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PRE-SERVICE TEACHERS' SCIENTIFIC EPISTEMOLOGICAL BELIEFS AND SCIENCE TEACHING EFFICACY BELIEFS: A CORRELATIONAL STUDY

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Abstract:
The purpose of the study was to determine the relationship between pre-service teachers' scientific epistemological beliefs and their science teaching efficacy beliefs. A correlational research design was used. The sample consisted of 115 level 100 pre-service teachers (73 males and 42 females). The Students Scientific Epistemological Views questionnaire (SSEV) and the Science Teaching Efficacy Beliefs Inventory (STEBI-B) were used to collect the data. It was found that scientific epistemological views of pre-service teachers were availing as indicated by the overall mean above 3 (M = 3.58, SD = .49). The dimensions of methodological approach and scientific attitude (M =3.90, SD = .62) and nature of scientific knowledge (M = 3.54, SD = .58 were availing. However, the dimension of authority and accuracy of scientific knowledge (M = 3.23, SD = .68) was less availing. It was also found that pre-service teachers' science teaching efficacy beliefs were low (M = 3.3, SD = .38).On the subscales, pre-service teachers' Personal Science Teaching Efficacy (PSTE) was low (M = 2.99, SD = .44). However, their Science Teaching Outcome Expectancy (STOE) was high (M = 3.76, SD = .58). The results indicated that there was a significant positive association between scientific epistemological views and science teaching efficacy beliefs (r = .591, p < .01). Also, the scores of STEBI significantly predicted SSEV scores (R^2 = .42, p = .01). Personal science teaching efficacy (PSTE) did not significantly predict scientific epistemological views (t = 2.441, p = .016). However, science

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teaching outcome expectancy (STOE) significantly predicted scientific epistemological views ($t = 8.184$, $p < .01$).

Keywords: scientific epistemology, self-efficacy, pre-service teachers, correlational study

1. Introduction

The teaching and learning processes are influenced by different cognitive variables. One important variable is epistemological beliefs. Epistemological beliefs express the beliefs on the nature of knowledge and gaining knowledge (Aypay, 2010). Conley et al (2004) defined epistemological beliefs as the beliefs about nature of knowledge and knowing. Epistemological belief refers to individual views about the nature of knowledge and knowing (Hofer & Pintrich, 2002). Aypay (2010) indicated that epistemological beliefs were related to variables such as achievement motivation, learning approaches, motivation and learning, study strategies and problem solving (Phillips, 2001), learning styles and reflective thinking (Phan, 2008), academic performance (Schommer, 1993). Again, studies show that epistemological beliefs were related to teaching and learning conceptions (Chan & Elliot, 2004; Cheng, Chan, Tang, and Cheng, 2009).

According to Bondy et al (2007), one of the beliefs that influence teaching and learning fall within the domain of personal epistemology. Research indicated that teacher' beliefs about knowledge and how one comes to know influence their practice. Hofer (2002) noted that beliefs about knowledge and knowing have a powerful influence on learning and thus deepening teachers understanding of this process can enhance teaching effectiveness (as cited in Bondy et al, 2007). Hammer and Elby (2002) also elaborated on this point when they asserted that epistemological beliefs can provide an alternative interpretive lens for teachers to use in understanding their students' ideas and behavior, in assessing students' abilities and needs, and in adapting their plans and strategies for instruction (as cited in Bondy et al, 2007). Teachers' epistemological beliefs affect their behaviour and consequently students' beliefs and learning (Schommer-Aikins, 2004). Research found that students with more availing belief profiles had higher levels of motivation and task performance in general (Buelh & Alexander, 2005). Research showed that students with sophisticated epistemological beliefs are able to explain science and scientific knowledge; to think like scientists and use scientific methods; to use scientific knowledge in daily life; to express an opinion about the results of their studies and to make decisions about the quality of scientific knowledge (Kirmizigul & Bektas, 2019).

1.1 Problem

According to Schommer (1990), there is a theoretical assumption that learners have identifiable conceptions and beliefs about the nature and development of knowledge, and that these conceptions and beliefs actually affect the interpretation of learning tasks, the engagement in particular learning activities, and comprehension (as cited in

Clarebout, Elen, Luyten, & Bamps, 2010). Again, Schommer reported that there is a relationship between epistemological beliefs and learning outcomes (as cited in Clarebout, Elen, Luyten, & Bamps, 2010).

