been studied in recent years (Buehl, 2003). There are studies which have analyzed the relationship between epistemological beliefs and different variables, some of which are given as follows: Academic achievement

(Buehl & Alexander, 2005; Cano & Cardelle-Elawar, 2004, 2008; Hofer, 2000; Schommer, 1993; Paulsen & Wells, 1998), the use of learning and study strategies with learning approaches (Aypay, 2011; Cano & Cardelle-Elawar, 2008; Chan, 2003; Deryakulu, 2004; Kizilgunes, Tekkaya, & Sungur, 2009; Sinatra & Kardash, 2004), the use of self-regulated learning strategies (Braten & Stromso, 2005; Dahl et al., 2005; Neber & Schommer-Aikins, 2002), construction of knowledge (Tsai, 2000; Windschitl & Andre, 1998), culture (Youn, 2000), cognitive processing strategies (Kardash & Howell, 2000; Ravindran, Grene, & Debacker, 2005), gender (Aypay, 2011; Koç Erdamar & Bangir Alpan, 2011; Er, 2013; Eren, 2007; Neber & Schommer-Aikins, 2002; Schommer, 1993; Tümkeya, 2012), field of study (Buehl, 2003; Hofer, 2001; Paulsen & Wells, 1998), grade level (Belet & Güven, 2011; Tümkeya, 2012), and learning environment (Neber & Schommer-Aikins, 2002). Wyre (2007) stated that the number of studies in recent years about the mechanisms of epistemological beliefs or the relationship between epistemological beliefs and some variables such as metacognition has increased. Some such studies were carried out on student teachers with a special reference to their epistemological beliefs and metacognitive abilities (Brownlee, Purdie, & Bolton-Lewis, 2001). In addition, research suggests that changing the epistemological beliefs of student teachers will also affect their learning ability and teaching performance (Cheng, Chan, Tang, & Cheng, 2009). Research on the metacognition of student teachers has focused on the effects of some variables such as gender, grade, university, and academic achievement on their metacognition (Doğanay & Demir, 2011; Gürşimşek, Çetingöz, & Yoleri, 2009; Yıldız, Akpınar, & Ergin, 2006).

Research also argues that studying the relationship between epistemological beliefs and metacognition is both significant and necessary. Dahl et al. (2005) analyzed the epistemological beliefs and learning strategies of undergraduate students. They found that the participants used metacognitive strategies less often. Similarly, Kardash and Howell (2000) found that students with sophisticated epistemological beliefs employed distinct cognitive strategies. In addition, students' epistemological beliefs were found to be closely related to their motivation and metacognition (Chan, 2003; Paulsen & Feldman, 1999). Belet and Güven (2011) found that the epistemological beliefs of classroom student teachers were significantly related to gender, grade level, academic achievement, and the university being attended. They also found that the most developed epistemological belief of student teachers was about the fact that learning is based on individual attempt. The epistemological beliefs

of “learning is based on ability” and “there is one truth” were less common among student teachers. Concerning metacognition strategies, the use of these strategies by student classroom teachers was found to significantly vary by such variables as gender, grade level, and university; however, no relationship was found between metacognition strategies and academic achievement. The most frequently-used metacognition strategies were found to be self-control, followed by cognitive strategies and self-assessment. Awareness-related strategies were found to be used less often by student classroom teachers. In addition, there was a low but significant correlation between their epistemological beliefs and use of metacognitive strategies. Sapançı (2012) analyzed the correlation between student teachers’ epistemological beliefs and use of metacognitive strategies with their academic achievement. The use of metacognitive strategies was found to be positively related to their beliefs about the fact that learning is based on attempt, and negatively but significantly related to their beliefs on ability-based learning. The belief of “there is one truth” was further found to negatively and insignificantly be related to the use of metacognitive strategies. Citing Schommer (1990), Clarebout, Alan, Luyten, and Bamps (2001, p. 53) argued that “Individuals have concepts and beliefs about the nature of science and its development. These concepts and beliefs affect the interpretations of individuals about the necessary tasks related to learning.” All of these findings and statements point to the fact that epistemological beliefs and the use of metacognitive strategies should be emphasized in teacher-training programs (Brownlee, 2001; Öztürk, 1995).

