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Investigating the Teaching and Learning Conceptions and Scientific Epistemological Beliefs of Pre-service Teachers': A Longitudinal Study

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Abstract

In recent years, because of the rapid changes in education, the ideas and views of teachers has gained increased value. Studies have revealed that the pedagogic activities utilized by teachers in the classroom, as well as, the decisions they make during the teaching-learning process are profoundly shaped by their pre-existing beliefs. The purpose of this study is to determine what changes occurred in the teaching learning conceptions (TLC) and scientific epistemological beliefs (SEB) of pre-service teachers following their entrance into studies in education and to determine whether a significant relationship exists between these variables. The data collection methodology employed for this study was a longitudinal survey in which data from the same sample elements was collected on multiple occasions over an extended period of time. Sample element data was collected on six occasions over a four-year period from 41 pre-service teachers using both TLC and SEB survey instruments. The results revealed that pre-service teachers started their first year with strong CTLCs (Constructivist Teaching and Learning Conceptions) and the mean scores increased slightly when the grade level increased. Also, throughout the program while the CTLCs mean scores were increasing, the TTLCs (Traditional Teaching and Learning Conceptions) mean scores were decreasing. Furthermore, SEBs' mean scores obtained from each measurement were very similar and almost all mean scores were in agreement that pre-service teachers hold TSEBs (Traditional Scientific Epistemological Beliefs). Also, positive and moderate significant relationships were discovered between all measurements of the CTLCs and SEBs. This meant that while CTLCs mean scores were increasing the TSEBs were also increasing. Because of these results, it is suggested that teacher educators create unique opportunities that will enhance pre-service teachers' awareness of their pre-existing beliefs in order to create some consistency of beliefs. Further studies should be conducted on pre-service teachers' beliefs and conceptions as they relate to their pedagogical practices, as well as, to what types of experiences impact the development of these beliefs and conceptions.

Keywords

Teaching and learning conceptions
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Introduction

In the recent past, because of their key role in reflecting rapid changes in education, the beliefs of teachers and the variables these beliefs affect have garnered increased interest from researchers', as well as, greater importance in teaching and learning circles. Researches have indicated that the decisions made and the activities performed in the classroom by teachers are profoundly influenced by the teachers' beliefs (Jones & Carter, 2007; Wilson, Readence, & Konopak, 2002; Flores, 2001; Fennema & Franke, 1992; Pajares, 1992; Thompson, 1992). Research has also revealed that the pre-teaching professional identity held by pre-service teachers' is composed of their beliefs, their images of teachers, and their personal theories about teaching (Flores & Day, 2006; Sugrue, 1997). Although there have been many studies conducted regarding teachers' beliefs, there continues to be uncertainty and no clear consensus on how to define their beliefs. Therefore, many concepts have been used interchangeably in the research literature for defining teachers' beliefs such as "attitudes, values, judgments, opinions, ideologies, perceptions, conceptions, conceptual systems, dispositions, implicit theories, explicit theories, internal mental processes, action strategies, rules of practice, and perspectives" (Pajares, 1992).

As personal constructs, beliefs are defined as a cognitive representation comprised of understanding and knowledge of the principles of a phenomenon or of one's surroundings (Richardson, 1996). Kember (1997) defines teaching conceptions as beliefs about teaching which guide teacher's perception of a situation and shapes their actions. Lofstrom and Poom-Valickis (2013) then concluded that conceptions appeared to be narrower concepts than beliefs.

Teachers' beliefs seem to be closely linked to the strategies they choose for coping with challenges that they encounter during the teaching and learning process (OECD, 2009). Also, beliefs about the nature of knowledge, as well as, knowledge acquisition are often associated with teachers' conceptions relating to teaching and learning (Chan, 2004). As Coble and Koballa (1996) indicated, in order for teaching practices to change teachers need to first change their conceptions about curriculum, knowledge, learning, and teaching. Furthermore, when we have a solid understanding of teachers' beliefs about curriculum, knowledge, learning, and teaching then we can be more informed about their pedagogic acumen, as well as, their choices for classroom practices (Hauglustaine-Charlier, 1997; Bryan, 2003). As a result, it is clear that a teacher's beliefs play a considerable role in their development as a teacher (Uzuntiryaki & Boz, 2007).

