



An Investigation of Epistemological Beliefs of Physics Teachers According to Different Variables

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ABSTRACT

Epistemological beliefs adopted by individuals determine their knowledge, learning and teaching orientations. For this reason, the purpose of this research is to investigate physics teachers' belief levels, as well as the questions about what effect gender, professional experience, and educational background variables have on these levels. Causal-comparative model was used to study these variables. Participants were 205 physics teachers consisting of 106 women and 99 men who work in the Central Anatolia Region of Turkey. All the data was collected with the Scientific Epistemological Beliefs Scale developed by Conley, Pintrich, Vekiri & Harrison (2004). This scale was adapted into Turkish by Özkan (2008). The data was analyzed using parametric tests. Ultimately, findings indicated that physics teachers had sophisticated epistemological beliefs. In addition, there was no statistically significant difference between female and male teachers in terms of beliefs. Educational background variable was found not to have any effect on epistemological beliefs of physics teachers. In regards to professional experience variable, teachers with less experience had more sophisticated epistemological beliefs about the source of knowledge, certainty of knowledge and justification of knowledge.

Keywords: Epistemological beliefs, physics teachers, gender, professional experience, educational background

Fizik Öğretmenlerinin Bilimsel Epistemolojik İnançlarının Farklı Değişkenlere Göre İncelenmesi

Öz

Bireylerin sahip olduğu epistemolojik inançlar, bilgiye, öğrenmeye ve öğretmeye yönelik tutumlarını belirler. Bu araştırmada fizik öğretmenlerinin epistemolojik inanç düzeyleri ve bu inançlar üzerinde cinsiyet, mesleki deneyim ve öğrenim durumu değişkenlerinin etkisi araştırılmıştır. Araştırmada, nedensel karşılaştırma modeli kullanılmıştır. Araştırmaya İç Anadolu Bölgesinde görev yapmakta olan 106'sı kadın, 99'u erkek toplam 205 fizik öğretmeni katılmıştır. Veriler, Conley, Pintrich, Vekiri ve Harrison (2004) tarafından geliştirilen ve Özkan (2008) tarafından Türkçeye uyarlanmış olan Bilimsel Epistemolojik İnanç Ölçeği ile toplanmıştır. Verilerin analizinde parametrik testlerden yararlanılmıştır. Elde edilen bulgular fizik öğretmenlerinin gelişmiş epistemolojik inançlara sahip olduğunu göstermiştir. Ayrıca epistemolojik inançlar açısından kadın ve erkek öğretmenler arasında istatistiksel açıdan anlamlı farklılık olmadığı görülmüştür. Öğrenim durumu değişkeninin de fizik öğretmenlerinin epistemolojik inançları üzerinde etkili olmadığı bulgusuna ulaşılmıştır. Mesleki deneyim değişkeninin etkisi araştırıldığında ise, mesleki deneyimi daha az olan öğretmenlerin bilginin kaynağına, bilginin kesinliğine ve bilginin gerekçelendirilmesine yönelik olarak daha gelişmiş epistemolojik inançlara sahip oldukları görülmüştür.

Anahtar kelimeler: Epistemolojik inançlar, fizik öğretmenleri, cinsiyet, mesleki deneyim, öğrenim durumu

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1 | INTRODUCTION

Efforts towards acquiring knowledge began when humans had an urge to understand the world in which they live. As knowledge was revealed, it was subsequently questioned. Not only in science and philosophy, but in all disciplines, it became a common goal to find sound knowledge. Hence the discipline of questioning knowledge, in other words, epistemology was born. Epistemology is a branch of philosophy that studies the nature, borders, and rationale of knowledge. Epistemological beliefs are a personal and subjective system of beliefs regarding the nature of knowledge and how 'knowing' occurs (Hofer & Pintrich, 1997; Schommer, 1990).

Epistemological beliefs are concerned with whether knowledge is certain or mutable, where to obtain reliable knowledge, how knowledge is produced, and how knowledge is justified (Ryder et al., 1999; Schommer, 1990; Duell & Schommer-Aikins, 2001). An individual's epistemological beliefs determine their viewpoint about what knowledge is, how it is produced, and how knowing, learning and teaching processes take place (Cano & Cardelle-Elewar, 2004; Deryakulu, 2004; Paulsen & Wells, 1998; Tezci & Uysal, 2004).