This study is significant in that it deals with the views and subjective beliefs of student science teachers about what knowledge is and how knowing and learning occur, as well as their cognitive patterns about the nature of science and the variables affecting these patterns. There are a limited number of studies which have analyzed the correlation between the epistemological beliefs of student science teachers and their use of metacognitive strategies both in other countries (Peters, 2007) and in Turkey. This study has been carried out in order to identify the relationship between the epistemological beliefs of student teachers and their metacognitive perceptions about the nature of science. In parallel with this aim, the study tries to answer the following research questions:

- At which level do student science teachers have epistemological beliefs and metacognitive perceptions about the nature of science?

- Do their epistemological beliefs and metacognitive perceptions about the nature of science significantly vary based on variables such as gender or grade level?

- Are their epistemological beliefs and metacognitive perceptions about the nature of science related to each other?

Method

Model of The Study

This study is a descriptive research study and employs the correlational scanning model. Such models attempt to identify the change or level of change between two or more variables (Karasar, 2007). Descriptive research aims at describing the current situation, evaluating it based on standard conditions and identifying the relationship between events. Field scanning is one of the descriptive research methods. It tries to provide answers to the question of what the current situation is regarding the problem at hand. In order to achieve this goal, the most available means is the use of questionnaires, which makes it possible to describe and account for the situation in detail (Çepni, 2009).

Participants

The participants of the study, who were volunteers, included a total of 336 student teachers attending the elementary science education division of a department of elementary education at the faculty of educational sciences in a state university in western Turkey. Of the 336 participants, 248 were females (73.8%) and 88 (26.2%) were males. In terms of grade levels, 89 were attending their first year (26.5%), 88 were attending their second year (26.2%), 83 were attending their third year (24.7%), and 76 were attending their fourth year (22.6%).

Data Collection Tools

Data from the study was collected through the scale of epistemological beliefs, the scale of metacognitive perceptions about the nature of science, and a personal information form. The scale of epistemological beliefs was developed by Schommer (1990) and adapted into Turkish by Deryakulu

and Büyüköztürk (2002). It was used to reveal the participants' epistemological beliefs. The scale of metacognitive perceptions about the nature of science was developed by Peters (2007) and adapted to Turkish by the author. This scale was employed to identify participants' metacognitive perceptions about the nature of science. Moreover the personal information form was developed by the author.

The scale of epistemological beliefs is made up of three factors: "Belief that learning is based on attempt" (attempt), "Belief that learning is based on ability" (ability), and "Belief that there is one truth" (one truth). The factor of attempt included 18 items, of which 17 were negative and one was positive. The factor of ability comprised nine items, all of which were positive statements. The factor of one truth consisted of eight items, all of which were positive statements. The participants responded to all items using the Likert-type scale where (1) was "completely disagree" and (5) was "completely agree." In this scale, only factor scores were used; the total scores were not taken into consideration. Higher scores for each factor refers to the fact that participants have underdeveloped beliefs about the factor at hand, whereas lower scores in each factor refers to the fact that participants have developed beliefs about the factor at hand (Deryakulu & Büyüköztürk, 2002). Test-retest reliability of the original scale was .74. Test-retest reliability of the original factors varied between .85 and .63 (Schommer, 1993). In the current study, the Cronbach alpha coefficient for the factors was found to vary between .51 and .75. The Cronbach alpha coefficient for the scale as a whole was found to be .75.

The scale of metacognitive perceptions about the nature of science is a likert-type scale made up of 16 items and five sub-dimensions. The scale was designed to measure the following perceptions: (a) attitudes towards science, (b) the use of metacognition in observations, (c) the use of metacognition in data collection, (d) the use of metacognition in measurement, and (e) the ability to explain the rationale behind inferences. These perceptions were included in the scale, as each perception has significance in teaching science as a way of knowing. Factor analysis showed that one factor accounted for 54% of the total variance (Peters & Kitsantas, 2010). Therefore, the total scores in the scale could be used. The Cronbach alpha coefficient of the original scale was found to be .89 (Peters, 2007).

This scale was translated into Turkish by the author, reviewed by specialists in terms of translation validity, then finalized based upon their feedback.