According to Phan (2008), epistemological views of individuals are considered to have an important role in their learning and teaching processes (as cited in Gunes & Bati, 2018). These views influence students' efforts and academic achievement (Cano, Cardelle-Elawar 2004; Buehl, Alexander 2001). According to Hofer (2001), individuals' perspectives concerning the definition, structuring, evaluation and formation of knowledge are shaped by their epistemological beliefs (as cited in Gunes & Bati, 2018). Epistemological beliefs are viewed as an important factor with respect to the interpretation of information and knowledge and, therefore, with respect to the process of learning in general (Kampa, Neumann, Heitmann, & Kremer, 2016). Epistemic cognition influences the extent to which individuals make meaning of and engage with complex problem solving (Hofer, 2002). For example, Epistemological beliefs have been found to be associated with students' learning motivation, learning strategies, learning outcomes, and achievement as well as students' conceptual understanding (Kampa, Neumann, Heitmann, & Kremer, 2016).

Hashweh (1996) reported that teachers' epistemological beliefs were consistent with their preferred ways of teaching (as cited in Kirmizigul & Bektas, 2019). Also, studies indicated that naive epistemological beliefs are associated with traditional pedagogical beliefs, while sophisticated epistemological beliefs are more associated with constructivist views of teaching (Deng, Chai, Tsai & Lee, 2014; Ismail & Abdel-Majeed, 2006). Pre-service teachers' epistemic cognition is thought to impact the depth of understanding achieved during teacher education courses and teachers' decision making, planning, orchestrating, and assessment in subsequent practice (Buehl & Fives, 2016; Yadav & Koehler, 2007). Ismail and Abdel-Majeed (2006) stated that pre-service teachers with sophisticated epistemological beliefs were more likely to adopt a student-centered teaching orientation compared to the pre-service teachers who hold naive epistemological beliefs.

The success of educational reforms is contingent on the development of influential self-efficacy among teachers (Chin, 2005). Erdem and Demirel reported that teachers who lack confidence in their capability to bring about success in the classroom are unable to teach effectively (as cited in Flores, 2019). More studies support the idea that teachers with a relatively higher self-efficacy exhibit inclination towards utilization of cooperative and child centered learning strategies while those with lower self-efficacy tends to employ the traditional teacher approach (Flores, 2019).

Teachers' sense of efficacy has been shown to be a significant indicator of effective teachers. Pedagogical preparation and content knowledge are linked to science teaching efficacy. According to Joseph (2010), efficacy has two dimensions: self-efficacy and outcome expectancy. According to Mansfield & Woods-McConney (2012), science teaching efficacy can be defined as a teacher's perception of his or her capability to successfully teach science to students (as cited in Petersen, 2018). Gorski, Davis, and

Reiter (2012) posit that teachers and teacher educators are increasingly recognizing the significance of the connection between self-perception of teaching ability and competence to teach. Riggs and Enochs (1990) concluded that the manner in which pre-service teachers view themselves and their roles in science teaching is partly derived from their self-efficacy and thus affects persistence, classroom academic focus, and other classroom behaviors (as cited in Flores, 2015). Research such as (Kizilgunes, Tekkaya & Sungur, 2009; Tsai *et al*. 2011) have reported a relationship between epistemological beliefs and self-efficacy in learning (as cited in Kapucu & Bahçivan, 2015). Kizilgunes, Tekkaya, and Sungur (2009) found that, while the source and development dimensions of scientific epistemological beliefs are significantly and positively related to self-efficacy in learning science, the justification dimension is significantly and negatively related to self-efficacy in learning science (as cited in Kapucu & Bahçivan, 2015). Tsai *et al*. (2011) also reported that only the 'certainty' dimension among four dimensions of scientific epistemological beliefs is significantly related to self-efficacy in learning science, but their finding for directionality was negative. Looking at the empirical evidence on the importance of epistemological beliefs and self-efficacy, and the association between them, this study wants to ascertain the relationship between epistemological beliefs of pre-service teachers and their science teaching efficacy. The findings of this study will form a basis for explicit epistemological beliefs instruction and the need to develop pre-service teachers' self-efficacy.

1.2 Research Questions

1) What are pre-service teachers' scientific epistemological beliefs?
2) What are pre-service teachers' science teaching efficacy beliefs?
3) What is the relationship between pre-service teachers' scientific epistemological beliefs and their science teaching efficacy beliefs?