There is another perspective different from the framework of the epistemological belief as "epistemological resources". According to this perspective, individual's beliefs about his own knowledge and learning are defined as personal epistemology (Lising & Elby, 2005). Some researchers have claimed that successful science education will be achieved by replacing students' personal epistemology with scientific epistemology (King & Kitchener, 1994; Strike & Posner, 1985). However, according to Hammer and Elby (2003), these epistemologies are not concepts that need to be overcome. Instead, they suggest the definition of "epistemological sources" for student epistemologies. According to them, epistemological sources are different from misbeliefs and misconceptions. They define epistemological sources as epistemologies that are developed in students' daily lives and "knowledge in pieces" that can be built (Bang & Medin, 2010; diSessa, 2006). They emphasized the importance of recognizing students' epistemological resources for science teaching and making it easier for students to use them appropriately. In their studies (Hammer & Elby, 2002; Hammer & Elby, 2003), they grouped these sources as "knowledge as propagated stuff", "knowledge as free creation", and "knowledge as fabricated stuff". They explained these sources as follows:

- Knowledge as propagated stuff: It is knowledge that transfer from a source to a recipient ("Mommy told me").
- Knowledge as free creation: It is knowledge that emerge spontaneously from the mind of the child such as story, game or character.
- Knowledge as fabricated stuff: It is knowledge that inferred or developed from other knowledge.

According to Schommer (1993), epistemological beliefs are represented in two different ways. Individuals with naive beliefs hold the view that an absolute truth exists, and knowledge is certain. These individuals believe that the possessor of knowledge is the authority, and knowledge can be shared with learners solely by this authority. This belief entails reliance on the innate ability of students in the matter of quick learning. Individuals with sophisticated beliefs on the other hand are those that believe knowledge is relative and mutable. They consider knowledge to be constructed by individuals through resources such as wisdom, intuition, and observation. In this notion, learning efforts of students are valuable and learning ability can be improved (Deryakulu & Büyüköztürk, 2002).

Therefore, scientific epistemological beliefs bear significance in education. There are various studies correlating epistemological beliefs with learning and academic success (Brownlee et al., 2001; Cano, 2005; Demirel, 2014; Demirli et al., 2010; Deryakulu, 2004; Koç-Erdamar & Bangir-Alpan, 2011; Özkan, 2008; Sapanç, 2012; Schommer & Dunnell, 1994; Windschitl & Andre, 1998). Moreover; Brownlee et al., (2001) proved in their studies that teachers with sophisticated beliefs are more successful in their jobs.

Epistemological beliefs are not an innate or immutable personal characteristic; they are rather psychological constructs that are developed over time. Studies indicate that epistemological beliefs can be affected by several factors. In this study, the main variables such as gender, educational background, and professional experience were included. The results of the literature are presented by grouping as studies consisting of students, prospective teachers, and teachers.

Studies about the effect of gender on epistemological beliefs have produced diverse results. Studies conducted with students mostly indicate that female students have more sophisticated beliefs in comparison to male students. Considering the studies conducted at primary schools (Islıcık, 2012; Neber & Schommer-Aikins, 2002; Özkal, 2007; Özkan & Tekkaya, 2011; Topçu & Yılmaz Tüzün, 2009), high schools (Aydemir et al., 2013; Kurt, 2009; Schommer, 1993; Schommer & Dunnell, 1994), and at university level (Deryakulu & Büyüköztürk, 2005; Enman & Lupart, 2000; Terzi, 2005), it is seen that female students have higher scores. Some studies have shown that male students have higher levels of epistemological beliefs (Chai et al., 2006; Wood & Kardash, 2002). On the other hand, there are a few studies pointing out that gender has no effect on epistemological beliefs (Chan & Elliott, 2002; Chan & Sachs, 2001; Conley et al., 2004; Karabulut & Ulucan, 2012; Trautwein & Lüdtke, 2007).

In the findings of the studies conducted with prospective teachers, it is seen that there is a significant difference in favor of women (Aksan, 2006; Aypay, 2011b; Chai et al., 2006; Ertugay, 2019; Oğuz, 2008; Öngen, 2003; Yılmaz, 2014) and in favor of men (Meral & Çolak, 2009; Yılmaz & Şahin, 2011). Also, it was found that gender does not have a significant effect on epistemological beliefs for prospective teachers (Balci, 2009; Chan, 2003; Rakıcioğlu, 2005; Terzi, 2005). In the studies in which the working group was formed by the teachers, most studies reveal that epistemological beliefs do not differ according to gender (Kaya & Ekici, 2017; Karhan, 2007; Phan, 2008). Apart from this, while some studies have obtained results in favor of female teachers (Akyıldız, 2018), some studies show that the results are in favor of male teachers (İçen & Akpınar, 2016).