The scale was first analyzed using exploratory factor analysis to see how it was perceived in a Turkish situation. The scale was then analyzed using confirmatory factor analysis to see how consistent it was with Turkish culture. The results of exploratory factor analysis and confirmatory factor analysis showed that the scale consisted of 12 items and three sub-dimensions ($\chi^2_{\text{difference}} = 129.18$; $df = 43$, $p = .00$). It has been stated that the rate between chi-square goodness of fit and degree of freedom should be five or lower. If the rate of χ^2/sd is lower than five, the factor structure is consistent (Kline, 2005; Meyers, Gamst, & Guarino, 2006). In regard to consistency index, the average-error square root (RMSEA) was found to be .064. An RMSEA value between .00 and .05 shows good fit, and an RMSEA value between .05 and .08 shows acceptable fit (Byrne & Campbel, 1999; Şimşek, 2007; Yılmaz & Çelik, 2009). In this study, the RMSEA value was found to be .064, suggesting an acceptable fit. Normalized fit index (NFI) was found to be .91, and comparative fit index (CFI) was found to be .93.

As stated earlier, the scale was found to have three factors: *Attitude towards science* (3 items, F1), *cause-and-effect capability* (4 items, F2), and *use of metacognition in science* (5 items, F3). Four items from the original scale were excluded as those items occurred in multiple sub-dimensions, thus resulting in a scale with 12 items. The original factor analysis showed that common factor variance for items was higher than .45 (Büyüköztürk, 2011, p. 124). This shows that the total score for the scale could be used (Tabachnick & Fidell, 2012). In the current study, common factor variance for items was found to be higher than .45, also suggesting that the total score in the scale could be used. The highest and lowest possible scores from the scale are 60 and 12, respectively. Reliability coefficients for the factors of the adapted scale were found to be .76 for the factor *attitudes towards science*, .70 for the factor *cause-and-effect capability*, and .73 for the factor *use of metacognition in science*. The total reliability coefficient was found to be .87. Therefore, the adapted scale is a valid and reliable data collection tool for measuring participants' metacognitive perceptions about the nature of science.

Data Analysis

The data obtained was analyzed using descriptive statistics (arithmetical mean, standard deviation, percentage, frequency). The Kolmogorov-Smirnov

test was carried out to see whether or not the factor scores for the epistemological scale and total score for the scale of metacognitive perceptions about the nature of science were normally distributed based on the variables of gender and grade level. Analysis showed that the scores were not normally distributed ($p < .05$). Therefore, the Mann-Whitney U-test, Kruskal-Wallis H Test, and multiple regression analysis were employed to identify the correlations of the factor scores of the epistemological scale and total score for the scale of metacognitive perceptions about the nature of science with the variables of gender and grade level.

Findings

First, the levels of participants' epistemological beliefs and metacognitive perceptions about the nature of science were determined. Table 1 presents the mean factor scores of the epistemological scale and total mean score for the scale of metacognitive perceptions about the nature of science.

Table 1
Arithmetical Mean, Standard Deviation, Minimum and Maximum Values about the Factor Scores of the Epistemological Scale and Total Score of Scale of Metacognitive Perceptions about the Nature of Science

	N	M	Sd	Min	Max
Belief of Learning is Based on Attempt	336	35.0	6.73	20.00	73.00
Belief of Learning is Based on Ability	336	22.8	5.45	12.00	38.00
Belief of There is One Truth	336	25.7	4.59	12.00	49.00
Metacognitive Perceptions about The Nature of Science	336	3.95	.49	2.32	5.00

Table 1 shows that the participants' mean score for the factor of attempt from the epistemological scale was 35.0. The highest score for this factor was 90 and the lowest score was 18. More specifically, scores for this factor between 18 and 42 refer to developed epistemological beliefs, those between 43 and 66 refer to intermediate epistemological beliefs, and those between 67 and 90 refer to underdeveloped epistemological beliefs. Given that the participants' mean score for the factor of

attempt from the epistemological scale was 35.0 shows that they have developed epistemological beliefs. The highest and lowest scores from the factor of ability were 45 and 9, respectively. More specifically, scores for this factor between 9 and 21 refer to developed epistemological beliefs, those between 22 and 33 refer to intermediate epistemological beliefs, and those between 34 and 45 refer to underdeveloped epistemological beliefs. The mean score for the participants in this factor was found to be 22.8, indicating that they have intermediate epistemological beliefs.