2. Literature Review

2.1 Epistemological Beliefs

The construct epistemological belief is a subset of the wider belief system, defined to be one's conceptions about the nature of knowledge and learning (Schommer, 1990).

Epistemic beliefs are individuals' beliefs about the nature of knowledge, how knowledge is constructed, and how knowledge can be justified (Gu, 2016). Epistemology is a branch of philosophy that addresses questions about the nature of human knowledge and justification of knowing (Muis et al., 2006). Researchers are concerned about beliefs individuals hold about how one comes to know, how knowledge can be justified, and how these theories and beliefs influence individuals' cognitive processes (Hofer & Pintrich, 1997).

Researchers employ diverse terms (e.g., epistemic beliefs, epistemological beliefs, personal epistemology and epistemic cognition) when they refer to the beliefs people hold regarding the nature of knowledge and knowing (Gu, 2016). Epistemological belief

refers to individual views about the nature of knowledge and knowing (Hofer & Pintrich, 2002). Personal epistemological beliefs have an important influence on personal cognitive and meta-cognitive processes. These beliefs also influence learning not only individually but also as a whole (Aypay, 2010). Schommer (1990) stated that, epistemological belief consists of the following five sub-dimensions: "*source of knowledge*", "*certainty of knowledge*", "*organization of knowledge*", "*control of learning*", and "*speed of learning*". Source of knowledge refers to the belief in or rejection of authority; certainty of knowledge questions whether knowledge is absolute/unchanging or changing/developing; organization of knowledge is related to the knowledge being compartmentalized or integrated; control of learning examines whether learning is genetic or acquired through efforts, and speed of learning is associated with whether learning is rapid or a gradual process that takes place over time (Schommer, 1990).

Schommer characterized epistemological beliefs in each dimension along the ends of a continuum ranging from "*naive*" or "*sophisticated*", respectively (Muis, 2004). According to Schommer (1990), naïve epistemological beliefs are those believing that knowledge is certain, that is comprised of isolated pieces, handed down by authority, that the process of learning is quick, and the ability to learn is fixed and innate. On the contrary, a person who holds the opposite beliefs is considered to have "*sophisticated*" beliefs. Muis (2004) argued that the terms "*sophisticated*" and "*naive*" carry a value judgment with positive and negative connotation and proposed the terms "*availing*" and "*non-availing*" respectively (as cited in Chrysostomou & Philippou, 2010). Epistemological views are not only related to the knowledge of individuals, but they also affect their approach, attitudes and behavior concerning success, development, and learning (Güneş, Batı, Katrancı 2017). Tsai (2001) stated that students were influenced by their teachers in the development of their epistemological views and that teachers' reflection of their own epistemological views in the classroom environment may have a positive effect on their students.

This interaction between the teacher and students is a determining factor for the development of epistemological views of both prospective teachers and their prospective students. It has also been suggested that the epistemological views of prospective teachers may provide clues as to how they will approach learning activities (Ravindran, Greene, & DeBacker, 2005) and future classroom teaching activities (Brownlee, 2003; Pajares, 1992). According to Buelh and Alexander (2001), epistemological beliefs are domain specific, meaning they may vary depending on the domain under consideration (as cited in Chrysostomou & Philippou, 2010).

2.2 Dimensions of Epistemological Beliefs

Perry and his colleagues clustered intellectual development into four sequential categories: dualism, multiplicity, relativism, and commitment within relativism (Hofer & Pintrich, 1997). Dualism represents right or wrong view of the world and the individuals who have dualistic views believe that authorities know the truth and convey it to the learner. Multiplicity represents a modification of dualism and the individuals who are in

this position believes that all views are equally valid, and that each person has a right to have his or her own opinion. The individuals at relativistic category believed that knowledge is relative and contingent, and they realized the need to choose and affirm one's own commitments. The individuals at commitment within relativism category make and affirm commitments to values, careers, relationships, and personal identity (Hofer & Pintrich, 1997). Schommer (1990) hypothesized five dimensions of epistemological beliefs including: Stability (tentative to unchanging), structure (isolated to integrated), source (authority to observation and reason), speed of acquisition (quick or gradual), and control of acquisition (fixed at birth or lifelong improvement) (as cited in Conley, Pintrich, Vekiri & Harrison, 2004)