Considering the studies examining the effect of the educational background on epistemological beliefs, studies revealed that students at higher educational levels have more sophisticated beliefs (Eren, 2006; Hofer & Pintrich, 1997; Kurt, 2009; Law et al., 2008; Mason et al., 2006; Schommer, 1993; Schommer et al., 1997; Schommer, 1998). Also, Jehng et al. (1993) found that postgraduate students' epistemological beliefs are more developed than those of undergraduate students.

Various findings were found in the studies in which the sample of prospective teachers was formed. While some of the studies have demonstrated that epistemological beliefs become sophisticated as the grade level of prospective teachers increases (Chai et al., 2006; Karabulut & Ulucan, 2012; Meral & Çolak, 2009; Yılmaz & Şahin, 2011), some of them have results revealing the opposite (Aypay, 2011b). There are also studies that conclude that the epistemological beliefs of prospective teacher candidates do not vary according to the grade level (Balci, 2009; Öngen, 2003; Rakıcioğlu, 2005). Only one study examining the relationship between teachers' education levels and epistemological beliefs was found. In this study (Karhan, 2007), a significant difference was found between university graduate teachers and non-university graduate teachers in favor of university graduate teachers.

In the literature, studies examining the epistemological beliefs of teachers show that epistemological beliefs differ according to professional experience. In these studies, it was examined that teachers who have worked for a longer time have more sophisticated beliefs (İçen, 2012; İçen & Akpınar, 2016; Karhan, 2007; Kaya & Ekici, 2017; Özdemir & Köksal 2014). When the results of these studies were examined according to the dimensions of the scales used, it was found that teachers with more experience had a firmer belief that teacher is the source of knowledge and that learning is a student's innate trait. Yılmaz (2014) determined in her study that teachers with more experience believed that learning depends on effort and that learning should take place instantly. Kaya and Ekici (2017) found that young teachers

believe that learning depends more on ability. In the studies, while there was no significant difference in beliefs about the source of knowledge (İçen & Akpınar, 2016), it was observed that teachers with more experience had more developed beliefs than younger teachers in terms of beliefs about the certainty of knowledge (İçen & Akpınar, 2016; Karhan, 2007; Kaya & Ekici, 2017). On the other hand, Chai et al. (2006) concluded that professional experience does not affect epistemological beliefs.

Nowadays, the way knowledge is presented is as important as the knowledge itself in the field of teacher education. Donaghue (2003) stated that beliefs play an equally important role as orientations in teachers' adoption of new approaches, techniques, and classroom activities. Driscoll (2012) underlined that epistemological beliefs determine the way teachers utilize different teaching strategies. Therefore, teachers' scientific epistemological beliefs should always be taken into account (Kaleci & Yazıcı, 2012; Tümkaya, 2012). Studies show that teachers with naive beliefs tend to regard knowledge as immutable and certain; and they also believe that teacher possesses knowledge, learning is an innate ability, and learning quickly or not depends on the student (Schommer, 1998). However, it has been reported that teachers with sophisticated epistemological beliefs think that knowledge is developed over time, it can also change over time, and students construct knowledge themselves. (Howard et al., 2000). Studies indicate that there is a correlation between teachers' epistemological beliefs and (1) planning and implementing all learning-teaching processes (Eren, 2006; Aypay, 2011a), (2) improving efficiency in learning environments (Eren, 2009), and (3) structuring educational classroom activities (Öngen, 2003). Taking all of these findings into consideration, it is clear that which epistemological beliefs teachers adopt has an effect on how students develop their own epistemological beliefs. Moreover, teachers' beliefs also impede reforms in education (Demir, 2012).