Participants were found to have a mean score of 25.7 in the factor of one truth. The highest and lowest scores from this factor were 40 and 8, respectively. The score ranges for this factor are as follows: Scores between 8 and 18 refer to developed epistemological beliefs, those between 19 and 29 refer to intermediate epistemological beliefs, and those between 30 and 40 refer to underdeveloped epistemological beliefs. Therefore, participants were found to have intermediate epistemological beliefs in this factor with a mean score of 25.7.

The mean total score of the participants for the scale of metacognitive perceptions about the nature of science was found to be 3.95. The highest and lowest scores from this scale were 5.00 and 1.00, respectively. Therefore, participants had a close-to-high metacognitive perception about the nature of science with a mean score of 3.95.

Parallel to the second research question are the effects of gender on participants' epistemological beliefs and their metacognitive perceptions about the nature of science. Therefore, the correlations between the scores from the epistemological scale and from the scale on metacognitive perceptions about the nature of science and gender were analyzed using the Mann-Whitney U Test. Table 2 presents the results obtained from this analysis.

Table 2 shows that gender does not have a significant effect on the factor of attempt ($U = 9720.00; p > .05$) and the factor of one truth ($U = 10581.00; p > .05$). However, the variable of gender was found to have a significant effect on the factor of ability ($U = 9294.00; p < .05$). It was further found that female student teachers had much more developed and mature epistemological beliefs. On the other hand, the variable of gender was found not to have any significant effect on participants' metacognitive perception about the nature of science ($U = 9799.50; p > .05$).

Table 2
Results of the Mann-Whitney-U Test Regarding Participants' Scores from the Epistemological Scale and from the Scale on Metacognitive Perceptions about the Nature of Science Based on Gender

	Gender	N	Mean Rank	U	p
Belief of Learning is Based on Attempt	Female	248	163.69	9720.00	.127
	Male	88	182.05		
Belief of Learning is Based on Ability	Female	248	161.98	9294.00*	.038
	Male	88	186.89		
Belief of There is One Truth	Female	248	169.83	10581.00	.672
	Male	88	164.74		
Metacognitive Perceptions about The Nature of Science	Female	248	172.99	9799.50	.155
	Male	88	155.86		

* $p < .05$.

Also parallel to the second research question are the effects of grade level on participants' epistemological beliefs and metacognitive perceptions about the nature of science. Therefore, correlations between the scores from the epistemological scale and from the scale on metacognitive perceptions about the nature of science and gender were analyzed using the Mann-Whitney U Test. Table 3 presents the results obtained from this analysis.

As Table 3 indicates, the variable of grade level does not have any significant effect on the three factors from the epistemological scale: The factor of attempt ($X^2_{(3)} = 5.784$; $p > .05$), the factor of ability ($X^2_{(3)} = 1.041$; $p > .05$) and the factor of one truth ($X^2_{(3)} = 2.951$; $p > .05$). Similarly, the variable of grade level was found not to have any significant effect on participants' metacognitive perception about the nature of science ($X^2_{(3)} = 7.557$; $p > .05$).

The third research question of the study is about the relationship between participants' epistemological beliefs and their metacognitive perceptions concerning the nature of science. This relation was analyzed using multiple regression analysis. Table 4 presents the results of the multiple regression analysis.

Table 4 shows participants' scores for the factor of attempt from the epistemological belief scale and for the scale on metacognitive perception about the nature of science to be negatively related at an intermediate level ($r = -.452$). However, when the scores for the other factors in the epistemological belief scale are controlled, this relationship occurs at $r = -.409$.

Participants' scores for the factor of ability in the epistemological belief scale and for the scale on metacognitive perception about the nature of science are negatively related at a low degree ($r =$

Table 3
Results of the Mann-Whitney-U Test Regarding Participant's Scores from the Epistemological Scale and from the Scale on Metacognitive Perceptions about the Nature of Science Based on Grade Level

	Grade Level	N	Mean Rank	sd	χ^2	Significant difference
Belief of Learning is Based on Attempt	Grade 1	89	155.27	3	5.784	-
	Grade 2	88	183.65			
	Grade 3	83	177.84			
	Grade 4	76	156.24			
Belief of Learning is Based on Ability	Grade 1	89	162.50	3	1.041	-
	Grade 2	88	172.14			
	Grade 3	83	175.28			
	Grade 4	76	163.91			
Belief of There is One Truth	Grade 1	89	166.61	3	2.951	-
	Grade 2	88	180.12			
	Grade 3	83	171.05			
	Grade 4	76	154.47			
Metacognitive Perceptions about The Nature of Science	Grade 1	89	172.78	3	7.557	-
	Grade 2	88	151.06			
	Grade 3	83	161.65			
	Grade 4	76	191.16			

* $p < .05$.

