# An instrument development study for determining prospective science teachers' science-specific epistemological beliefs

**[1*]Mustafa Serdar KOKSAL and [2]Pelin ERTEKIN**

**[1]Hacettepe University, Faculty of Education, Department of Special Education, Ankara-TURKEY**
**[2]Inonu University, Faculty of Education, Department of Elementary Education, Malatya-TURKEY**

**[1*]Corresponding author E-mail: bioeducator@gmail.com**
**[2]E-mail: pelin.ertekin@inonu.edu.tr**

Received 19 Feb., 2016
Revised 23 Jun., 2016

## Contents



## Abstract

The study is focusing on development of an instrument to determine science-specific epistemological beliefs of prospective science teachers. The study involved 364 (male = 82, female = 282) prospective science teachers enrolled in a science teacher education program. The confirmatory factor analysis, reliability analysis and correlation analysis were done for validating 15-item instrument. The confirmatory factor analysis results confirmed that the instrument had 5 dimensions (speed of knowledge acquisition, tentativeness of knowledge, structure of knowledge, source of knowledge and control over knowledge acquisition). The Cronbach alpha values of all dimensions ranged from .42 to .60. The correlation analysis showed that dimensions were partially independent from each other. The results of the study supported validation of a five-dimension instrument with partially independent dimensions except for low reliability values.

**Keywords**: Instrument development, prospective science teachers, science-specific epistemological beliefs, validity and reliability

# Introduction

Epistemological beliefs refer to beliefs about origin, justification, methods, nature, limits of knowledge and characteristics of knowledge acquisition (Hofer, 2002; Schommer-Aikins, 2002). For years, researchers tried to understand the concept of epistemological belief with the questions of "what is knowledge?", "how knowledge is acquired?", "what is the source of knowledge?", "what is the structure of knowledge?", "what are the limits of knowledge?" etc. As the pioneer of these endeavors, Perry (1968) observed undergraduate students for framing a definition of personal epistemological belief. After his longitudinal study, Perry (1968) presented a model that includes personal developmental stages in a single dimension to define personal epistemological belief (Moore, 2002). In the history of models for explaining epistemological beliefs (Belenky, Clinchy, Goldberger & Tarule, 1986, Baxter Magolda, 1992; King & Kitchener, 1994), developmental models accepting epistemological beliefs as gradually developing and associated beliefs were common up to model of Schommer (1994). According to Schomer (1990), a multidimensional model is more sufficient for the nature of complex knowledge. So Schommer (1994) defined epistemological beliefs as a multidimensional system of partially independent beliefs including five dimensions; speed of knowledge acquisition, tentativeness of knowledge, structure of knowledge, source of knowledge and control over knowledge acquisition. Tentativeness of knowledge refers to beliefs about changeability of knowledge while structure of knowledge involves beliefs about accepting knowledge with isolated parts vs. interrelated concepts. Source of knowledge refers to beliefs about authority as knowledge owner vs. individual as knowledge producer while speed of knowledge acquisition refers to beliefs about learning as a gradual process vs. quick process. Control over knowledge acquisition involves beliefs about learning ability as an unchangeable vs. improvable characteristics (Schommer 1994; Hofer, 2001). Previous studies associated sophisticated epistemological beliefs with belief in complex and tentive knowledge, no immediate learning, improvable learning ability and self-generated sources of knowledge production (Olafson & Schraw, 2006; Schommer, 1994). The studies using Schommer (1994) model as a framework showed that epistemological beliefs of students had direct and indirect effects on learning (Schommer-Aikins, 2002; Topcu & Yilmaz-Tuzun, 2008). Indirectly it was shown that individuals' epistemological beliefs predicted significantly their conceptions about learning (Chan, 2011). Further, epistemological beliefs were examined by considering their relations to other factors and it was shown that epistemological beliefs of students were associated with their academic performance (Cano, 2005), academic achievement (Lodewyk, 2007), goal orientation (Phan, 2008), information processing levels (Schreiber & Shinn, 2003), test anxiety and task value (Paulsen & Feldman, 1999). In science domain, these beliefs also were shown to be associated with attitudes toward science (Fulmer, 2014) and science achievement (Topcu & Yilmaz-Tuzun, 2008). Moreover, studies showed that epistemological beliefs of students predicted self-regulated learning of students (Braten & Stromso, 2005; Metallidou, 2013; Köksal &Yaman, 2012). According to study results of Karimi and Atai (2014), epistemological beliefs of students were associated with comprehension of texts. Similarly Mateos, Sole, Castells and Lamas (2014) pointed out the epistemological beliefs of university students were associated with their comprehension of texts about nuclear energy. Chan, Ho and Ku (2011) investigated relationship between epistemological beliefs and critical thinking of 111 undergraduate students. Their findings addressed that students believing unchangeable knowledge represented lower degree of two-sided thinking and poor performance in evaluating counterarguments.