Considering how critical the role of epistemological beliefs in learning-teaching process is, it is important to understand these beliefs; in particular, those that affect how teachers shape learning environments (Chan & Elliott, 2002) and adopt new teaching approaches (Sinatra & Kardash, 2004). In the limited number of studies that focus on teachers' epistemological beliefs, samples were social studies teachers (Kaya & Ekici, 2017) and teachers that work in elementary schools (Findlan, 2006; Kahramanoğlu & Özbakiş, 2018; Karhan, 2007; Özdemir et al., 2018; Özdemir & Köksal, 2014). For this study, participants were chosen among physics teachers. It is thought that the study will contribute to the literature as both the selection of physics teachers as the study group and the teachers having doctorate level are included in the educational background variable. In the scope of this study, answers to following questions were sought:

- 1) What are the scientific epistemological belief levels of physics teachers?
- 2) Do scientific epistemological beliefs of physics teachers vary depending on gender?
- 3) Do scientific epistemological beliefs of physics teachers vary depending on professional experience?
- 4) Do scientific epistemological beliefs of physics teachers vary depending on educational background?

2 | METHOD

In this study, causal-comparative model was used to determine epistemological beliefs of physics teachers and the effect of gender, professional experience, and educational background on these beliefs. Causal-comparative research investigates whether or not a current situation or phenomenon differs depending on one or more variables (Sönmez & Alacapınar, 2013). Causal-comparative research studies also aim to determine the reason of an emerging or existing situation or event, the variables that affect these reasons, or the effects themselves; without interfering with current conditions or participants (Büyüköztürk et al., 2009; Büyüköztürk, 2011; Cohen & Manion, 1998). In this study, the dependent variable (epistemological beliefs of teachers) was grouped on the basis of independent variables (gender,

professional experience, and educational background), and then the source of difference among these groups was explored.

PARTICIPANTS

Simple random sampling method was used to choose the sample. The sample consisted of physics teachers working in the Central Anatolia Region of Turkey. 205 physics teachers could be contacted with and volunteered to participate in the study. 106 (52%) of the participating physics teachers were female and 99 (48%) were male. 93 (45%) of these physics teachers worked in Ankara, 51 (25%) in Kayseri, 25 (12%) in Kırşehir, 20 (10%) in Nevşehir, and 16 (8%) in Konya.

In terms of the place of work; 80 (39%) of them worked in Anatolian high schools, 45 (22%) in vocational high schools, 38 (19%) in science high schools, 25 (12%) in Anatolian religious vocational high schools, and 17 in regular high schools. In regards to professional experience; 99 (48%) of the participants had 1-10, 47 (23%) had 11-20, 59 (29%) had 21 or more years of professional experience. With respect to educational background; 129 (63%) of the participants had a bachelor's degree, 59 (24%) had a master's degree, and 26 (13%) had a doctorate degree. Teachers ranged in age from 25 to 52 years ($X = 38.6$; $SS = 2.54$).

Physics teachers comprising the sample were asked if they had ever taken classes on knowledge philosophy (nature of science, history of science, philosophy of science, etc.) since it was thought that it might have had an impact on their epistemological beliefs, 142 (69%) of them declared that they had taken such classes over the course of their undergraduate education, 16 (8%) during postgraduate education, and 13 (6%) during both undergraduate and postgraduate education.

COLLECTION AND ANALYSIS OF DATA

Scientific Epistemological Belief Scale (SEBS) developed by Conley et al. (2004) was used to determine physics teachers' scientific epistemological beliefs. This scale was adapted into Turkish by Özkan (2008). It is a 5-point Likert type scale (5= strongly agree, 1= strongly disagree) and has 26 questions.

SEBS has four dimensions: source, certainty, development and justification of knowledge. High scores in a dimension of this scale implies a high level of belief in the relevant factor (İlhan et al., 2013). Source of knowledge dimension determines if individuals believe in an outer authority as the source of knowledge (Özkan & Tekkaya, 2011). If individuals score a high point in this dimension, then they believe that knowledge is constructed by the learner. Certainty of knowledge dimension measures beliefs regarding the existence of an absolute truth. High scores in this dimension represent beliefs in the existence of multiple truths. Development of knowledge evaluates beliefs regarding the mutable nature of knowledge. Individuals that score high in this dimension believe that knowledge is not immutable; it can change, and individuals are able to develop their knowledge. Finally, justification of knowledge dimension determines whether individuals accept knowledge as-is or judge it in a critical manner based on evidence and expert opinion. High scores in this dimension point to a belief that knowledge is created by a critical review of evidence.

