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EXAMINING RELATIONSHIPS AMONG TURKISH PRE-SERVICE SCIENCE TEACHERS' CONCEPTIONS OF TEACHING AND LEARNING, SCIENTIFIC EPISTEMOLOGICAL BELIEFS AND SCIENCE TEACHING EFFICACY BELIEFS

Eralp Bahcivan

Abstract. *This study was conducted to examine the relationships among pre-service science teachers' (PSTs') teaching and learning conceptions, scientific epistemological beliefs and science teaching efficacy beliefs. 310 Turkish PSTs from different regions of the country participated in the study. Three different instruments were validated by confirmatory factor analyses. Structural equation modeling analyses revealed that participants' constructivist conceptions of teaching and learning promoted sophisticated science related epistemologies. Sophisticated epistemologies, to some extent, also contributed participants' science teaching efficacy beliefs. Certain assumptions were not supported by the results which pointed out that curricular reform in teacher education system met expectations partly. Implications were presented considering the results.*

Key words: *conceptions of learning and teaching, pre-service science teachers, science teaching efficacy beliefs, scientific epistemological beliefs, structural equation modeling.*

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Introduction

Examining pre-service teachers' belief systems significantly contribute to educational enhancement (Fang, 1996), since teachers' beliefs are widely accepted as predictors of their practice (Kane, Sandretto & Heath; 2002; Pajares, 1992). Today, educators approve that teachers´ beliefs, as implicit theories (Fang, 1996), filter how they know and teach their subject matters (e.g. Nisbett and Ross, 1980). Considering this close relationship between beliefs and practices, we still need to investigate whether pre-service teachers hold beliefs aligned with contemporary learning and teaching approaches.

Belief systems include countless of beliefs in a hierarchy (Fishbein & Ajzen, 1975), labeled as core and peripheral, interplaying with each other (Rokeach, 1968). Core beliefs are centralized and connected with others in the systems and resist to change, whereas peripheral beliefs are not so difficult to change, because they have limited number of connections with knowledge and other beliefs. Additionally, core beliefs affect formation of peripheral ones (Brownlee, Boulton-Lewis & Puride, 2002; Rokeach, 1968). (Pre-service) teachers' conceptions of teaching and learning, personal epistemology and teaching efficacy appear among different types of beliefs that they hold (Fives & Buehl, 2008). In this study, conceptions of teaching and learning were utilized as core beliefs because of their domain generality.

Turkey has attempted to adapt constructivist curricula in all educational levels since 2005. Ministry of National Education has arranged training programs for in-service teachers. Considering these changes, education faculties have given much importance to constructivist philosophy of education for contributing pre-service teachers' readiness to curricular adaptations.

Kane et al. (2002), in their review about teaching beliefs, have argued that pre-service teachers enter teacher education departments with their preexisting beliefs which may be resistant to change. Current Turkish PSTs were educated by traditional approaches in their elementary and secondary school years. In other words, they were educated by teacher centered classroom implementations which do not consider properly learners' preconceptions and qualifications as knowledge constructers. However, today, these PSTs are asked to adapt constructivist conceptions of learning in their teaching, because of curricular reforms in the country. What are Turkish PSTs' conceptions of teaching and learning? Do they hold sophisticated scientific epistemological beliefs? Do they feel efficacious themselves in science teaching? Do they have consistent belief systems promoting curricular reforms? This study was conducted to shed light on these queries.

Theoretical Background

Conceptions of Teaching and Learning

As Pajares (1992) has mentioned that researchers use 'belief' and 'conception' interchangeably, Chan and Elliott (2004) define teachers' conceptions of teaching and learning as "the beliefs held by teachers about their preferred ways of teaching and learning" (p.819). Researchers have explored (pre-service) teachers' conceptions of teaching and learning for more than 30 years, because these conceptions have a potential to directly affect their classroom implementations (Hewson & Kerby, 1993; Koballa, Glynn, Upson & Coleman, 2005; Koballa & Graber; 2001). Research attempts concerning conceptions of teaching and learning have two main traditions.

First tradition is descriptive in nature and dates back to initial attempt of Saljö (1979) who revealed students' conceptions of learning. Phenomenographic studies conducted by the following researchers (e.g. Marton, Beaty and Dall'Alba, 1993; Tsai, 2004) have also investigated conceptions of learning that students have. *Increase of knowledge, memorizing, applying* and *understanding* exemplify some of the prominent conceptions of learning held by different samples. Researchers have also explored pre-service and in-service teachers' conceptions of teaching. Koballa, Graber, Coleman and Kemp (2000) have conducted a phenomenographic study to reveal pre-service chemistry teachers' conceptions of teaching. The researchers have found out three different teaching conceptions: *transferring knowledge, posing problems* and *interacting*. In a similar study, Tsai (2002) has explored that Taiwanese science teachers have three different conceptions of teaching: *traditional, process* and *constructivist*. Koballa et al. (2000) and Tsai (2002) have evidenced that (pre-service) teachers' conceptions of learning relate to their conceptions of teaching. That is if a (pre-service) teacher has a traditional conception of learning, s/he, at the same time, has a traditional conception of teaching. To sum up, descriptive studies about conceptions of teaching and learning have actually confirmed that these conceptions relate to each other and could be categorized as traditional vs. constructivist (Chan & Elliott, 2004). Al-Amoush, Usak, Erdogan, Markic and Eilks (2013) have investigated Turkish chemistry pre-/in-service teachers' conceptions about teaching and learning and labeled these conceptions as traditional vs. modern beliefs, therefore the author of this report believes that it is possible to adapt the categorization of traditional vs. constructivist in this study.