Table 4
Results of Multiple Regression Analysis

Variable	B	Standard Error	β	t	Binary r	Partial r
Constant	5.092	.188	-	27.131	-	-
Attempt	-.031	.004	-.415	-8.172	-.452	-.409
Ability	-.013	.005	-.139	-2.432	-.211	-.132
One Truth	.009	.006	.080	1.451	-.021	.079
R = .468	R ² = .219					
F _(3,155) = 30.994	p = .000					

Confidence Interval = 95%

-.211). However, when scores for the other factors in the epistemological belief scale are controlled, this relationship occurs at $r = -.132$.

Participants' scores for the factor of one truth in the epistemological belief scale and for the scale on metacognitive perception about the nature of science are negatively related at a low degree ($r = -.021$). However, when the scores for other factors in the epistemological belief scale are controlled this relationship becomes positive at a low degree ($r = .079$).

Participants' scores from three factors of the epistemological beliefs scale (attempt, ability, and one truth) and their scores from the scale of metacognitive perception about the nature of science were found to be significant at an intermediate level ($R = .468$, $R^2 = .219$, $p < .001$). These scores account for 22% of the total variance. The factors of attempt and of ability were both further found to be significant predictors of participants' scores for the scale of metacognitive perception about the nature of science. The related regression equation is as follows: *METACOGNITIVE PERCEPTION* = $5.092 - .415 \cdot$ *ATTEMPT* - $.139 \cdot$ *ABILITY* + $.080 \cdot$ *ONE TRUTH*.

Discussion and Conclusions

In the study, the participants were found to have developed and mature epistemological beliefs about the fact that learning is based on attempt. Other epistemological beliefs such as "learning is based on ability and there is only one truth," were found to be less developed and immature. Therefore, they believed knowledge to be acquired through personal attempt rather than ability, and that they might acquire absolute knowledge. This may stem from the fact that the constructivist educational approach in Turkey is not totally practiced at teacher-training programs, even though this approach has been adopted. Additionally, their developed epistemological beliefs about the role of

attempt in learning can be related to this approach (Belet & Güven, 2011). Research suggests that constructivist approach affects development of the epistemological beliefs of student teachers (Howard et al., 2000, as cited in Öngen, 2003). Therefore, it can be argued that the sample of student teachers had experienced the role of attempt in developing novice knowledge in their courses. Their study on the epistemological belief of participants about the role of attempt in learning found that it was more developed and mature than the role of ability in learning, as consistent with the findings of the study carried out by Cheng et al. (2009) on student teachers. Similarly, this finding is consistent with that of the study by Belet and Güven (2011). They also concluded that student classroom teachers have much more developed epistemological beliefs about the role of attempt in learning than that about the role of ability in learning. However the current finding that participants had less developed epistemological beliefs about one truth is not consistent with that of the study by Cheng et al. (2009). On the other hand, it is consistent with the findings by Öngen (2003), Oğuz (2007), and Belet and Güven (2011). Schommer and Dunnell (1997) argued that epistemological beliefs are independent from one another, and therefore some epistemological beliefs may be developed and mature while others may be underdeveloped.