The dimension of the source of knowledge consists of 5 items, the dimension of certainty of knowledge consists of 5 items, the dimension of development of knowledge consists of 6 items, and the dimension of justification of knowledge consists of 9 items. The minimum scores that can be obtained from these dimensions are (5, 5, 6, 9) and the maximum scores (25, 25, 30, 45), respectively. The items in the dimension of the source of information and the certainty of information in the scale were reverse-coded during data entry, so that the high scores from the scale reflect sophisticated (high) epistemological beliefs.

Confirmatory factor analysis resulted in a good model fit ($\chi^2/df=1.44$, $CFI=0.95$, $TLI=0.93$, and $RMSEA=0.04$). Cronbach's Alpha coefficients of the scale were calculated as .68, .66, .71, and .82 at dimensions.

The type of tests to be conducted were determined prior to analysis of data. The data was normally distributed and equal variances were observed, thus parametric tests were used in this study.

3 | FINDINGS

FINDINGS RELATED TO EPISTEMOLOGICAL BELIEF LEVELS OF PHYSICS TEACHERS

Pursuant to the descriptive analysis results of the participating physics teachers' SEBS scores, mean scores were as follows: (3.81 ± 3.66) for the source of knowledge dimension, (3.79 ± 3.19) for the certainty of knowledge dimension, (3.99 ± 3.47) for the development of knowledge dimension, and (4.21 ± 5.76) for the justification of knowledge dimension. According to these results, physics teachers have the most sophisticated epistemological beliefs in the justification of knowledge dimension. Contrarily, certainty of knowledge dimension involves the least sophisticated beliefs. Descriptive analysis results were reported in Table 1.

Table 1. Physics teachers' SEBS scores

Dimension	N	Min	Max	Total mean	SS	Mean
Source of knowledge	205	10	25	19.06	3.66	3.81
Certainty of knowledge	205	10	25	18.97	3.19	3.79
Development of knowledge	205	8	30	23.93	3.47	3.99
Justification of knowledge	205	11	45	37.87	5.76	4.21
Total	205	48	140	111,42	14,27	3,95

Epistemological belief levels were calculated separately for each dimension, taking into account the lowest and highest scores and standard deviations. The level criteria is determined as in Table 2 and the results are presented in Figure 1.

Table 2. Level determining criteria of SEBS

Score ranges of SEBS dimensions	Low level (Naive)	Medium level (Less sophisticated)	High level (Sophisticated)
Source of knowledge ($5\leq x\leq 25$)	$5\leq x<11.33$	$11.33\leq x<17.66$	$17.66\leq x\leq 25$
Certainty of knowledge ($5\leq x\leq 25$)	$5\leq x<11.33$	$11.33\leq x<17.66$	$17.66\leq x\leq 25$
Development of knowledge ($6\leq x\leq 30$)	$6\leq x<13.67$	$13.67\leq x<21.34$	$21.34\leq x\leq 30$
Justification of knowledge ($9\leq x\leq 45$)	$9\leq x<20.50$	$20.50\leq x<32.05$	$32.05\leq x\leq 45$