Association of epistemological beliefs with learning might change across domains of learning such as psychology or science (Hofer, 2000). Hofer (2000) criticized Schommer (1990)'s Model that the model is about general epistemological beliefs and it is not an appropriate model to explain domain-specific epistemological beliefs. Hofer (2000) reported that students in her study accepted knowledge in science as more certain than knowledge in psychology. Hofer (2006) also added that determining epistemological beliefs by using domain-general instruments is not sensitive to domain-specific aspects of epistemological beliefs. In disciplinary level, Tsai (2006) studied with 428 high school students and the author found that students accepted biology knowledge as more tentative than physics knowledge. Topcu (2013) also investigated disciplinary differences in terms of epistemological beliefs and the author addressed that pre-service teachers have different epistemological beliefs about chemistry and biology in terms of tentativeness of knowledge and source of knowledge. Buehl, Alexander and Murphy (2002) investigated difference in domain-specific epistemological beliefs and they reached the finding that college students believed learning mathematics necessitates more effort than learning history. By considering domain-specific nature of epistemological beliefs, some researchers investigated science-specific epistemological beliefs of students (Ozkal, Tekkaya, Sungur, Cakıroglu & Cakıroglu, 2011; Liang & Tsai, 2010; Wu & Tsai, 2011; Liang, Lee & Tsai, 2010). Science-specific epistemological beliefs refer to beliefs about origin, justification, methods, nature, limits of scientific knowledge and characteristics of science knowledge acquisition. In terms of learning and teaching science, teachers' and prospective science teachers' scientific epistemological beliefs have an important place due to their beliefs effect on their actions. Jones and Carter (2006) addressed that epistemological beliefs of teachers influence their classroom practices while Schraw and Olafson (2002) said that epistemological beliefs of teachers is associated with their tendency to select a teaching method. Moreover, Hammer, Elby, Scherr and Redish (2005) pointed out effect of epistemological beliefs of teachers on their construction of learning environment. Similar situations are also valid for prospective teachers. Boz and Boz (2014) found that epistemological beliefs of prospective teachers have a relationship with their teaching concerns. Taskın Sahin (2012) determined that epistemological beliefs of prospective teachers predicted their approaches to learning. In addition Erdamar and Alpan (2013) found that epistemological beliefs of prospective teachers affected their teaching practice and problem solving skills. As seen from the literature, epistemological beliefs of prospective teachers have associations with their learning and teaching. However there is a need to investigate epistemological beliefs of prospective teachers and their association of different variables in terms of domain-specific epistemological beliefs. Especially science as a domain of learning should be investigated due to epistemological status of science knowledge understood by people. Hofer (2000) stated science knowledge is accepted as more certain than other knowledge types and domain-general measurements are not enough to explain these beliefs. Moreover Schraw (2001) addressed that domain-specific epistemological beliefs have a predominant role in task-specific learning. Liu and Tsai (2008) suggested a more contextualized assessment of scientific epistemological beliefs. Hence determining science-specific epistemological beliefs of prospective science teachers by using science-specific instruments has importance in terms of explaining their epistemological beliefs, learning and approaches to teaching.

For measuring science-specific beliefs various ways of measurement were used up to now (Pomeroy, 1993; Rubba & Anderson, 1978; Stathopoulou & Vosniadou, 2007; Conley, Pintrich, Vekiri & Harrison, 2004; Tsai & Liu, 2005). However there is limited number of measurement instruments or ways for science-specific epistemological beliefs of prospective teachers (Brauer &Wilde, 2014; Topcu, 2013; Guven, Sulun & Cam, 2014). Brauer and Wilde (2014) developed a scale with 5-point Likert type items while Topcu (2013) used a scale and interview to determine science-specific epistemological beliefs of prospective teachers. In another study, Guven, Sulun and Cam (2014) used reflective diaries and open-ended questionnaire to investigate science-specific epistemological beliefs of prospective teachers. However none of them include components to increase attention to the items and to situate the items. But content-embedded items increase attention to the items due to stimulus provided by the description. Also embedding items into a scientific text contextualizes and situates the items (Drechsel , Carstensen & Prenzel, 2011). Content-embedded items involve a short description of the scientific phenomena discovered by the scientists and then the items are represented by relating them to the beginning description. The contents flow provide readers to inquire process of the scientific knowledge acquisition of the scientist and so this provides making decisions about their personal scientific epistemological belief based on the context. Therefore the purpose of this study is to develop an instrument with content-embedded items for determining science-specific epistemological beliefs of prospective science teachers.

# Methodology of Research

This study was conducted to develop an instrument with content-embedded items for determining science-specific epistemological beliefs of prospective science teachers. For this purpose, the validity and reliability of the instrument were examined.