In this study, gender was found to have had no significant effect on participants' epistemological beliefs about the role of attempt in learning and there being one truth, and that gender significantly affected participants' epistemological beliefs about the role of ability in learning. More specifically, female participants were found to have much more developed and mature epistemological beliefs in contrast to male participants. In other words, female participants more frequently believed that learning occurs through personal attempt rather than through ability to learn. It may stem from the fact that the post-modern paradigm in teacher training programs has shaped the epistemological beliefs of student teachers. In the modern period,

beliefs were completely shaped in educational institutions, but in the postmodern period such beliefs may also be formed through extracurricular activities (Terzi, 2005). Therefore, it can be argued that female student teachers are active in extracurricular situations. Schommer (1993) found that female students believe less that immediate learning occurs, in contrast to male students. Chai, Khine, and Teo (2006) analyzed the epistemological beliefs and learning levels of 537 Singaporean student teachers. They concluded that female student teachers had much more developed epistemological beliefs. Similarly, Deryakulu and Büyüköztürk (2005), Oğuz (2007), Öngen (2003), Vural and Gömleksiz (2007), and Belet and Güven (2011) found that female student teachers had much more developed epistemological beliefs about the roles of attempt and ability in learning in contrast to male student teachers. There have also been other studies confirming these results (Belenky, Clinchy, Goldberger, & Tarule, 1986; Demir, 2005; Deryakulu & Büyüköztürk, 2005; Enman & Lupart, 2000; Erdem, 2008; Eroğlu & Güven, 2006; Neber & Schommer-Aikins, 2002; Öngen, 2003; Schommer, 1993). Deryakulu (2004) stated that female students believe in the role of attempt for achieving goals. However, there have also been studies which concluded that epistemological beliefs do not vary based on gender (Aksan & Sözer, 2007; Izgar & Dılmaç, 2008; Sapanıcı, 2012; Terzi, 2005; Tümkaya, 2012).

The other finding of the present study has been that grade level does not have any significant effect on the epistemological beliefs of the participants. Therefore, participants' epistemological beliefs about knowledge and learning can be argued to not change based on grade level. However, student teachers took the course *The Nature and History of Science* in their third year, expecting that they and others who had previously taken this course would have a clear understanding of the concept of the nature of science. They were not seen to have developed this understanding. Findings in the studies about the correlation between epistemological beliefs and grade level are not consistent (Belet & Güven, 2011; Eroğlu & Güven, 2006; Meral & Çolak, 2009; Sapanıcı, 2012; Tümkaya, 2012). For instance, Jehng, Johnson, and Anderson (1993), Paulsen and Wells (1998), and Schommer (1993) found that the higher the grade level, the more developed the epistemological beliefs of student teachers. However, the reasons for the more developed epistemological beliefs may have been due to the attitudes of the teacher trainers, perceived classroom atmosphere, and

assessment conditions, rather than grade level (Tümkaya, 2012). Chan (2003) analyzed the epistemological beliefs of student teachers in Hong Kong and grade level was found to have significant effects on participants' epistemological beliefs about one truth. More specifically, student teachers in their first and second year much more frequently believed that there was only one absolute truth which did not change over time, in contrast to student teachers in their third and fourth years. Tümkaya (2012) also found that grade level has a significant effect on participants' epistemological beliefs about the role of attempt in learning and one truth. More specifically, in contrast to student teachers in their third year, the student teachers in their first and fourth years believed that learning depends on attempts rather than ability. Belet and Güven (2011) found that grade level did not have any significant effect on participants' epistemological beliefs about the roles of attempt or ability in learning but did significantly affect their epistemological beliefs about one truth. This difference was in favor of student teachers in their third and fourth year of school.

In this study, the participants were also found to have positive attitudes towards science, a good command of accounting for cause-and-effect relations, and the use of metacognitive skills. However, this does not mean that they had higher levels of metacognitive perceptions about the nature of science. Instead, they actively used their metacognition in the scientific process, questioning the scientific event at hand with positive attitudes towards science and scientific events. Although there are many studies about metacognition and the nature of science, there have been no mutually agreed-upon definitions for these concepts (Brown, 1987; Lederman 1992; Mccomas, 2005). In addition, there are many scales designed to measure metacognition and epistemological beliefs about the nature of science (Abd-El-Khalick & Lederman, 2000; Abd-El-Khalick, Bell, & Lederman, 1998; Başbay, 2008; Irak & Tosun, 2008; Lederman & Khishfe, 2002). However, given that there are no mutually agreed-upon definitions of these concepts, reliably measuring them is very difficult. On the other hand, there are seven dimensions of the nature of science which have been commonly agreed upon (Lederman 1992; Mccomas, 2005), yet there is no single scale measuring these seven dimensions, nor is it easy to relate these dimensions to the concept of metacognition.