In the second tradition, researchers have pointed out that (pre-service) teachers' conceptions of teaching and learning relate to some educationally valuable variables. For example, Chan and Elliott (2004) have mentioned that fixed ability, expert and certainty knowledge dimensions of epistemological beliefs are positively related to pre-services' traditional conceptions, whereas learning effort is negatively related to their constructivist conceptions. Otting et al. (2010) confirmed some of these relations in another study. Additionally, Tsai (2002) have argued that in-service science teachers' beliefs about learning, teaching and science are related to each other, so he called these closely aligned beliefs as 'nested epistemologies'. He also found that this alignment was more probably observed with more experienced teachers. Furthermore, Eren (2009), by a regression analysis, and Bahçivan and Kapucu (2014), by structural equation modeling analysis, have evidenced that pre-services' teaching efficacy beliefs are related to their conceptions of teaching and learning.

Personal Epistemology

Personal epistemology comprises individuals' beliefs and ideas about knowledge and how they come to know (Hofer & Pintrich, 1997). Personal epistemology, as including core beliefs, affects formation of beliefs regarding learning, teaching and intelligence (Brownlee, Boulton-Lewis & Puride, 2002; Hofer & Pintrich, 1997). Perry (1970), based on his longitudinal research attempts on white male Harvard students, (as parallel to Piagetian viewpoint) has argued that personal epistemology has a developmental nature. According to this perspective, education

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contributes to epistemological sophistication since aim of education and school is fostering development (Hofer, 2001). Followers of developmental perspective, in general, have argued that individuals' personal epistemology develops stage by stage from dualistic to evaluativist stance (King & Kitchener, 1994; Kuhn & Weinstock, 2002). On the other hand, Schommer (1994) has proposed a belief system approach. According to her, personal epistemology involves set of beliefs (regarding knowledge and knowing), more or less independent. Schommer (1994) has hypothesized that epistemological belief system has five dimensions, but individuals may represent different levels of epistemological status for different dimensions which contradicts to developmental perspective. In addition to this, Schommer's two dimensions, fixed ability and quick learning, have been criticized by developmental researchers since they have argued that these two dimensions relate to learning instead of knowledge and knowing (Hofer & Pintrich, 1997). Hofer and Pintrich (1997) have proposed four epistemological dimensions which are certainty, simplicity, source and justification. Except for justification, these dimensions have already been offered by Schommer (1994). Justification, on the other hand, is a dimension offered by developmental researchers (Hofer, 2000). Hofer and Pintrich (1997) have also proposed that certainty and simplicity involve individuals' beliefs about nature of knowledge, whereas source and justification comprises beliefs about nature of knowing.

Domain-specificity of epistemological beliefs is also another tradition recognized widely. According to this tradition, individuals have domain general epistemological beliefs, but these beliefs may particularize to domains (Buehl, Alexander & Murphy, 2002; Palmer & Marra, 2008). Buehl and Alexander (2006) have asserted that individuals hold domain general epistemological beliefs which may not reflect their particularized beliefs regarding any specific domain. To reveal or activate domain specific epistemological beliefs, assessments should be realized at particular domains or tasks. Hofer (2006) has indicated that there are two different approaches in assessment of domain specific epistemology: disciplinary perspectives on beliefs and discipline-specific beliefs. Participants are requested to answer domain general items considering any specific domain within the first approach. In the second approach, items are developed focusing exact structure of any domain such as scientific epistemological beliefs survey validated by Conley, Pintrich, Vekiri & Harrison (2004). The second approach will be implemented in this study. Such an approach will contribute more definitely to determination of what indeed Turkish PSTs' epistemological beliefs reveal about scientific knowledge in comparison to the first one.

To sum up, in the literature, there are three different epistemological models (traditions): developmental, belief system approach and domain specificity. Hofer (2008) queries the generalizability of epistemological models across different cultures since the current studies mostly base on western individuals. Many research studies have evidenced relational patterns different from what especially developmental researchers propose between epistemological beliefs and other educationally valuable variables. Chan and Elliott (2004), for example, have presented evidence how Confucian Chinese culture interferes with pre-service teachers epistemological beliefs.

Teaching Efficacy

Self-efficacy refers to individuals' perceived beliefs and evaluations concerning what they can make or achieve by their own abilities, skills and knowledge (Bandura, 1977). Considering this definition, teaching efficacy can be described as teachers' efficacy beliefs (comprising own judgments about their skills and abilities) related to teaching and managing students' learning (Gibson & Dembo, 1984). Bandura (1977) proposes four prominent sources which shape self-efficacy beliefs: **mastery experiences** (basing on past performance), **vicarious experience** (observation of others' performance), **social persuasion** (receiving judgments from others), and **physiological state** (believing in the information according to psychological state).

In science education literature there are many studies evidencing that more efficacious science teachers have a strong motivation and persist longer even if they encounter students' learning problems (Ramey-Gassert, Shroyer & Staver, 1996). Science teaching efficacy beliefs include two dimensions: personal science teaching efficacy and science teaching outcome expectancy (Enochs & Riggs, 1990). However, outcome expectancy has been criticized widely (e.g. Bandura, 2001; Cakiroglu, Capa-Aydin & Woolfolk Hoy, 2012) since this dimension does not focus solely on personal abilities and judgments. Therefore, personal science teaching efficacy is a sufficient dimension for representing science teachers' teaching efficacy beliefs about their own teaching abilities. In Turkish context, certain researchers (e.g. Tekkaya, Cakiroglu & Ozkan, 2004) have found that PSTs feel confident about teaching science. Yilmaz-Tuzun and Topcu (2008) have found that when Turkish PSTs feel more efficacious themselves in science teaching they also hold more sophisticated domain general epistemological beliefs.