### Participants

The participants of the study were 364 (Male=82, Female=282) prospective science teachers enrolled in science teacher education program of a middle scale university. The participants were freshmen (n=94), sophomore (n=87), junior (n=98), and senior students (n=85). When looked at their history about epistemology, 148 of them took course about epistemology and 58 of them participated into conferences about epistemology before. Prospective science teacher's epistemological beliefs shape their learning (Taskın Sahin, 2012). Moreover, their future science teaching environment from the methods used to their students' epistemological beliefs is also affected by these beliefs (Alpan, 2013; Boz & Boz, 2014; Elby, Scherr & Redish, 2005; Torres & Vasconcelos, 2015). Consequently, starting from the teacher education, determining their science-specific epistemological beliefs in a reliable and valid way is the first and important step for forming their scientific epistemological belief.

### Development process of the instrument

In this study the purpose of the instrument (Science-specific Epistemological Beliefs Inventory) was to determine scientific-epistemological beliefs of the prospective science teachers by focusing on five dimensions of science-specific epistemological beliefs: speed of knowledge acquisition, tentativeness of knowledge, structure of knowledge, source of knowledge and control over knowledge acquisition. These five dimensions were suggested by Schommer (1990) and her model of five-dimension epistemological beliefs system or sub-components of the model was used to study epistemological beliefs of prospective teachers (Sinatra & Kardash, 2004). The instrument involved 15 items. Considering with the five dimensions, the instrument involved 15 science-specific items (three per the dimension) were selected from the literature (Pomeroy, 1993; Schomer, 1990). The items were embedded into three different texts about well-known science topics and scientists (Action and reaction forces, Isaac Newton, Law of dominance, Gregory Mendel, Conservation of mass, Antoine Lavoisier) from physics, biology and chemistry. These topics and scientists were known enough by the prospective science teachers, by this way we decreased cognitive load of the texts. Just two participants did report that they did not know about Newton and Mendel. However Lavoisier were known less than Newton and Mendel, 110 of the participants did not know about Lavoisier. But after recalling conservation of mass, they indicated their unfamiliarity was confusion.

In the text the items were inserted into short descriptions of the topic and following story of a prospective science teacher. Each text involved five different groups of items about each dimension of the beliefs; hence 15 items were involved in three texts. Each item had five choices representing sophisticated and unsophisticated beliefs. In answering the items one prospective teacher could select no choice or more choices than one. In scoring prospective students' answers were categorized as "blank (0)", "unsophisticated belief (1)", "mixed belief (2)" and "sophisticated belief (3)" by considering model of Schommer (1990). The inventory can be seen in the appendix. Completing the inventory took 30 minutes.

In development of the instrument following stages were conducted. (1) Determining purpose of the instrument, (2) Researching for related literature, (3) Deciding about dimensional structure of the instrument, (4) Writing items from the literature, (5) Deciding about science content in which the items were embedded, (6) Deciding about embedding design of the items (7) Preparing draft of the instrument, (8) Asking three prospective science teachers about their ideas on understandability, easiness to answer and reading load (9) Taking two science education experts' ideas about the draft, (10) Making revisions based on the ideas (11) Applying the instrument to prospective science teachers, (12) Making confirmatory factor analysis, (13) Making reliability analysis and (14) Preparing final form of the instrument.

## Research Method

This study was conducted to develop an instrument with content-embedded items for determining science-specific epistemological beliefs of prospective science teachers. For this purpose, the validity and reliability of the instrument were examined.

## Content Validity

For content validity, table of specifications were used. Following Table 1 involves content and dimensions of the instrument.

**Table 1.** Specifications for alignment of *Items of the Instrument and Dimensions of Science Epistemological Beliefs*

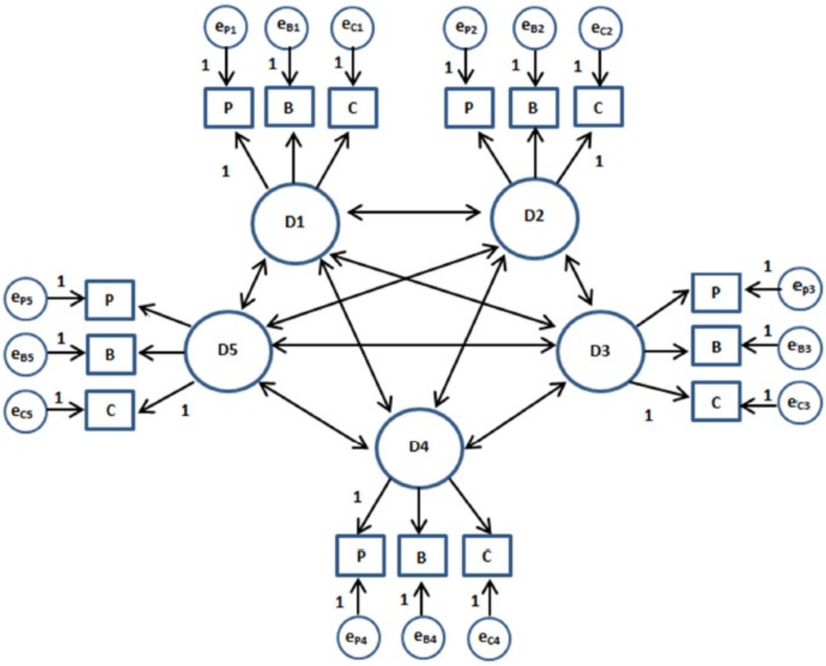
| **Dimensions of Science Epistemological Beliefs** | **Items of the Instrument (Numbers = Item numbers)** | | |
|---|---|---|---|
| | **Physics (Newton, Action and reaction forces)** | **Biology (Mendel, Law of dominance)** | **Chemistry (Lavoisier, Conservation of mass)** |
| Speed of science knowledge acquisition | **1** | **1** | **1** |
| Tentativeness of | **2** | **2** | **2** |