Schraw, Bendixen, and Dunkle (2002) developed the Epistemic Beliefs Inventory (EBI) to measure dimensions; certain knowledge (stability), simple knowledge (structure), omniscient authority (source), quick learning (speed), and innate ability (control). Hofer and Pintrich (1997) suggested four general epistemological dimensions including certainty of knowledge (stability), simplicity of knowledge (structure), source of knowing (authority), and justification for knowing (evaluation of knowledge claims). Elder (2002), identified several dimensions that characterized fifth grade science students' epistemological beliefs. The dimensions were: Changing nature of science (stability), coherence of knowledge (structure), source of knowledge (source), and role of experiments (refers to knowledge justification in science) (as cited in Conley, Pintrich, Vekiri, & Harrison, 2004). Less sophisticated stances on the source dimension view knowledge as external to the self, originating and residing in outside authorities. The justification dimension is concerned with the ways in which students use evidence and evaluate claims. In science, justification is concerned with the role of experiments and the use of data to support arguments (Conley, Pintrich, Vekiri, & Harrison, 2004). Individuals at lower levels on justification of knowledge use authority or observation rather than experiments, data, and rules of inquiry to justify knowledge (Hofer, 2000).

The certainty and development dimensions reflect beliefs about the nature of knowledge. Less sophisticated belief on the certainty dimension belief in a right answer, in comparison to more sophisticated views that there may be more than one answer to complex problems. The development dimension is concerned with a belief that recognizes science as an evolving subject and that idea and theories can change on the basis of new data and evidence. Students with more sophisticated stances endorse statements about ideas in science continuing to change, or discoveries in science leading experts to change what they think is true (Conley, Pintrich, Vekiri, & Harrison, 2004). Hofer and Pintrich (1997) argued that the central part of individuals' epistemological theories is beliefs about the nature of knowing, and beliefs about the nature of knowledge. Less sophisticated beliefs about Source of Knowledge believe that knowledge originates outside the self and resides in external authority and more sophisticated beliefs understand that knowledge is constructed by the knower in interaction with others (Hofer & Pintrich, 1997). The beliefs about Certainty of

Knowledge range from a belief in a right answer to belief in more than one answer to complex problems (Conley et al., 2004).

Less sophisticated beliefs about Development of Knowledge believe that science is unchanging subject. On the other hand, more sophisticated beliefs believe that science is evolving and changing subject (Conley et al., 2004).

2.3 Self-Efficacy

Bandura (1977) defined self-efficacy as a judgment of one's own capabilities to perform actions that they believe could lead to desired results. Bandura (1986) claimed that self-efficacy beliefs are the strongest predictors of motivation and performance (1986). According to Bandura (as cited in Menon & Sadler, 2017), the concept of self-efficacy beliefs consists of two dimensions: outcome expectancy and personal efficacy. While outcome expectancy corresponds to a person's belief that his/her behavior will produce desired outcomes, personal efficacy is a person's confidence to execute actions leading to the achievement of a desired goal. Guskey and Passaro suggest that both dimensions of self-efficacy are significant for teaching but act independently of each other (as cited in Menon & Sadler, 2017). For instance, elementary teachers might expect that certain actions and classroom behaviors performed well will bring desired results in student learning (high outcome expectancy) but might not have sufficient confidence to execute those actions (low personal efficacy) (as cited in Menon & Sadler, 2017). Efficacy beliefs according to Bandura, determine to what extent people will try to cope with the situation as well as how much time they will spend on the action (as cited in Aydin & Boz, 2010). Bandura posit that self-efficacy beliefs play a major role in determining teaching practices including the choice of instructional activities, organization of lessons, and preparation to handle challenging situations (as cited in Menon & Sadler, 2017). Bandura (1997) proposed that four factors might produce changes in self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological/affective states (as cited in Palmer, Dixon & Archer, 2015). The first source, Enactive mastery experiences are authentic experiences in which one demonstrates the capability to succeed in the task. The second source of efficacy was vicarious experiences, and these occur when attainment is modeled by another person (as cited in Palmer, Dixon & Archer, 2015). Thus, seeing or visualizing a person perform a task successfully can enhance the observer's belief in his/her capability. The third source of efficacy information were verbal persuasion, which occurs when "*significant others express faith in one's capabilities*" (Bandura, 1997, p. 101). The fourth source of self-efficacy is physiological/affective states, which refers to one's reactions to stress, fatigue and mood (as cited in (Palmer, Dixon & Archer, 2015).