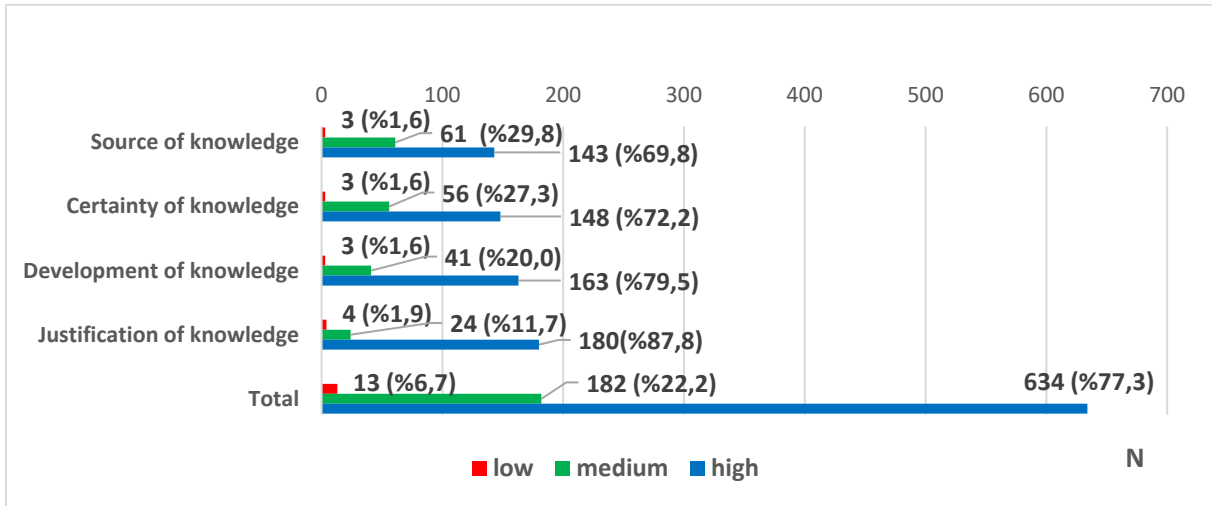


Figure 1. Epistemological belief levels of physics teachers

Answer to the first question of this study (epistemological belief levels of physics teachers) is displayed in Figure 1. According to Figure 1, physics teachers have sophisticated beliefs on all dimensions of SEBS.

GENDER-RELATED FINDINGS

Independent samples t-test was performed to find out whether physics teachers’ scientific epistemological beliefs differ by gender. Relevant results can be found in Table 3.

Table 3. Independent samples t-test results concerning the gender-based comparison of physics teachers’ SEBS scores

SEBS dimensions	Gender	N	X	sd	t	df	p
Source of knowledge	Female	106	19.16	3.478	.410	203	.682
	Male	99	18,95	3.882			
Certainty of knowledge	Female	106	19.19	3.154	1.033	203	.303
	Male	99	18.73	3.238			
Development of knowledge	Female	106	23.84	3.002	-.371	203	.711
	Male	99	24.02	3.936			
Justification of knowledge	Female	106	38.43	5.193	1.442	203	.151
	Male	99	37.27	6.311			
Total	Female	106	112.26	13.13	.880	203	.380
	Male	99	110.51	15.43			

The results of the independent samples t-test presented in Table 3 indicates that mean score of SEBS dimension of female and male participants suggest a certain score difference between the two genders. Female participants have a higher score than male participants in all dimensions but for the development of knowledge dimension, female scores are lower than the scores of men ($\bar{X}_{female}=23.84\pm3.002$, $\bar{X}_{male}=24.02\pm3.936$). Nevertheless, there is not a significant difference in physics teachers’ scores ($t=.880$, $p=.380$) for females ($\bar{X}=112.26\pm13.13$) and males ($\bar{X}=110.51\pm15.43$).

PROFESSIONAL EXPERIENCE-RELATED FINDINGS

One-way ANOVA test was used to detect if there is any difference in the epistemological beliefs of physics teachers with different years of professional experience. The analysis demonstrated that epistemological beliefs of physics teachers show significant difference depending on professional

experience in all dimensions but the certainty of knowledge dimension [$F = 2.606; 6.268; 3.142, p < .05$]. Levene test results showed homogeneity of variance in each dimension ($p = .829; .451; .622; .517$). Results are shown in Table 4.

Table 4. ANOVA results on SEBS sub-dimensions regarding physics teachers' professional experience

SEBS dimensions	Source of Variation	Sum of squares	of sd	Mean square	F	p	Significant difference*
Source of knowledge	Between-group	102.918	3	34.306	2.606	.045	(11-20) – (21+)
	Within-group	2646.379	201	13.166			
	Sum	2749.298	204				
Certainty of knowledge	Between-group	178.187	3	59.396	6.268	.000	(1-10) – (11-20) (11-20) – (21+)
	Within-group	1904.574	201	9.475			
	Sum	2082.761	204				
Development of knowledge	Between-group	49.954	3	16.651	1.385	.248	
	Within-group	2415.948	201	12.020			
	Sum	2465.902	204				
Justification	Between-group	304.798	3	101.599	3.142	.026	(11-20) – (21+)
	Within-group	6499.904	201	32.338			
	Sum	6804.702	204				
Total	Between-group	2233,831	3	744,610	-	,011	
	Within-group	39346,904	201	195,756			
	Sum	41580,735	204				

*Values in bold represent the group that the difference is in favor of.