| | | | |
|---|---|---|---|
| scientific knowledge | | | |
| Structure of scientific knowledge | **3** | **3** | **3** |
| Source of scientific knowledge | **4** | **4** | **4** |
| Control over science knowledge acquisition | **5** | **5** | **5** |

## Construct Validity and Reliability

Before making confirmatory factor analysis, multivariate normality, missing data and outlier analyses were conducted. Multivariate normality value was found as 2.06, it was in acceptable range (Raykov & Marcoulides, 2008). Also there was no missing data and outliers. The results of the confirmatory factor analysis indicated that data on scientific epistemological beliefs of prospective science teachers supported five dimensional epistemological beliefs structure. The fit indexes and non-fit indexes for model confirmation were Chi-square ratio (CMIN/DF), Goodness-of-fit index (GFI), Comparative fit index (CFI), Root mean square error of approximation (RMSEA) and root mean square residual (RMR) (Arbuckle, 1997). Proposed model for confirmatory factor analysis results are represented in Figure 1.

Figure 1. Proposed factorial structure model for measurement on scientific epistemological beliefs test

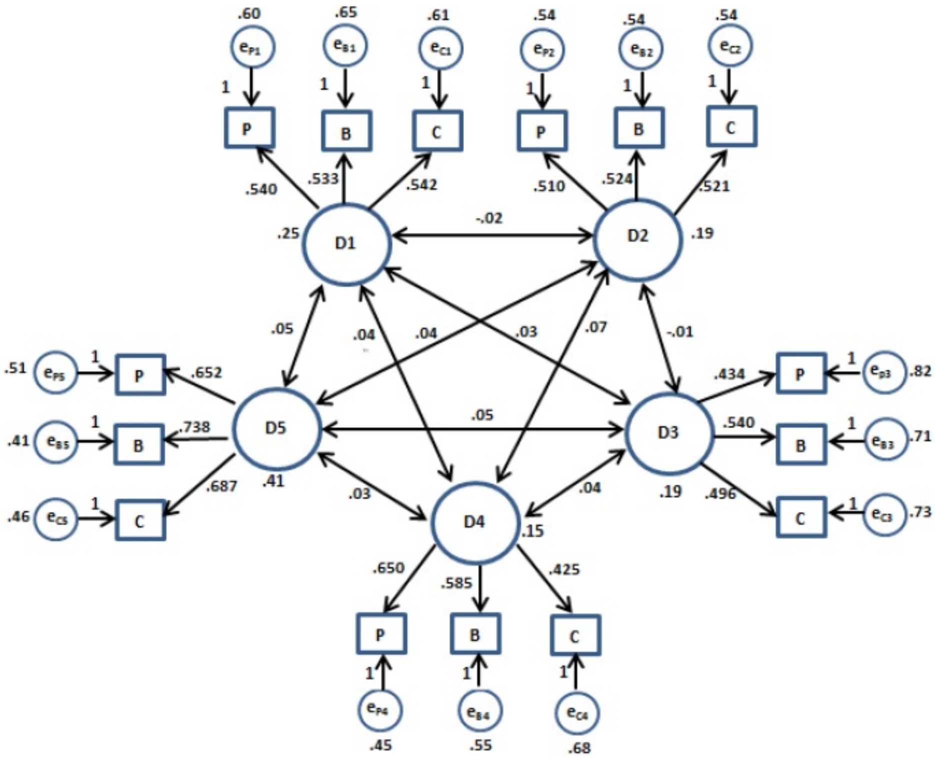



**D1:** Dimension 1 (Learning Time), **D2:** Dimension 2 (Tentativeness), **D3:** Dimension 3 (Structure of Knowledge), **D4:** Dimension 4 (Source of Knowledge), **D5:** Dimension 5 (Learning Ability) **P:** Physics, **B:** Biology, **C:** Chemistry

# Results of Research

After confirmatory factor analysis, values regarding standardized model was examined. It is represented in Figure 2.

**Figure 2.** The result of confirmatory factor analysis for five-factor solution




**D1:** *Dimension 1 (Learning Time),* **D2:** *Dimension 2 (Tentativeness),* **D3:** *Dimension 3 (Structure of Knowledge),* **D4:** *Dimension 4 (Source of Knowledge),* **D5:** *Dimension 5 (Learning Ability)* **P:** *Physics,* **B:** *Biology*, **C:** *Chemistry*

The fit values regarding the data also showed that fit indexes are in acceptable ranges. The values are represented in Table 2.