Proposed Model

Based on the aforementioned research studies the theoretical model in Figure 1 has been proposed. Accordingly, PSTs' teaching and learning conceptions predict their scientific epistemological beliefs which also relate to their science teaching efficacy beliefs. The model represents a system from core beliefs to peripheral beliefs. Teaching and learning conceptions have been accepted as more central (core) in accordance to epistemological beliefs since the latter have a domain (science) specific structure, whereas teaching and learning conceptions comprise domain general beliefs. Additionally, scientific epistemological beliefs have been accepted as more central in PSTs' belief systems in comparison to science teaching efficacy beliefs. Because both of these beliefs are particularized to science and theoretically researchers (e.g. Brownlee, Boulton-Lewis & Puride, 2002; Hofer & Pintrich, 1997) approve that domain specific epistemological beliefs affect formation of domain specific teaching beliefs which are peripheral to PSTs' belief system. Tsai (2002) has already evidenced nested nature of these beliefs.

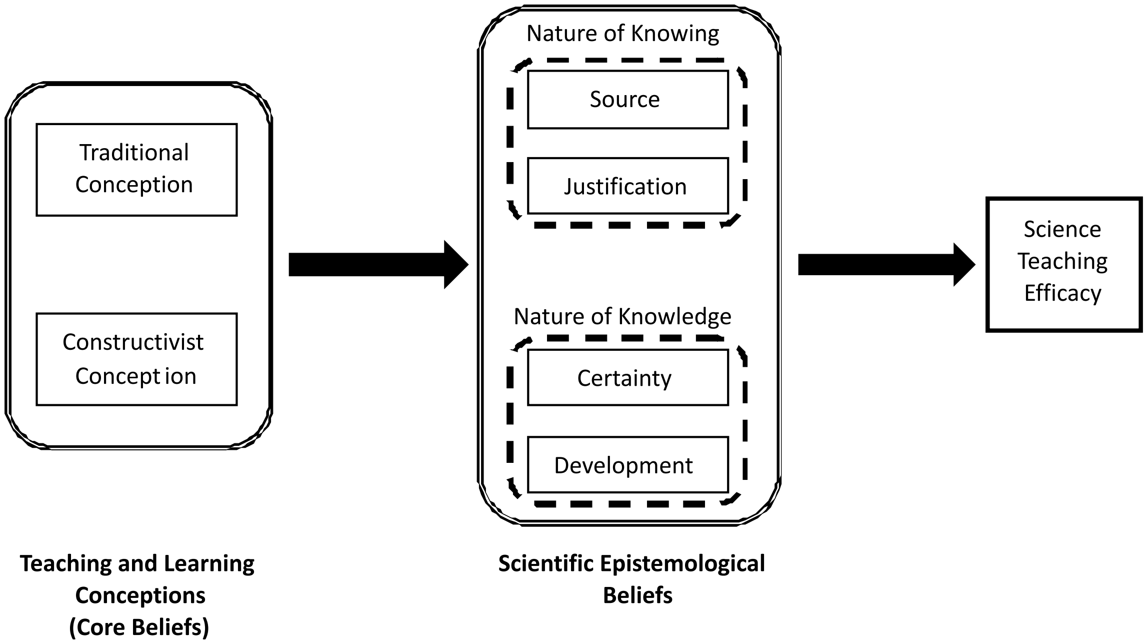

Figure 1: Proposed model of research.

Examining proposed relations has three potential significances. Firstly, it is assumed that epistemological beliefs can be admitted as peripheral when they are domain specific. In this respect, teaching and learning conceptions are accepted as core beliefs since they have domain general nature. Epistemological beliefs are, on the other hand, more central (core) in comparison to teaching efficacy beliefs when both types of beliefs have domain specificity. The proposed model in Figure 1 has the potential to visualize such theoretical relations.

Secondly, it is argued that education contributes to epistemological sophistication especially for researchers who have developmental perspective. In Turkey, for about a decade, PST education system has attempted to increase PSTs' awareness concerning constructivist approach in education. Science teacher educators have attempted to convince PSTs that constructivist implementations have invaluable advantages in terms of progresses in personal qualifications. School practicum, science teaching courses and general education courses are structured to promote positive mastery experiences, vicarious experiences and social persuasion so that PSTs feel themselves efficacious in science teaching. Therefore, the proposed model gives us a chance to test the assumption whether pre-service teacher education in Turkey has provided PSTs to hold a constructivist conception of teaching and learning, and if so, whether such a conception has created sophistication in their scientific epistemological beliefs and increased their confidence in teaching science.

Finally, considering that epistemological beliefs may have cultural dependence, this study presents empirical

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evidence regarding the context of Turkey which is argued to possess a transitional culture between east and west. Investigating the proposed relations contribute to literature in terms of how sophistication in scientific epistemological beliefs can be succeeded and what such sophistication means in Turkish culture.