3. Methodology

3.1 Design of the Study

The study used a correlational research design. Correlational research is a type of non-experimental research in which the researcher measures two variables and assesses the statistical relationship (i.e., the correlation) between them with little or no effort to control extraneous variables (Price, Jhangiani, Chiang, Leighton & Cuttler, 2017).

3.2 Sampling and Instrument

Participants were selected by convenience sampling. The sample consisted of 115 level 100 pre-service teachers (73 males and 42 females). Two instruments were used for the study. These are the Students Scientific Epistemological Views (SSEV) questionnaire and the Science Teaching Efficacy Beliefs Inventory (STEBI-B). Participants completed both the SSEV and the STEBI-B online.

3.3 Scale on Scientific Epistemological Views (SSEV)

The Scale on Scientific Epistemological Views (SSEV) was developed and validated by Gunes and Bati (2018) to elicit the epistemological views of prospective teachers. The SSEV consisted of three sub-dimensions; "authority and accuracy in scientific knowledge", "methodological approach and scientific attitude", and "nature of scientific knowledge". The internal consistency (Cronbach's alpha) was calculated to be .861. The Cronbach's alpha of the three factors of the SSEV ranged from .727 to .762. The SSEV consisted of 23 items on a 5-point Likert-scale, ranging from strongly disagree to strongly agree (Gunes & Bati, 2018). The items were formulated based on the most commonly used scales and the sub-dimension of epistemological views defined by Schommer, Hofer and Pintrich, and Elder (as cited in Gunes & Bati, 2018).

3.4 Science Teaching Efficacy Beliefs Inventory (STEBI-B)

The Science Teaching Efficacy Beliefs Inventory (STEBI-B) was developed by Enochs and Riggs (1990). The STEBI-B consisted of two components; Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). The PSTE has 13 items while the STOE has 10 items. In the entire instrument consisted of 23 items in a five-point Likert scale from (strongly disagree = 1) to (strongly agree = 5). The scales include some negative items, and so were reversed during the analysis. After reversing the negative items, a high mean score in PSTE indicates high self-efficacy in science teaching. Similarly, a high mean score in STOE means high outcome expectancy for science teaching. The Cronbach's alpha for all 23 statements was .90 (Enochs & Riggs, 1990). The internal consistency of the 13 PSTE statements and the 10 STOE statements was α = .90 and α = .76 respectively.

3.5 Data Analysis

The data was analyzed using IBM SPSS version 21. Descriptive statistics (means and standard deviations) were used to determine the level of participants' epistemological beliefs and their science teaching efficacy beliefs. Pearson correlations and multiple linear regression analyses were used to determine the relationship between epistemological beliefs and self-efficacy.

4. Results and Discussions

4.1 Characteristics of Participants

Table 1 presents the sex and ages of participants of the study. Participants consisted of 73 (63.5%) males and 42 (36.5%) females. The ages of participants ranged from 17 to 31. Majority of participant aged between 20-26 years.

Table 1: Gender and age of participants

		f	**%**
Sex	Male	73	63.5
	Female	42	36.5
	Total	**115**	**100**
Age	17	1	0.9
	18	4	3.5
	19	4	3.5
	20	12	10.4
	21	8	7
	22	19	16.5
	23	17	14.8
	24	16	13.9
	25	14	12.2
	26	11	9.6
	27	6	5.2
	28	1	0.9
	30	1	0.9
	31	1	0.9
	Total	**115**	**100**

4.2 Pre-Service Teachers' Scientific Epistemological Beliefs

Table 2 shows the overall mean scores and standard deviations of the students' scientific epistemological views (SSEV) scale and the three dimensions of authority and accuracy of scientific knowledge (ACSK), methodological approach and scientific attitude (MASA) and nature of scientific knowledge. In general, from the results the scientific epistemological views of pre-service teachers were availing as indicated by the mean score above 3 (M = 3.58, SD = .49). The dimensions of methodological approach and scientific attitude (M =3.90, SD = .62) and nature of scientific knowledge (M = 3.54, SD = .58 were also more availing. However, the dimension of authority and accuracy of scientific knowledge (M = 3.23, SD = .68) was less availing.