**Table 2.** Fit indexes for confirmatory factor analysis

| Fit Indexes | | | | |
|---|---|---|---|---|
| **CMIN/DF** | **GFI** | **CFI** | **RMSEA** | **RMR** |
| 1.10 | .97 | .99 | .02 | .03 |

As seen in Table 2, all of the fit indexes for the scores of the participants are in acceptable range. Chi-square ratio (CMIN/DF**)** index on self-efficacy scores is under 3.00 as a highest cut-off acceptable value (Arbuckle, 1997). The Comparative Fit

Index (CFI) and Goodness of Fit Index (GFI) for the scores of the participants respectively are higher than .90 cut-off lower limit for CFI and .85 for GFI (Hoyle, 2000, Marsh, Balla, & McDonald, 1988). As the other indexes considered in this study, RMR is smaller than .10 as an acceptable value (Jaccard & Wan, 1996) and RMSEA is lower than cut-off .08 (Raykov & Marcoulides, 2006).

**Table 3.** Correlation coefficients for factors

| | Learning Time | Tentativeness | Structure of Knowledge | Source of Knowledge | Learning Ability | Total |
|---|---|---|---|---|---|---|
| **Learning Time** | - | | | | | |
| **Tentativeness** | .02 | - | | | | |
| **Structure of Knowledge** | .07 | .01 | - | | | |
| **Source of Knowledge** | .15* | .24* | .14* | - | | |
| **Learning Ability** | .10 | .06 | .10 | .11* | - | |
| **Total** | .48* | .42* | .50* | .60* | .56* | - |

Note: All of the correlation coefficients indicated are significant at the level of .05.

Table 3 summarized correlations between dimensions of scientific epistemological beliefs of prospective science teachers. As seen in the table, they are partially independent from each other.

**Table 4.** Factor loadings and Factor Score Weights of the scores on the Items

| **Item Content** | **Items** | **Factors** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Learning Time** | | **Tentativeness** | | **Structure of Knowledge** | | **Source of Knowledge** | | **Learning Ability** | |
| | | **Factor Loading** | **FSW** | **Factor Loading** | **FSW** | **Factor Loading** | **FSW** | **Factor Loading** | **FSW** | **Factor Loading** | **FSW** |
| **Learning Time** | P | .54 | .18 | | .01 | | .01 | | .01 | | .01 |
| | B | .53 | .17 | | .01 | | .01 | | .01 | | .01 |
| | C | .54 | .18 | | .01 | | .01 | | .01 | | .01 |
| **Tentativeness** | P | | .01 | .51 | .16 | | .01 | | .03 | | .00 |
| | B | | .01 | .52 | .16 | | .01 | | .03 | | .01 |
| | C | | .02 | .52 | .18 | | .01 | | .01 | | .01 |
| **Structure of** | P | | .01 | | .01 | .43 | .11 | | .01 | | .00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Knowledge** | B | | *.01* | | *.01* | *.54* | *.16* | | *.02* | | *.01* |
| | C | | *.02* | | *.01* | *.50* | *.14* | | *.02* | | *.00* |
| **Source of Knowledge** | P | | *.01* | | *.02* | | *.01* | *.65* | *.08* | | *.00* |
| | B | | *.02* | | *.04* | | *.02* | *.58* | *.14* | | *.00* |
| | C | | *.02* | | *.05* | | *.03* | *.65* | *.19* | | *.01* |
| **Source of Knowledge** | P | | *.01* | | *.01* | | *.01* | | *.00* | *.65* | *.23* |
| | B | | *.02* | | *.01* | | *.02* | | *.00* | *.74* | *.28* |
| | C | | *.01* | | *.01* | | *.01* | | *.00* | *.69* | *.20* |
| Cronbach Alpha Values (Total = .59) | | *.55* | | *52* | | *.48* | | *.56* | | *.73* | |

*Note: Factor loading refers to standardized regression weight and FSW refers to Factor Score Weights, (* ) indicates factor loading below .40. P: Physics, B: Biology, C: Chemistry.*

In table 4, factor loadings of each dimension and Cronbach alpha reliabilities regarding to the dimensions are represented. All of the dimensions have a factor loading over .40 that is actable cut-off value for factor loadings (Li, McCoach, Swaminathan & Tang, 2008). However Cronbach alpha values are low but this situation is common (Liang et al., 2008; Koksal & Cakiroglu, 2010; Topcu & Yilmaz-Tuzun, 2008; Schommer-Aikins, Duell & Hutter, 2005). Hatcher and Stepanski (1994) stated that Cronbach alpha value as like 0.55 can be accepted for statistical processes in social studies.