Purpose Statement and Research Questions

The purpose of the study is to investigate the hierarchy of relationships among PSTs' teaching and learning conceptions (as core beliefs), scientific epistemological beliefs and science teaching efficacy beliefs. For this purpose, the following research questions have been strived to answer:

1) what are the relationships between Turkish PSTs' teaching and learning conceptions, and their scientific epistemological beliefs?
2) what are the relationships between Turkish PSTs' scientific epistemological beliefs and their science teaching efficacy beliefs?

Methodology of Research

In this study, the hierarchy among Turkish PSTs' certain beliefs was examined by structural equation modeling (SEM) analysis. The following sections will introduce details about the participants constituting sample, the instruments utilized to collect data, procedures of data collection and the details about SEM analysis examined in the study.

Sample

310 Turkish PSTs (89 male, 213 female, 8 participants have not marked gender) participated in the study. The mean age of the participants' is 22 (min.=20, max.=34). The participants were selected from 4 different universities (89, 81, 53 and 87 PSTs), each of which represents different regions of Turkey, by convenience sampling (Creswell, 2008). There are 191 year 3 and 119 year 4 PSTs in the sample. I purposefully studied with year 3 and 4 PSTs, because they have already been introduced with constructivism as a philosophy of education and constructivism based curricula implementations by various types of educational courses. Such a sample represents potentially developed constructivist conceptions of teaching and learning. Also, year 3 and 4 participants are probably more efficacious in science teaching then prior year groups because the courses they take and school practicum. This situation increases probability for observing actual relations between PSTs' conceptions of teaching and learning (as core beliefs), scientific epistemological beliefs, and teaching efficacy beliefs.

Instruments

Three instruments were used: Teaching and learning conceptions (TLC) questionnaire (Chan and Elliott, 2004), Scientific epistemological beliefs (SEB) questionnaire (Conley et. al., 2004) and Science teaching efficacy beliefs instrument (STEBI-B).

TLC questionnaire: This instrument was used for assessment of PSTs' conceptions of teaching and learning. The instrument originally includes 30 items distributed to two factors: constructivist conception and traditional conception. In the constructivist conception, "learning is the creation and acquisition of knowledge by the learner through reasoning, and justification. "Teaching is a provision and facilitation of the learning process"(Chan & Elliott, 2004, p. 821). In the traditional conception, learning is accepted as a passive process mostly basing on memorizing and executive training and teaching is viewed as transfer of knowledge directly from teacher to student. Constructivist conception includes 12 items (e.g. effective teaching encourages more discussion and hands on activities for students). Traditional conception is represented through 18 items (e.g. good teaching occurs when there is mostly teacher talk in the classroom). The items were presented to PSTs in 5-point Likert mode (1=strongly disagree to 5=strongly agree). The instrument was previously administered to Turkish samples. For example, Eren (2009) confirmed the factorial structure ($\chi 2/df = 2.42$; NNFI = .93; CFI = .94; RMSEA = .061) and reported high internal reliabilities for constructivist (α=.92) and traditional conception (α=.89).

SEB questionnaire: The instrument was utilized for assessment of PSTs' scientific epistemological beliefs. SEB questionnaire includes 26 items capturing individuals' beliefs about nature of knowledge (represented by certainty and development dimensions) and nature of knowing (represented by source and justification dimensions). Certainty dimension examines epistemological beliefs about whether science has unique answers or there may be other solutions by 6 items (e.g. all questions in science have one right answer). Development dimension represents the beliefs about whether knowledge in science is stable or evolving by 6 items (e.g. some ideas in science today are different than what scientists used to think). Source dimension uncovers individuals' beliefs about whether knowledge is outside of self and coming from authorities by 5 items (e.g. everybody has to believe what scientists say). The last dimension, justification, queries individuals' epistemological beliefs about the role of experiments and other supportive arguments in science by 9 items (e.g. ideas about science experiments come from being curious and thinking about how things work). 5-point Likert mode (1=strongly disagree to 5=strongly agree) was applied. Items in source and certainty dimension were recoded so that higher scores corresponded to more sophisticated epistemological beliefs for all items. This questionnaire was previously used by Turkish researchers (e.g. Kizilgunes, Tekkaya & Sungur, 2009; Kurt, 2009) who confirmed the factorial structure (GFI=0.94, RMSEA=0.056, S-RMR=0.059) by a sample of elementary and/or secondary school students. Kurt (2009) reported acceptable Cronbach alphas (.59, .61, .59 and .83 respectively) for certainty, development, source and justification.

STEBI-B: This instrument was used for assessment of PSTs' science teaching efficacy beliefs. The instrument actually includes two dimensions: personal science teaching efficacy and science teaching outcome expectancy. In this study, personal science teaching efficacy dimension was used because of the aforementioned reasons. This dimension (so the version of STEBI-B for this study) involved 13 items (e.g. I will continually find better ways to teach science). The items were presented to PSTs with a 5-point mode (1=strongly disagree to 5=strongly agree). 8 items were recoded so that higher scores referred to higher efficiency in science teaching. This instrument was widely used by previous researchers (e.g. Tekkaya et al., 2004) who confirmed the factorial structure and reported Cronbach alpha values (.84 for personal science teaching efficacy).

Data Collection

The aforementioned three instruments were combined into a unique questionnaire which included four parts. The first part probed demographic information such as gender, age and year group. The following parts included epistemology, conceptions and teaching efficacy instruments, respectively. Data were collected in the second semester of 2013-2014 academic year. Participants, firstly, were informed about the purpose of the study and then responded to the questionnaire. PSTs were allowed enough time for responding which took approximately 25 minutes. Data was entered into SPSS.