Table 2: Descriptive statistics of scores of SSEV and subscales (N = 115)

Scale and dimensions	M	SD
Students scientific epistemological views (SSEV)	3.58	0.49
Authority and accuracy of scientific knowledge (ACSK)	3.23	0.68
Methodological approaches and scientific attitude (MASA)	3.90	0.62
Nature of scientific knowledge (NOSK)	3.54	0.58

4.3 Pre-Service Teachers' Science Teaching Efficacy Beliefs

Table 3 shows the overall mean scores and standard deviations of the STEBI-B scale and the subscales of personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). As indicated by the mean scores, in general pre-service teachers' science teaching efficacy beliefs were low as indicated by the low overall mean score (M = 3.3, SD = .38). Pre-service teachers' personal science teaching efficacy (PSTE) was low (M = 2.99, SD = .44). However, their science teaching outcome expectancy was high (M = 3.76, SD = .58).

Table 3: Descriptive statistics of scores of STEBI-B and their subscales (N = 115)

Scale and subscales	M	SD
Science teaching efficacy beliefs (STEBI-B) scale	3.33	0.38
Personal science teaching efficacy (PSTE)	2.99	0.44
Science teaching outcome expectancy (STOE)	3.76	0.58

4.4 Scientific Epistemological Beliefs and Science Teaching Efficacy Beliefs

A Pearson product-moment correlation coefficient was computed to assess the relationship between pre-service teachers' scientific epistemological beliefs and their science teaching efficacy beliefs.

Table 4 shows the results of the Pearson correlations. The results indicated that there was a significant positive association between scientific epistemological views and science teaching efficacy beliefs (r (112) = .591, $p < .01$). A scatterplot summarizes the results (see figure 1).

Table 4: Correlations between SSEV and STEBI-B total scores

		SSEV	STEB
SSEV	Pearson Correlation	1	.591**
	Sig. (2-tailed)		.000
	N	115	115

** Correlation is significant at the 0.01 level (2-tailed).

Table 5 shows the Pearson correlations of the dimensions of scientific epistemological beliefs and the dimensions of science teaching efficacy beliefs. The Pearson correlations results revealed significant positive relationship between authority and accuracy of scientific knowledge and science teaching outcome efficacy (r = .458, p < .01), personal science teaching efficacy (r = .266, p = .004). The results also revealed significant positive relationships between methodological approach and scientific attitude (MASA) and

STOE (r = .520, p < .01). There was no significant relationship between MASA and PSTE (r = .134, p = .154). Also, there was significant relationships between nature of scientific knowledge (NOSK) and STOE (r = .471, p < .01), between NOSK and PSTE (r = .272, p = .003). For the subscales of the science teaching efficacy beliefs, the Pearson correlation results showed no significant relationship between personal science teaching efficacy and science teaching outcome expectancy (r = .155, p = .098). For the dimensions of the scientific epistemological views, there was significant relationship between ACSK and MASA (r = .340, p < .01), between ACSK and NOSK (r = .301, p = .001), and between MASA and NOSK (r = .515, *p* < .01).