**Table 5.** Minimum group scores, maximum group scores regarding each factor and mean of the scores for each factor.

| **Descriptive Statistics Regarding Minimum Group Scores, Maximum Group Score, Mean of Scores** | | | | | |
|---|---|---|---|---|---|
| | **N** | **Minimum Group Scores** | **Maximum Gourp Scores** | **Mean** | **Std. Deviation** |
| F1 | 364 | 1.00 | 3.00 | 1.85 | .67 |
| F2 | 364 | .67 | 3.00 | 1.48 | .59 |
| F3 | 364 | .33 | 3.00 | 1.81 | .69 |
| F4 | 364 | .33 | 3.00 | 1.65 | .65 |
| F5 | 364 | 1.00 | 3.00 | 1.77 | .76 |
| Total | 364 | 1.00 | 2.60 | 1.71 | .35 |
| Valid N (listwise) | 364 | | | | |

In Table 5 scores of the participants on the inventory are represented, it can be seen that the participants had unsophisticated beliefs regarding F1 while they had mixed beliefs regarding F2, F3, F4 and F5.

## Conclusions and Implications

The findings of this study supported the idea that the inventory has satisfactory validity and reliability measures. The inventory contributes to the tools about scientific epistemological beliefs in the literature by suggestion a different way of measurement. This inventory can be used for determine prospective science teachers' science-specific epistemological beliefs and helps analyzing the association between science-specific epistemological beliefs, and science learning and teaching. Since the studies showed that epistemological beliefs of prospective teachers are associated with their teaching concerns and with their approaches to learning (Boz & Boz, 2014; Taskın Sahin, 2012). Moreover, Erdamar and Alpan (2013) represented that epistemological beliefs of prospective teachers are effective on their teaching practice and problem solving skills. By using the inventory one can also investigate complex interactions between science-specific epistemological beliefs and other educationally important variables.

The findings of this study showed that the prospective science teachers do not have sophisticated beliefs regarding speed of science knowledge acquisition, tentativeness of science knowledge, structure of science knowledge, source of science knowledge and control over science knowledge acquisition. Similar findings were also reported in the previous studies. Liu and Tsai (2008) investigated science-specific epistemological beliefs of college students and their findings showed that students do not believe in tentative knowledge. Olafson and Schraw (2006) found that practicing teachers have mixed beliefs regarding characteristics of knowledge.

Moreover correlational analysis results represented that dimensions of science-specific epistemological beliefs are partially independent due to low correlations of some dimensions with other dimensions. This result supported a multidimensional and partially independent model as Schommer (1990) stated. Futhermore, the theoretical structure of science-specific epistemological beliefs in the literature supported by this finding that dimensions of science-specific epistemological beliefs are partially independent (Deniz, 2011; Hofer, 2000; Tsai &Liu, 2005; Schommer-Aikins, 2002). By considering the independent nature of the dimensions, future researchers can make investigations on science-specific epistemological beliefs of prospective teachers by considering each dimension as a discrete factor.

In conclusion it can be suggested making researcher with more number of the participants by using the inventory might increase reliability values regarding the dimensions. Moreover there is need to conduct further studies with a bigger samples to examine science-specific epistemological beliefs of prospective science teachers in terms of their association with science teaching beliefs, methods and behaviors. Another suggestion is that additional dimensions regarding science-related epistemological beliefs can be studied by using the way suggested in this study.

## References


Arbuckle, J.L..(1997) *Amos Users' Guide; version 3.6*. Chicago, IL: Small Waters Corporation.

Baxter Magolda, M. (1992). *Knowing and reasoning in college: Gender related patterns in students' intellectual development.* San Francisco, CA: Jossey-Bass.

Belenky, M., Clinchy, B. M., Goldberger, N. R., & Tarule, J. (1986). *Women's ways of knowing: The evelopment of self, mind, and voice.* New York, NY: Basic Books.

Boz, N. & Boz, Y. (2014). Are Pre-Service Mathematics Teachers' Teaching Concerns Related to Their Epistemological Beliefs?, *Croatian Journal of Education*, *16* (2), 335-362.

Braten, I. & Stromso, H.I. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian postsecondary students, *British Journal of Educational Psychology*, *75*, 539–565.

Brauer, H. & Wilde, M. (2014) Pre-service Science Teachers' Development of Epistemological Beliefs, *Reflecting education*, *9*(2), 44-62.

Buehl, M. M., Alexander, P. A. & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, *27*, 415–449.

Cano, F., 2005. Epistemological beliefs and approaches to learning: their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology 75* (2), 203–221.

Chan, K. (2011). Preservice teacher education students' epistemological beliefs and conceptions about learning, *Instructional Science*, *39*, 87–108.

Chan, N., Ho, I.T. & Ku, K.Y.L. (2011). Epistemic beliefs and critical thinking of Chinese students, *Learning and Individual Differences*, *21*(1), 67-77.

Conley, M. A., Pintrich, R. P., Vekiri L. & Harrison D.(2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, 29, 186-204.