Data Analysis

Both descriptive and inferential analyses were used. For descriptive analyses SPSS was used. Mean and standard deviation scores were examined for descriptive purposes which allowed the researcher to investigate general properties of Turkish PSTs in the related factors. Confirmatory factor analysis (CFA) was executed for examining the construct related validity of each instrument because all the instruments were previously utilized with Turkish samples in different studies. After validation of the instrument scores, SEM analysis was conducted for examining fit of the proposed model in Figure 1. AMOS program was used for CFA and SEM analysis.

Results of Research

Validation of Instruments

TLC questionnaire: A CFA (n=310) was executed to the first order model including 30 items. The items 7, 9, 11, 15, 26 and 30 (e.g. teachers should have control over what students do all the time) of the traditional conception had factor loading scores lower than 0.40, so that I excluded these items and run the analysis again. Table 1 presents the factor loadings (FL), means (M), standard deviations (SD) of each item and Cronbach alphas (α) of each dimension.

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Table 1. CFA result of TLC questionnaire.

Code*	Items	FL	M	SD	α
C1	It is important that a teacher understands the feelings of the students	0.67	4.24	0.92	0.81
C2	Good teachers always encourage students to think for answers themselves	0.60	4.26	0.84	
C5	Learning means students have ample opportunities to explore, discuss and express their ideas	0.52	4.04	0.87	
C6	In good classrooms there is a democratic and free atmosphere which stimulates students to think and interact	0.56	4.05	0.87	
C10	The ideas of students are important and should be carefully considered	0.62	4.23	0.86	
C13	Every child is unique or special and deserves an education tailored to his or her particular needs	0.70	4.22	1.00	
C14	Effective teaching encourages more discussion and hands on activities for students	0.66	4.20	0.94	
C18	The focus of teaching is to help students construct knowledge from their learning experience instead of knowledge communication	0.49	3.90	0.83	
C19	Instruction should be flexible enough to accommodate individual differences among students	0.54	3.84	0.83	
C24	Different objectives and expectations in learning should be applied to different students	0.47	3.77	0.99	
C25	Students should be given many opportunities to express their ideas	0.68	4.17	0.94	
C28	Good teachers always make their students feel important	0.48	3.91	0.89	
T3	Good teaching occurs when there is mostly teacher talk in the classroom	0.61	2.17	1.08	0.84
T4	Learning mainly involves absorbing as much information as possible	0.52	2.67	1.17	
T8	Learning to teach simply means practicing the ideas from lecturers without questioning them	0.52	2.36	1.08	
T12	During the lesson, it is important to keep Students confined to the textbooks and the desks	0.60	2.42	1.20	
T16	Good students keep quiet and follow teacher's instruction in class	0.54	2.61	1.16	
T17	The traditional/lecture method for teaching is best because it covers more information/knowledge	0.65	2.30	1.11	
T20	It is best if teachers exercise as much authority as possible in the classroom	0.47	2.79	1.07	
T21	Students have to be called on all the time to keep them under control	0.59	2.21	1.03	
T22	Teaching is to provide students with accurate and complete knowledge rather than encourage them to discover it	0.54	2.77	1.12	
T23	A teacher's task is to correct learning misconceptions of students right away instead of verify them for themselves	0.52	2.88	1.18	
T27	Teaching is simply telling, presenting or explaining the subject matter	0.57	2.31	1.15	
T29	The major role of a teacher is to transmit knowledge to students	0.57	2.91	1.14	

** Letters represent factors (C for constructivist and T for traditional), numbers represent item rankings.*

As can be seen in Table 1, 12 items were retained for each dimension together with factor loadings greater than 0.40 ($p<0.001$). Reliability score of each dimension was higher than 0.80. Certain fit indices which were chi-square value for per degree of freedom (χ^2/df), CFI, TLI and RMSEA were also examined. Fit indices were observed respectively as 1.22, 0.98, 0.97 and 0.03 corresponding a good model fit.

Keeping attention on descriptive statistics, it is obviously seen that PSTs' mean scores in constructivist (conception) items exceed the midpoint score. PSTs seem to care students' feelings, particular needs and ideas, arranging hands on activities and discussions considering these crucial points, and believe that encouraging learners to find their own answers is necessary for learning environments. Whereas in the half of the items in traditional conception factor, PSTs' mean scores are higher than (but also close to) midpoint. Considering these items it can be argued that PSTs believe that teachers should transmit necessary knowledge and correct misconceptions as the authority, and true answers should be absorbed by students. In addition, standard deviations also take attention in descriptive analysis. Standard deviations for constructivist items are smaller than traditional ones. This result reveals that PSTs' scores in constructivist items are closer to mean scores which are over midpoint for all the items.

SEB questionnaire: CFA (n=310) was conducted on the first order model including SEB dimensions. For the initial trial, item 7 (the most important part of doing science is coming up with the right answer) of the certainty dimension had a factor value lower than 0.40. This item was excluded from the confirmatory model and the analysis was executed again. Table 2 presents the factor loadings, means, and standard deviations of each item and Cronbach alphas of each dimension.

According to Table 2 all the items had a factor loading value equal to or greater than 0.40 (p<0.001) and alphas were observed as .68, .66, .71 and .82 respectively for dimensions of source, certainty, development and justification. Fit indices (χ^2/df=1.44, CFI=0.95, TLI=0.93 and RMSEA=0.04) indicated that the model had a good model fit.

Table 2. CFA result of SEB questionnaire.