There are numerous studies which have analyzed metacognition in student teachers, students, and teachers in terms of different variables (Azevedo, Grene, & Moss, 2007; Bannert & Mengekamp, 2007; Cooper, 2008; Demir, 2009; Demir-Gülşen, 2000; Demir & Özmen, 2011; Gelen, 2003; Georghiadis 2004; Küçük-Özcan, 2000). However, there have been a limited number of studies which focus on metacognition in student teachers related to a specific field. Çetinkaya and Karışan (2012) studied metacognition in science student teachers and concluded that most of them had good levels of understanding over the nature of science and good levels of metacognitive skills about the nature of science. This finding indicated that student teachers who comprehended and understood the nature of science and the characteristics of scientific knowledge had trust in their ability to understand and learn about science. Therefore, the findings of the current study are consistent with those of the previous studies mentioned above.

In the current study, the metacognitive perceptions of the student teachers about the nature of science were found to not significantly vary based on the variables of gender or grade level. However, the mean scores of female participants appeared to be higher than those of male participants. In terms of grade level, the mean scores related to first-year student teachers' metacognitive perceptions about the nature of science were higher than those of second- and third-year student teachers but lower than those of fourth-year student teachers. There is no study which has analyzed the correlations between the metacognitive perceptions of student teachers about the nature of science and the effects of the variables of gender and grade level. Therefore, the findings of the current study present new insights into these correlations.

The current study has also found that there are intermediate and significant correlations between three factors of the epistemological beliefs scale (the factors of attempt, ability, and one truth) and their scores on the metacognitive perceptions scale. Furthermore, scores for the factors of attempt and ability were found to be significant predictors of scores on the metacognitive perceptions scale. Therefore, student teachers who believed that learning may not occur immediately but occurs as a result of a process can be argued to not have certain information about their metacognition. Therefore, there is a negative correlation between their metacognitive perceptions and the belief that learning occurs based on personal attempts. On the other hand, correlations between

their metacognitive perceptions and the belief that learning occurs on the basis of ability were observed since the participants thought ability to be innate and unable to be improved. A negative correlation between their metacognitive perceptions and the belief that there is only one truth is a desired condition. This finding showed that participants had positive epistemological beliefs and that they were aware of other alternatives. Given that epistemological beliefs are part of human metacognition (Mason & Bromme, 2010), as stated by Schraw (2001), education should aim at changing beliefs and improving the higher-level thinking capacity of individuals. Therefore, metacognitive-based activities should be part of teaching and learning activities (Başbay, 2013). There have been no specific studies about the correlations between science student teachers' metacognitive perceptions about the nature of science and their epistemological beliefs. However, Belet and Güven (2011) found a significant but low correlation between the epistemological beliefs of classroom teachers and the usage level of metacognitive strategies. Sapancı (2012) found a positive correlation between student teachers' metacognitive levels and the factor of attempt, a negative but significant correlation between student teachers' metacognitive levels and the factor of ability, and a negative but insignificant correlation between student teachers' metacognitive levels and the factor of one truth. Başbay (2013) concluded that critical thinking affects epistemological beliefs and metacognitive awareness has a partial instrumental role in this correlation. Özgelen (2012) found a significant correlation between student teachers' metacognitive levels and their epistemological beliefs. Research concluded that individuals with developed epistemological beliefs have much more developed metacognitive awareness (Abd-El-Khalick & Akerson, 2004; Deniz, 2011). Therefore, it is safe to argue that the higher the epistemological beliefs of student teachers, the higher their metacognitive perceptions about the nature of science.

Based on the findings of this study the following suggestions have been developed for future studies:

- The reasons for underdeveloped epistemological beliefs and lower levels of metacognitive perceptions about the nature of science by male science student teachers may be analyzed to reveal the factors affecting them.
- Metacognitive perceptions of student teachers have not been studied based on the variables of gender and grade level. Therefore, such studies can be carried out.

- Given that the epistemological beliefs of student teachers predict their views about the nature of science, their epistemological beliefs may be improved through different activities in teacher training programs.
- Similar studies can be carried out on different groups of participants and on the effects of other variables besides gender and grade level on epistemological beliefs and metacognitive perceptions about the nature of science.

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