The results of the one-way ANOVA test presented in Table 4 indicated that the mean scores of the physics teachers on the dimension of SEBS statistically varied according to the variable of professional experience. Tukey's HSD test was carried out to identify the source of these differences. The results of this test demonstrated that:

- In regard to the source of knowledge dimension, the mean scores of the physics teachers with 11 to 20 years of experience ($\bar{X} = 20.17 \pm 3.59$) were significantly higher than that of those with 21 years of experience or more ($\bar{X} = 18.27 \pm 3.59$).
- In regard to the certainty of knowledge dimension, the mean scores of the physics teachers with 1 to 10 years of experience ($\bar{X} = 19.42 \pm 3.60$) were significantly higher than that of those 11 to 20 years of experience ($\bar{X} = 17.51 \pm 2.92$). Also, the mean scores of the physics teachers with 11 to 20 years of experience ($\bar{X} = 20.13 \pm 2.88$) were significantly higher than that of those with 21 years of experience or more ($\bar{X} = 18.86 \pm 2.87$).

- In regard to the justification dimension, the mean scores of the physics teachers with 11 to 20 years of experience ($\bar{X}=37.49\pm5.75$) were significantly higher than that of those with 21 years of experience or more ($\bar{X}= 37.00\pm5.95$).

EDUCATIONAL BACKGROUND-RELATED FINDINGS

One-way ANOVA test was performed to determine whether there is any difference in the epistemological beliefs of physics teachers with different educational backgrounds. Results are shown in Table 5.

Table 5. ANOVA results on SEBS sub-dimensions regarding physics teachers' educational background

SEBS dimensions	Source Variation	of	Sum squares	of	sd	Mean square	F	p
Source of knowledge	Between-group		35.005	2		17.503	1.303	.274
	Within-group		2714.292	202		13.437		
	Sum		2749.298	204				
Certainty of knowledge	Between-group		40.203	2		20.101	1.988	.140
	Within-group		2042.558	202		10.112		
	Sum		2082.761	204				
Development of knowledge	Between-group		31.245	2		15.622	1.296	.276
	Within-group		2434.658	202		12.053		
	Sum		2465.902	204				
Justification	Between-group		54.527	2		27.264	.816	.444
	Within-group		6750.175	202		33.417		
	Sum		6804.702	204				
Total	Between-group		35,005	2		17,503	1,303	,274
	Within-group		2714,292	202		13,437		
	Sum		2749,298	204				

The results of the one-way ANOVA test presented in Table 5 indicated that there is not a significant difference in the total SEBS scores of the physics teachers ($F= 1.303$; $p>.05$). According to the dimensions of SEBS, in regard to the source of knowledge dimension ($F= 1.303$; $p>.05$), the certainty of knowledge dimension ($F= 1.988$; $p>.05$), the development of knowledge dimension ($F= 1.296$; $p>.05$) and the justification dimension ($F= .816$; $p>.05$) did not vary according to the physics teachers' educational background.

4 | DISCUSSION & CONCLUSION

This study examined the epistemological belief levels of physics teachers who work in the Central Anatolia Region of Turkey, and whether gender, professional experience and educational background have any effect on these beliefs. In the studies in which epistemological beliefs were examined in the literature, it was found that teachers had sophisticated beliefs in some subjects, but they could have naive beliefs in other subjects. To illustrate, it has been determined that teachers mostly have sophisticated beliefs about the commitment to learning (İçen, 2012; Kaleci & Yazıcı, 2012; Karhan, 2007; Kaya & Ekici, 2017; Murat, 2018; Yılmaz, 2014), but naive beliefs about the certainty of knowledge (Akyıldız, 2014; Bacanlı Kurt, 2010; Karhan, 2007; Murat, 2018). In this study, analyses aiming to determine the epistemological belief levels of physics teachers proved that physics teachers have sophisticated beliefs in all SEBS dimensions. The most sophisticated epistemological beliefs were observed in the justification of knowledge dimension. This

result indicates that physics teachers do not accept knowledge unconditionally. On the contrary, it might be interpreted as they have a critical perspective on knowledge and tend to look for evidence from different sources in the presence of new knowledge. Considering that it is effective in shaping the educational environment, this result is very promising for the future.