Code*	Items	FL	M	SD	α
S1	Everybody has to believe what scientists say	0.43	4.05	0.79	0.68
S6	In science, you have to believe what the science books say about stuff	0.63	3.74	1.07	
S10	Whatever the teacher says in science class is true	0.51	3.97	0.95	
S15	If you read something in a science book, you can be sure it's true	0.58	3.18	0.95	
S19	Only scientists know for sure what is true in science	0.61	3.72	1.01	
C2	All questions in science have one right answer	0.42	3.80	1.08	0.66
C12	Scientists pretty much know everything about science; there is not much more to know	0.52	4.13	1.02	
C16	Scientific knowledge is always true	0.68	3.60	1.01	
C20	Once scientists have a result from an experiment, that is the only answer	0.45	3.80	1.03	
C23	Scientists always agree about what is true in science	0.45	3.56	1.03	
D4	Some ideas in science today are different than what scientists used to think	0.40	3.67	1.02	0.71
D8	The ideas in science books sometimes change	0.65	3.96	0.95	
D13	There are some questions that even scientists cannot answer	0.52	3.97	1.08	
D17	Ideas in science sometimes change	0.56	4.04	0.85	
D21	New discoveries can change what scientists think is true	0.51	3.77	0.96	
D25	Sometimes scientists change their minds about what is true in science	0.60	3.82	0.79	
J3	Ideas about science experiments come from being curious and thinking about how things work	0.53	3.92	0.83	0.82
J5	It is good to have an idea before you start an experiment	0.52	3.98	1.05	
J9	In science, there can be more than one way for scientists to test their ideas	0.93	4.00	0.93	
J11	Ideas in science can come from your own questions and experiments	0.43	3.65	0.89	
J14	One important part of science is doing experiments to come up with new ideas about how things work	0.74	3.99	0.94	
J18	It is good to try experiments more than once to make sure of your findings	0.69	4.22	0.94	
J22	Good ideas in science can come from anybody, not just from scientists	0.63	3.89	0.94	
J24	Good answers are based on evidence from many different experiments	0.55	3.88	0.85	
J26	A good way to know if something is true is to do an experiment	0.53	3.93	0.87	

** S for source, C for certainty, D for development and J for justification*

Looking through item mean scores, it seems that PSTs exceed midpoint scores indicating sophistication in scientific epistemological beliefs. Overall mean scores for each dimension was 3.73, 3.78, 3.87 and 4.02 respectively for source, certainty, development and justification. PSTs are questioning scientists and teachers as the source of knowledge and certainty of what scientists know. They believe that scientific knowledge evolves by repetition of experiments or finding alternative ways for research. Furthermore, standard deviations of certainty items, in general, have higher than other items indicating that there are more PSTs far away from sophistication in this dimension.

STEBI-B: CFA (n=310) was conducted on personal science teaching efficacy dimension of STEBI-B. Two items

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(e.g. when teaching science, I will usually welcome student questions) because their factor loadings values observed lower than 0.40. CFA was conducted again. Table 3 was presented to show each item's factor loading, mean score and standard deviation and internal reliability value of the instrument.

Table 3. CFA result of STEBI-B.

No	Item	FL	M	SD	α
1	I will continually find better ways to teach science	0.50	3.93	0.83	0.86
2	Even if I try very hard, I will not teach science as well as I will most subjects	0.72	4.06	0.89	
3	I know the steps necessary to teach science concepts effectively	0.42	3.69	0.79	
4	I will not be very effective in monitoring science experiments	0.75	4.01	0.88	
5	I will generally teach science ineffectively	0.68	4.06	0.90	
6	I understand science concepts well enough to be effective in teaching elementary science	0.46	3.75	0.81	
7	I will find it difficult to explain to students why science experiments work	0.60	3.81	0.92	
8	I will typically be able to answer students' science questions	0.50	3.89	0.77	
9	I wonder if I will have the necessary skills to teach science	0.75	3.74	0.94	
10	When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better	0.61	3.95	0.85	
11	I do not know what to do to turn students on to science	0.48	3.80	1.10	

All the factor loading values were observed higher than 0.40 ($p<0.001$). Internal reliability had a value of 0.86. Fit indices ($\chi^2/df=1.94$, CFI=0.97, TLI=0.95 and RMSEA=0.05) corresponded to a reasonable fit of model. Additionally, examining participants' item mean sores (which are above midpoint), it can be asserted that PSTs feel themselves efficacious in teaching science effectively.

The Relationships among TLC, SEB and Science Teaching Efficacy

SEM analysis was conducted on the proposed model in Figure 1 to examine the relationships among PSTs' TLC, SEB and science teaching efficacy beliefs. Figure 2 presents the structural relations generated. The model had a reasonable fit ($\chi^2/df=1.33$, CFI=0.92, TLI=0.91 and RMSEA=0.03).