Deniz, H. (2011). Examination of changes in prospective elementary teachers' epistemological beliefs in science and exploration of factors meditating that change, *Journal of Science Education and Technology*, *20*, 750–760.

Drechsel, B., Carstensen, C. & Prenzel, M. (2011) The Role of content and context in pisa interest scales: A study of the embedded interest items in the PISA 2006 science assessment, *International Journal of Science Education*, *33* (1), 73-95.

Erdamar, G., & Alpan,G. (2013). Examining the epistemological beliefs and problem solving skills of preservice teachers during teaching practice. *Teaching in Higher Education* , 18 (2), 129-143.

Fulmer, G.W. (2014). Undergraduates' attitudes toward science and their epistemological beliefs: positive effects of certainty and authority beliefs, *Journal of Science Education and Technology*, *23*, 198–206.

Güven,G., Sülün,Y. & Çam,A. (2014) The examination of elementary pre-service teachers' reflective diaries and epistemological beliefs in science laboratory, *Teaching in Higher Education*, *19*(8), 895-907.

Hammer, D., Elby A., Scherr R., & Redish E. F. (2005). *Resources, framing, and transfer*. In: J. Mestre (Ed.), Transfer of learning from a modern multidisciplinary perspective (89–119). Greenwich, CT: Information Age Publishing.

Hatcher, L. & Stepanski, E. J. (1994). *A step-by-step approach to using the SAS system for univariate and multivariate statistics*. Cary, NC: SAS Institute.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology, *Contemporary Educational Psychology*, *25*, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. Journal of Educational Psychology Review, 13, 353-383.

Hofer, B. K. (2002). Personal epistemology as a psychological and educational construct: An introduction. In B. K. Hofer & P. R. Pintrich (Eds.), Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 3-14). Mahwah, NJ: Lawrence Erlbaum

Hofer, B.K. (2006). Domain specificity of personal epistemology: Resolved questions, persistent issues, new models, *International Journal of Educational Research*, *45*, 85–95.

Hoyle, R. (2000) *Confirmatory factor analysis*. In H.E.A. Tinsley, and S. D. Brown (Eds.), Handbook of applied multivariate statistics and mathematical modeling. California: Academic Press.

Jaccard, J, & Wan, C. K. (1996). *LISREL approaches to interaction effects in multiple regression* (Sage University Paper series on Quantitative Applications in the Social Sciences, series no. 07-114). Thousand Oaks, CA: Sage.

Jones, M.G., & Carter. G. (2006). Science teacher attitudes and beliefs. In Handbook of research on science education,1067–104. New Jersey: Lawrence Erlbaum Associates.

Karimi, M.N. & Atai, M.R. (2012). ESAP Students' comprehension of multiple technical reading texts: insights from personal epistemological beliefs, *Reading Psychology*, *35*(8), 736-761.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment.* 1st Ed., San Francisco, CA: Jossey-Bass.

Koksal, M.S. & Cakiroglu, J. (2010a). Development of nature of science scale (NSS) for advanced science students. *Journal of Baltic Science Education*, *9*, 87-98.

Köksal, M.S. & Yaman, S. (2012) An Investigation of the Epistemological Predictors of Self-Regulated Learning of Advanced Science Students, Science Educator, 21 (2), 45.

Li, Q., McCoach, D.B., Swaminathan, H. & Tang, J. (2008) Development of an instrument to measure perspectives of engineering education among college students, *Journal of Engineering Education*, *97*(1), 47-56.

Liang, J.-C., Tsai, C.-C., (2010). Relational analysis of college science-major students' epistemological beliefs toward science and conceptions of learning science. *International Journal of Science Education 32* (17), 2273–2289.

Liang L. L., Chen, S., Chen, X., Kaya, O, N., Adams, A. D., Macklin, M. & Ebenezer, J. (2008). Assessing preservice elementary teachers views on the nature of scientific knowledge: A dual-response instrument. *Asia-Pacific Forum on Science Learning and Teaching, 9*(1), 1.

Liang, J.-C., Lee, M.,& Tsai, C.-C., (2010). The relations between scientific epistemological beliefs and approaches to learning science among science-major undergraduates in Taiwan, *The Asia-Pacific Education Researcher, 19* (1), 43-59.

Liu, S-Y. & Tsai, C-C. (2008) Differences in the scientific epistemological views of undergraduate students, *International Journal of Science Education, 30* (8), 1055-1073.

Lodewyk, K. R. (2007). Relations among epistemological beliefs, academic achievement and test performance in secondary school students. *Educational Psychology, 27*, 307-327.

Marsh, H. W., Balla, J. R. McDonald, R. P. (1988). Goodness-of- fit indexes in confirmatory factor analysis: The effect of sample size. *Psychological Bulletin. 103,* 391-410.

Mateos, M., Sole, I., Castells, N., & Lamas, J.G.(2014). *The role of epistemological beliefs and reading beliefs in multiple text comprehension*, (In Eds. Erica de Vries & Katharina Scheiter). EARLI Special Interest Group 2 Meeting Report, 139-141, Grenoble, France.