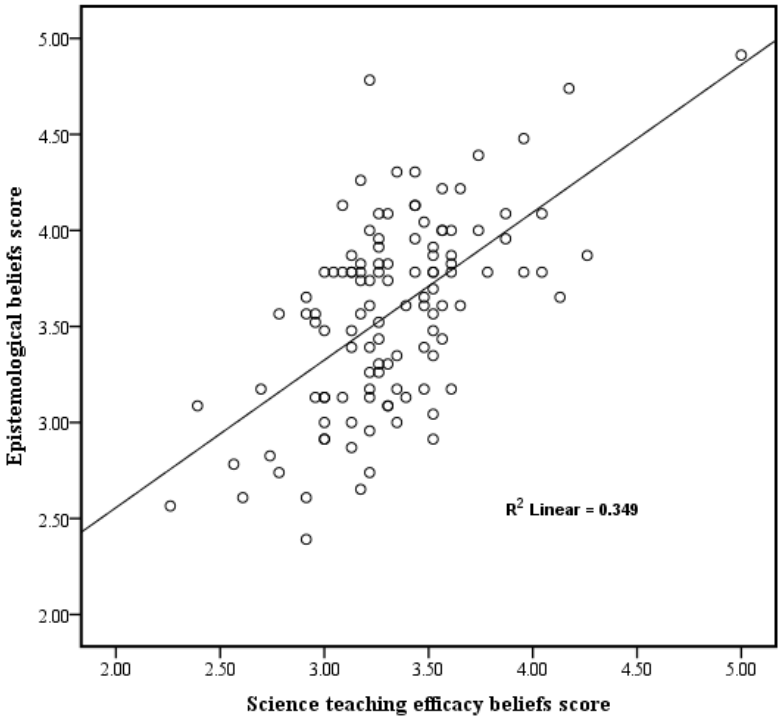

Figure 1: Scatter plot between SSEV and STEBI-B scores

Table 5: Correlations among the subscales of SSEV and STEBI-B

		ACSK	MASA	NOSK	PSTE	STOE
ACSK	Pearson Correlation	1				
	Sig. (2-tailed)					
MASA	Pearson Correlation	.340**	1			
	Sig. (2-tailed)	.000				
NOSK	Pearson Correlation	.301**	.515**	1		
	Sig. (2-tailed)	.001	.000			
PSTE	Pearson Correlation	.266**	0.134	.272**	1	
	Sig. (2-tailed)	0.004	0.154	0.003		
STOE	Pearson Correlation	.458**	.520**	.471**	0.155	1
	Sig. (2-tailed)	.000	.000	.000	0.098	

** Correlation is significant at the 0.01 level (2-tailed).

Multiple linear regression analysis was used to see if the scores on PSTE and STOE can predict SSEV scores (see table 6, table 7 and table 8). Results of the multiple linear regression indicated that there was a collective significant effect between PSTE, STOE and scientific epistemological views (SSEV). The results showed that the scores of STEBI significantly predicts of SSEV scores ($R = .648$, $R^2 = .42$, F (2, 112) = 40.548, $p = .01$). Personal science teaching efficacy (PSTE) did not significantly predict scientific epistemological views ($t = 2.441$, $p = .016$). However, science teaching outcome expectancy (STOE) significantly predicted scientific epistemological views ($t = 8.184$, $p < .01$).

Table 6: Model summary of multiple linear regressions

Model	R	R^2	Adjusted R^2	SE
1	.648a	0.42	0.41	0.38114

Predictors: (Constant), Science teaching outcome expectancy, Personal science teaching efficacy.

Table 7: Regression coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	sig
		B	Std. Error	Beta		
1	(Constant)	1.065	0.314		3.393	.001
	PSTE	0.201	0.082	0.178	2.441	.016
	STOE	0.508	0.062	0.596	8.184	.000

Dependent variable: epistemological beliefs.

Table 8: ANOVA of the regression analysis

Model		SS	df	MS	F	Sig.
1	Regression	11.78	2	5.89	40.548	.000
	Residual	16.27	112	0.145		
	Total	28.05	114			

Dependent variable: epistemological beliefs.

The regression model is: Epistemological beliefs (SSEV score) = 1.065 + 0.178 PSTE + 0.596 STOE. PSTE and STOE accounted for 42% of the variability in epistemological beliefs scores ($R^2 = .42$).

4.5 Discussion

The study aimed at determining pre-service teachers' scientific epistemological beliefs and their science teaching efficacy beliefs. The Scientific epistemological views of pre-service teachers were availing. The dimensions of methodological approach and scientific attitude (M =3.90, SD = .62) and nature of scientific knowledge (M = 3.54, SD = .58 were also more availing. However, the dimension of authority and accuracy of scientific knowledge (M = 3.23, SD = .68) was less availing. Gunes and Bati (2018) reported that prospective teachers had a higher mean score in the sub-dimension of authority and accuracy in scientific knowledge compared to the other sub-dimensions. They also found that prospective teachers had more developed/mature scientific epistemological views in the sub-dimension of authority and accuracy in scientific knowledge than in other sub

dimensions. It was found that developed/mature epistemological views of the participants were at a high level for the authority and accuracy sub-dimension (Gunes & Bati, 2018). Kaplan and Akgul (2009) reported that prospective elementary science teachers were "traditional" according to the epistemological beliefs they hold. Tarmo and Bevins (2016) reported that pre-service science teachers hold dualist views about science. They viewed science knowledge to be simple, rigid and derivative of specific bodies of knowledge handed down by authorities such as textbooks and experts.