To answer the second research question of this study, the existence of any significant difference in epistemological beliefs of physics teachers of different genders was investigated. Analyses showed that there is no statistically significant difference between female and male teachers in terms of epistemological beliefs. Results of this study are comparable to the findings of Izgar and Dilmaç (2008), İçen (2012) and Kaya and Ekici (2017), which indicate that the gender variable has no effect on teachers' epistemological beliefs. One can see diverse gender-related outcomes in the literature. Teachers who graduate from the same department of education faculties are expected to have similar epistemological beliefs. However, the reason for the different results in different studies may be the effect of different variables such as age, environment, and culture (apart from the variable that was investigated). In new studies, the effect of gender variable on epistemological beliefs can be examined together with the other variables.

The third question of this study was the following: Do epistemological beliefs of physics teachers vary depending on professional experience? Analyses conducted in line with this purpose resulted in a significant difference in the source of knowledge dimension of SEBS. Between physics teachers with (11-20) years and (21 and more years) of professional experience, this difference was in favor of those with less experience. In the certainty of knowledge dimension, teachers with (1-10) years of experience were significantly different in comparison to teachers with (11-20) years. Also, teachers with (11-20) years of experience were significantly different in comparison to teachers with (21 and more years) of experience. Similarly, the justification of knowledge dimension indicated a significant difference in favor of less experienced teachers, between those with (11-20) years and (21 and more years) of experience. Therefore, teachers with less experience are found out to have more sophisticated beliefs about the source, certainty and justification of knowledge. Such beliefs were seen to become more superficial as the amount of professional experience grew. Studies of Findlan (2006), Karhan (2007), and Özdemir and Köksal (2014) produced similar findings. This might have been caused by the curriculum implemented in schools until recently. Up until 2005, dominant approach in Turkey was behavioral education; knowledge was certain and absolute, teacher was the possessor of knowledge, and he/she was also responsible for sharing this knowledge with students (Özdemir & Köksal, 2014). Growing up with this educational philosophy and also working in accordance with it may have caused the teachers to develop similar epistemological beliefs. After 2005, this positivism-based approach was slowly replaced with a student-centred curriculum in which teachers guide students to aid them in acquiring knowledge. This situation was most likely reflected on the findings of this study.

In respect to educational background, there is no significant difference between epistemological beliefs of physics teachers in relation to different backgrounds. Yet, the study of Kaya and Ekici (2017) on social sciences teachers indicated that teachers holding a master's degree have more sophisticated beliefs than those with a bachelor's degree. This situation brings to mind a difference in interpretation: Some researchers think that epistemological beliefs do not only consist of knowledge-related beliefs. According to these researchers (Brownlee et al., 2002; Clarebout et al., 2001), beliefs associated with learning process should be addressed as epistemological beliefs. Likewise, Schommer (1990) stated that these beliefs have a multi-dimensional structure which encompasses the learning beliefs related to processes of acquisition and utilization of knowledge. In parallel with this opinion, Demir (2012) found in a study with prospective teachers that teachers who have taken scientific research methods class adopt higher epistemological beliefs than those who have not. Most of the physics teachers who took part in this study have taken courses about knowledge acquisition (scientific research methods, nature of science, history of science, etc.) at the time of their undergraduate education. It seems clear that the fact that these courses are not preferred at the master's and doctoral level explains this result. However, the low number of studies on this change in the literature and the fact that the samples are generally composed of students and

prospective teachers indicate that evidence is insufficient to form a general opinion at this point. It would be appropriate to include the effect of educational status in new studies with teachers.

On the other hand, according to the epistemological resource defined by Hammer and Elby (2002), everyone creates their own personal epistemological belief. "Knowledge as propagated stuff", "knowledge as free creation" and "knowledge as fabricated stuff" are unique to the individual. Different beliefs may develop even in individuals who have the same lives. This explains the different results obtained with the same scales and similar samples in the literature. In this case, it is clear that more detailed research is needed for explaining the development of epistemological beliefs. Designing new studies with methods such as case study and phenomenology that examine small samples in depth may explain the reasons why similar samples point to different epistemological beliefs. Similarly, more detailed information about the development of epistemological beliefs can be obtained with studies that would extend over a longer period, such as longitudinal studies.

The findings of this study are limited to the findings obtained from the SEBS and the SEBS was applied only to physics teachers. In new studies, the epistemological beliefs of teachers working in other branches can be examined. In addition to quantitative data, qualitative data collection methods such as interview and observation can be used to explain the reasons for the quantitative findings. In addition, the relationships of teachers with variables such as their epistemological beliefs and their behavior in the classroom environment and their teaching methods and techniques can be examined.

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