Metallidou, P. (2013). Epistemological beliefs as predictors of self-regulated learning strategies in middle school students, *School Psychology International, 34*(3) 283–298.

Moore, W.S. (2002). Understanding learning in a postmodern world: Reconsidering the Perry scheme of ıntellectual and ethical development. In B. K. Hofer & P. R. Pintrich (Eds.), Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 17-36). Mahwah, NJ: Lawrence Erlbaum

Olafson, L. & Schraw, G. (2006). Teachers' beliefs and practices within and across domains, *International Journal of Educational Research, 45*, 71–84.

Ozkal, K.,Tekkaya,C., Sungur,S., Cakıroglu,J. & Cakıroglu,E. (2011) Elementary students' scientific epistemological beliefs in relation to socio-economic status and gender, *Journal of Science Teacher Education, 22*,115–127

Paulsen, M. B., & Feldman, K. A. (1999). Student motivation and epistemological beliefs. *NewDirections for Teaching and Learning, 78*,77-80.

Perry, W. G., Jr. (1968). *Patterns of development in thought and values of students in a liberal arts college: A validation of a scheme*. Cambridge, MA: Bureau of Study Counsel, Harvard University. (ERIC Document Reproduction Service No. ED 024315)

Phan, H. P. (2008). Multiple regression analysis of epistemological beliefs, learning approaches and self-regulated learning. *Electronic Journal of Research in Educational Psychology, 6*, 157-184.

Pomeroy, D. (1993) Implications of teachers' beliefs about the nature of science: Comparision of beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education*.77 (3), 261-278.

Raykov, T. Marcoulides, G. A. (2006*) A first course instructural equation modeling*. Second Edition, London: Lawrence Erlbaum Associates, Publishers.

Raykov, T., & Marcoulides, G. A. (2008). *An introduction to applied multivariate analysis*. NY: Routledge.

Rubba, P.A., & Andersen, H. (1978). Development of an instrument to assess secondary school students' understanding of the nature of scientific knowledge. *Science Education, 62*(4), 449-458.

Schommer, M. (1990). The effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82*, 498–504.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review, 6*(4), 293-319.

Schommer-Aikins, M. (2002). An evolving theoretical framework for an epistemological belief system. In B. Hofer & P. Pintrich (Eds.), *Personal epistemology: The psychology of belief about knowledge and knowing*, (pp. 103-118). Hillsdale, NJ: Lawrence Erlbaum.

Schommer-Aikins, M., Duell, O. K., & Hutter, R. (2005). Epistemological beliefs, mathematical problem–solving beliefs, and academic performance of middle school students. *The Elementary School Journal*, *105*(3), 289-304.

Schraw, G. (2001). Current themes and future directions in epistemological research: A commentary. *Educational Psychology Review*, *13*(4), 451–464.

Schraw, G., & Olafson, L. J. (2002). Teachers' epistemological world views and educational practices. Issues in Education, 8, 99–148.

Schreiber J. B., & Shinn, D. (2003). Epistemological beliefs of community college students and their learning processes. *Community College Journal of Research and Practice 27*(8), 699-709.

Sinatra, G.M. & Kardash, C.M. (2004). Teacher candidates' epistemological beliefs, dispositions, and views on teaching as persuasion, *Contemporary Educational Psychology 29*, 483–498.

Stathopoulo, C. & Vosniadaou, S. (2007) Exploring the relationship between physics-related epistemologicalbeliefs and physics understanding. *Contemporaray Educational Psychology*, *32*, 255-281.

Taşkın Şahin, Ç. (2012). Epistemological Beliefs: As Predictors Of Preservice Teachers' Learning Aprroaches, *Mustafa Kemal University Journal of Social Sciences Institute, 9*(19), 273-285.

Tsai, C.-C. (2006). Biological knowledge is more tentative than physics knowledge: Taiwan high school adolescents' views about the nature of biology and physics. *Adolescence, 41*, 691–703.

Tsai, C. C., & Liu, S. Y. (2005). Developing a multi-dimensional instrument for assessing students' epistemological views toward science. *International Journal of Science Education, 27*, 1621–1638.

Topcu, M.S. & Yilmaz-Tuzun, O. (2008). Relationships among preservice science teachers' epistemological beliefs, epistemological world views, and self-efficacy beliefs, *International Journal of Science Education, 30*(1), 65-85.

Topcu, M.S. (2013). Preservice teachers' epistemological beliefs in physics, chemistry, and biology: A mixed study. *International Journal of Science and Mathematics Education, 11*, 433-458.

Torres, J. & Vasconcelos, C. (2015). Nature of science and models: Comparing Portuguese prospective teachers' views. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(6): 1473-1494.

Wu, Y. T., & Tsai, C. (2011). High school students' informal reasoning regarding a socioscientific issue, with relation to scientific epistemological beliefs and cognitive structures. *International Journal of Science Education, 33*, 371-400.