The study also found that in general pre-service teachers' science teaching efficacy beliefs was low. It was also found that pre-service teachers' personal science teaching efficacy (PSTE) was low (M = 2.99, SD = .44). However, their science teaching outcome expectancy was high (M = 3.76, SD = .58). On the contrary, Joseph (2010) reported that pre-service teachers had higher PSTE scores, but lower STOE scores. However, Ngman-Wara (2012) in a study of pre-service secondary school science teachers' science teaching efficacy beliefs found that pre-service secondary science teachers have very high level of secondary science teaching self-efficacy beliefs. Ates and Saylan (2015) found that pre-service science teachers' academic self-efficacy and academic motivation toward biology was high.

Zorlu (2017) also reported that the vast majority of pre-service science education teachers (95%) have epistemological beliefs closer to the traditional understanding of science. Results of the multiple linear regression indicated that there was a collective significant effect between PSTE, STOE and scientific epistemological views (SSEV). Personal science teaching efficacy (PSTE) did not significantly predict scientific epistemological views (t = 2.441, p = .016). However, science teaching outcome expectancy (STOE) significantly predicted scientific epistemological views (t = 8.184, p < .01). Zorlu (2017) in a study to investigation of the relationship between pre-service science teachers' epistemological beliefs about the nature of science and their self-efficacy perceptions, found that there was a positive linear relationship between the scores of scientific epistemological beliefs and science learning self-efficacy, and that science learning self-efficacy predicted and explained 23% of the scientific epistemological beliefs.

Yilmaz-Tuzun & Topcu (2008) in their study to determine the relationships among Pre-service Science Teachers' Epistemological Beliefs, Epistemological World Views, and Self-efficacy Beliefs found that three of the predictor variables (self-efficacy, outcome expectancy, and world view) contributed significantly to innate ability dimension of epistemological beliefs. Only epistemological world view contributed significantly to the simple knowledge dimension. Outcome expectancy contributed significantly to the certain knowledge dimension. None of the predictor variables significantly contributed to the dimension of omniscient Authority. Kapucu & Bahçivan (2015) reported that scientific epistemological belief dimensions of source and justification significantly and positively related to self-efficacy in learning physics. However, epistemological belief dimensions related to the nature of knowledge (certainty and development) did not have significant impact on self-efficacy in learning physics. They concluded that there was a positive and significant relationship among scientific epistemological beliefs, self-efficacy

in learning physics. Langcay, Gutierrez, Valencia, and Tindowen (2019) in their study of epistemological beliefs of pre-service teachers, revealed that pre-service teachers tend to be sophisticated and have a complex structure and reasoning along source of knowledge. They also reported that pre-service teachers tend to be naïve along ability to learn, stability of knowledge, and speed of learning. Kizilgunes, Tekkaya, and Sungur (2009) found that, while the source and development dimensions of scientific epistemological beliefs are significantly and positively related to self-efficacy in learning science, the justification dimension is significantly and negatively related to self-efficacy in learning science (as cited in Kapucu & Bahçivan, 2015).

Pearson correlations results revealed significant positive relationship between authority and accuracy of scientific knowledge (ACSK) and science teaching outcome efficacy [STO], personal science teaching efficacy (PSTE). The results also revealed significant positive relationships between methodological approach and scientific attitude (MASA) and science teaching outcome expectancy (STOE). However, there was no significant relationship between MASA and PSTE. Also, there was a significant relationship between nature of scientific knowledge (NOSK) and science teaching outcome expectancy (STOE). There was also a significant relationship between nature of scientific knowledge (NOSK) and personal science teaching efficacy (PSTE). For the subscales of the science teaching efficacy beliefs, the Pearson correlation results showed no significant relationship between personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). For the dimensions of the scientific epistemological views, there was significant relationship between ACSK and MASA, between ACSK and NOSK and between MASA and NOSK.

5. Conclusion

The study found that pre-service teachers' epistemological beliefs were informed. However, their science teaching efficacy beliefs were low. Also, there is a strong positive significant relationship between pre-service teachers' epistemological beliefs and science teaching efficacy. There is therefore the need for explicit teaching of epistemological beliefs to pre-service teachers such that it will affect their teaching efficacy beliefs positively. Teacher educators should give pre-service teachers the opportunity to explicate their epistemological and efficacy beliefs. This will gradually help them to develop sophisticated, availing and high epistemological and teaching efficacy beliefs. Also, teacher educators can design of appropriate activities that will effectively improve prospective teachers' beliefs and increase their confidence about science teaching.

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