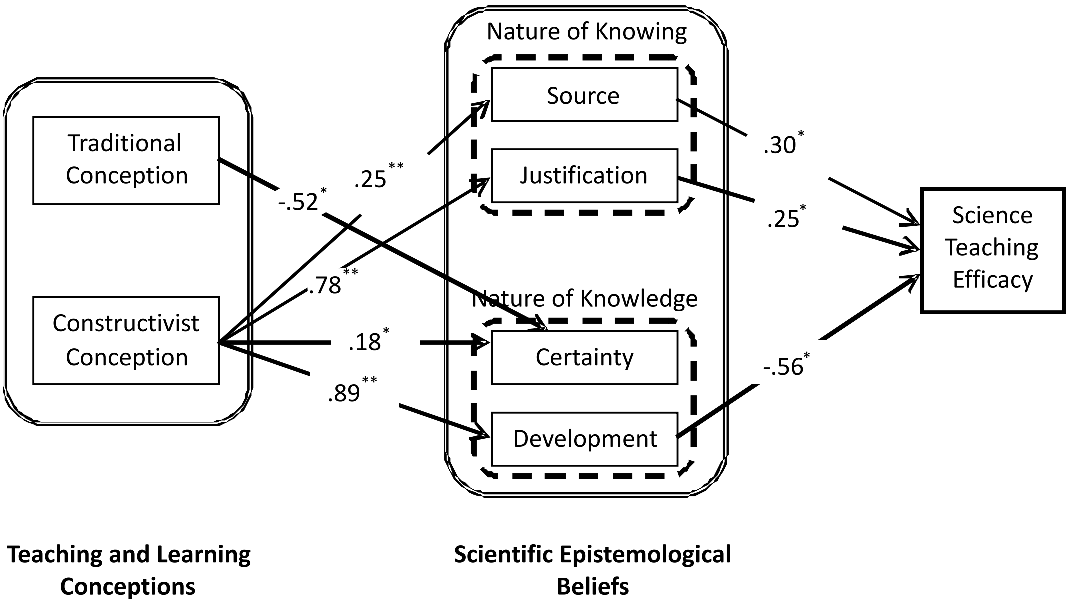

Figure 2: The path coefficients of the structured model (*$p<0.05$, ** $p<0.001$).

If PSTs hold a constructivist teaching and learning conceptions, they have more sophisticated scientific epistemological beliefs. This hypothetical relation was confirmed for all dimensions of scientific epistemology. Traditional conceptions, on the other hand, negatively related to just certainty beliefs. Direction of this relationship was already proposed, but this negative relation had been expected for also other epistemological dimensions. Moreover, sophistication in PSTs' beliefs uncovered by nature of knowing positively related to their science teaching efficacy. Such a relation was hypothesized in the proposed model. However, the relation between PSTs' beliefs about nature of scientific knowledge and science teaching efficacy beliefs is opposite to my estimations. Sophistication in developmental beliefs negatively related to science teaching efficacy beliefs, which was estimated as positive. Additionally, sophistication in certainty beliefs did not relate to science teaching efficacy beliefs. For this case, it was assumed a positive and significant relation.

Discussion

Descriptive results of the study point out that constructivist based curricula in teacher education system seems to shape Turkish PSTs' conceptions of teaching and learning to some extent. PSTs have much more tendency to constructivist conception in comparison to traditional conception. Participants have believed that learners' needs may be different from others and discussions should be implemented in learning environment considering these differences. Such a picture may satisfy some expectations of teacher educators; however, the picture has also puzzling sections since the participants also potentially hold traditional conceptions. Because in several items of traditional dimensions, item mean scores exceed midpoint. Therefore, although, PSTs' item mean scores in constructivist conception are higher than the ones observed for traditional conceptions, they still conceptualize teacher as a source for transmitting knowledge and student as a receiver. Koballa et al. (2000) have proclaimed that if PSTs have more than one conception, such inconsistencies can be observed. Additionally, Tsai (2002) states that pre-service science teachers' conceptions of teaching and learning are affected by their previous experience. As mentioned previously, participants of this study were educated with traditional implementations in their elementary and secondary school years, but have received a PST education promoting constructivist approaches in teaching and learning environments. Such opposite experiences may be responsible for my observations.

Moreover, PSTs believe that what scientists and teachers say should not be accepted as unchangeable and certain, scientific knowledge may change and replication of scientific experiments for approving truth is necessary. The results concerning PSTs' SEB point out sophistication since all mean scores are above midpoint and support the developmental perspective in two ways. Firstly, mean scores in each dimension are close to each other, so that sophistication has been realized in all dimensions (as what developmental perspective propose) instead of in a few dimensions (as what belief system approach argue) (Hofer, 2001). Secondly, when compared with previous studies (Kizilgunes et al., 2009; Kurt, 2009), utilized SEB survey with Turkish elementary and/or secondary school students, this study has acquired the highest mean scores for all dimensions. This study has included PSTs who are older than previously reported participants. To the Piagetian standpoint such a result is expected and so coherent with what developmental researchers claim.

As a final descriptive, it can be said that Turkish PSTs feel themselves efficacious in science teaching parallel to what previous researchers also found (Tekkaya et al., 2004). Most probably, school practicum (as mastery and vicarious experiences), science teaching method courses (as vicarious experiences) and educational courses (as social persuasion) contribute positively to their science teaching efficacy beliefs.

When it comes to structural modeling analysis discussions can be focused on two relations. Firstly, almost all the proposed relationships between conceptions of teaching and learning, and scientific epistemological beliefs have been observed. To the results, when a PST holds constructivist conceptions of teaching and learning, s/he has sophisticated epistemological beliefs about science in all dimensions. More specifically, when a PST believes that students may have different feelings, ideas and interests, those need to be taken into consideration and should be encouraged to find own solutions during teaching and learning environments, s/he also questions scientists as the source of knowledge and certainty of what they know as well as believe that scientific knowledge may change in time by repetition of experiments. Such a result is consistent with classification of beliefs argued by Rokeach (1968). In this study conceptions of teaching and learning have been proposed as core beliefs (because of their domain generality), scientific epistemic beliefs, on the other hand, have been proposed as peripheral beliefs (because of their domain specificity). In addition, certain researchers (e.g., Tsai, 2002) already observed similar relations.

Moreover, when a PST holds a traditional conception, sophistication has been reversed in certainty dimen-

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sion of scientific epistemological beliefs. Traditional conception has not been related to other dimensions. More specifically, when a PST believes that teachers (as the authority) should directly transmit true knowledge, correct misconceptions, and students should absorb what teachers transmit, s/he also believes that scientists know everything in science and there is no need to much more to know. Why the other proposed negative relations for traditional PSTs have not been found can be explained with their limited experiences in teaching science. Tsai (2002), based on a study including in-service science teachers, has also observed such inconsistencies. He has provided evidence that these inconsistencies were mostly observed with inexperienced teachers.

The relationship observed between PSTs' scientific epistemological beliefs and science teaching efficacy beliefs have partly supported the estimations in Figure 1. The results point out that pre-services' sophistication in beliefs concerning nature of knowing (include source and justification) have positively related to their science teaching efficacy beliefs. More specifically, when PSTs question the scientists and teachers as the sources and view experiments as necessary for approving scientific knowledge, they also feel themselves more efficacious in science teaching. This relationship has already been assumed in the structural model of the study and supported by the idea that when both epistemological and teaching efficacy beliefs are domain specific, epistemological beliefs (as core beliefs) shape teaching beliefs (Brownlee, Boulton-Lewis & Puride, 2002; Hofer & Pintrich, 1997). Also a speculation about educational context in Turkey supports this result. In Turkey, students are placed to elementary and secondary schools by different central exams. They have to enter another exam to determine where they will go to university. In such an educational context most of the students take additional supports from private course centers, tutorials by different teachers and a plethora of workbooks to be successful in central exams. Therefore, Turkish students justify what they should know by different sources. This situation may instinctively provide Turkish students to get sophistication in their beliefs of source and justification. At the end, these contextual factors, as mastery experiences, may force PSTs to form a positive relation between their scientific epistemological beliefs and science teaching efficacy beliefs.

The relationship between PSTs' beliefs regarding nature of scientific knowledge and their science teaching efficacy beliefs, however, are not consistent with the estimations. Certainty has not related, whereas development has related significantly to science teaching efficacy. In other words, if PSTs believe that there is the probability of growing (development) in scientific knowledge, then they feel themselves less efficacious in science teaching. These results need further investigations, but a speculation can be offered. Aforementioned Turkish educational context forces students and PSTs to acquire a bounded body of knowledge because of central exams. When PSTs feel that these bounds are not clear and have a potential to be more complex than now, they may question their science teaching qualifications so science teaching efficacy beliefs. I believe that this speculation actually takes support of certain researchers (e.g. Chan and Elliott, 2004; Hofer, 2008) who pay attention to cultural dependency of epistemological beliefs.

In conclusion, initiatives in science teacher education in Turkey seem to make progress in PSTs' belief systems to some extent. PSTs have a tendency to constructivist conceptions of teaching and learning. They hold sophisticated science related epistemologies and feel themselves efficacious in science teaching. However, the relations between their beliefs are still in needs of professional support.

Conclusions

Based on the results of the study, it can be concluded, that when Turkish PSTs have a constructivist conception of teaching and learning they also hold sophisticated scientific epistemological beliefs. In other words, having constructivist conceptions of teaching and learning, seems as a prerequisite for PSTs to believe that knowledge in science is not authoritarian (source), should be justified (justification), has not unique answers (certainty), and is evolving (development). Additionally, when PSTs have traditional conceptions of teaching and learning, they believe that scientific knowledge is certain. Furthermore, holding traditional conceptions does not relate to PSTs' beliefs uncovered by other epistemological dimensions which are source, justification and development. Moreover, when PSTs hold sophisticated beliefs about nature of knowing in science, they also feel themselves more efficacious in science teaching. However, their sophisticated beliefs regarding nature of scientific knowledge do not positively relate to their science teaching efficacy. Some implications regarding these conclusions were presented in the following section.

Limitations and Implications

There are two limitations. Firstly, the data of this study have been acquired depending on participants' self-reported responses. Therefore, I am not sure whether participants' responses reflect their actual beliefs or they understand all the items in a way what I suppose. Secondly, the data represents four different regions of Turkey although there are seven. In generalizing outputs of the study these limitations should be considered. Based on the results, several implications can be suggested.

First implication is about relationships among PSTs' conceptions of teaching and learning and scientific epistemological beliefs. The relationship between constructivist conception and epistemology has been consistent, but the one between traditional conception and epistemology needs reinforcement. Explicit interventions regarding when science teachers have traditional conceptions they will not have sophisticated epistemologies, can be realized by means of science teaching courses. Such cases should be displayed to PSTs by utilizing educational technologies, since all the educational faculties have this opportunity in Turkey. The second implication is about the relationship between scientific epistemological beliefs and science teaching efficacy beliefs. PSTs should be reinforced to have intended beliefs related to their potential practices to hold a belief that when science teachers believe that knowledge in science is developing and uncertain, they will be more efficacious in science teaching. The third implication is about future perspective and twofold in nature. Such studies should be replicated with high number of participants as well as representing more regions to contribute generalizability of results. Finally, a few speculations to clarify unexpected results have been proposed in this study. These speculations have been made considering cultural dependency of epistemology and need for further investigations. As a last, in this study, all the sophistications and developments in PSTs' beliefs were dedicated to science teacher education system. This is an assumption which needs empirical/experimental evidences.

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