Pajares (1992) suggested that the beliefs of teachers were formed well before they had enrolled in their teacher education programs and these pre-existing beliefs are often very difficult to change. In order to support pre-service teachers in their development of beliefs consistent with pedagogic reasonable practices then it is necessary to thoroughly investigate and understand the effects of teacher education programs have on teachers. Preconceptions about teaching held by pre-service teachers should be exposed at the out-set of their teacher education so that if necessary support can be provided for the pre-service teachers to consciously learn and choose more beneficial beliefs and practices (Darling-Hammond & Baratz-Snowden, 2007). Therefore, it would only seem logical that it is critical to first fully understand pre-service teachers' beliefs, as well as, how teacher education programs affect these beliefs before developing and/or improving upon a teacher education program for which a desired outcome is expected (Haser & Doğan, 2012). 4.1

Teaching and Learning Conceptions

Research has revealed that teaching-learning conceptions held by teachers correspond with their beliefs regarding educational activities (Chan, 2004). More specifically, teaching-learning conceptions are; "the beliefs held by teachers about their preferred ways of teaching and learning and their ideas about the role of teachers and learners within the knowledge acquisition process" (Chan & Elliot, 2004). Brownlee, Purdie, and Boulton-Lewis (2003) define this concept as teachers' conceptions about what constitutes good teaching and learning and how this influences students' approach to learning tasks and the learning process. Also, studies have reported that a strong correlation exists between teaching and learning conceptions and the decisions made by teachers' regarding their classroom and instructional activities (Biggs, 2003; Prosser & Trigwell, 1999). In the literature, teaching and learning beliefs are categorized in a variety of ways including; individual theory, implicit theory, conceptualization, image, educational philosophy and metaphors.

Conceptions of teaching and learning were generally classified into two broad themes, which are commonly known in the research literature as the constructivist and the traditional conceptions. In the traditional view it is conceived that a teacher's role is to communicate knowledge in a clear and structured way, to explain correct solutions, to give students clear and resolvable problems, and to ensure calm and concentration in the classroom. In contrast, a constructivist view focuses on students as active participants in the process of acquiring knowledge. Teachers who follow the constructivist view work to facilitate student inquiry, prefer to give students opportunities for developing independent problem solving skills, and allow students to play a more active role in instructional activities (Chan, 2004). The traditional conception of teaching and learning has long been applied in our schools. With recent changes in the field of education a shift has occurred and schools are intending to utilize the constructivist conception of teaching. Learning environments that encourage higher-order thinking skills (i.e., problem solving, decision making, critical thinking, creative thinking, etc.) are more likely possible when applying the constructivist conception of teaching. As a result, training pre-service teachers in the constructivist conception of teaching is seen as a critical aspect in the training of new teachers, as well as, the overall development of teaching and learning conceptions.

However, teachers have multiple ways of understanding teaching and learning and therefore may simultaneously hold multiple and contrasting perspectives regarding the teaching and learning process (Oxford et al., 1998). Levin and Nevo (2009) stated that views of teaching and learning are not on a developmental continuum but instead more resemble a set of possible views. Research has also shown that when pre-service teachers begin their teacher education program they often do not hold entirely the traditional or the constructivist view of teaching and learning. However, they often endorse the constructivist conceptions while inclining to follow the traditional conceptions. This phenomenon might be explained by the shift in educational philosophy from a teacher-centered to a student-centered pedagogical approach (Chan, Tan, & Khoo, 2007; Chan, 2001, 2004; Chan & Elliot, 2004; Otting, Zwaal, Tempelaar, & Gijselaers, 2010). The teaching process though, experience in the classroom and teaching, often causes substantial changes to occur in their conceptions (Tang, Wong, & Cheng, 2012).

Scientific Epistemological Beliefs

Epistemological beliefs refer to a collection of more or less independent beliefs' (Schommer, 1990) regarding the general nature of knowledge and knowing. Hofer and Pintrich (1997) proposed a framework which restricted personal epistemology to two general areas of epistemological theories. First, is the nature of knowledge as it concerns the beliefs that an individual holds regarding what knowledge is. This has two dimensions; certainty of knowledge and simplicity of knowledge. The second theory is the nature of knowing which concerns the beliefs of a person about how people acquire knowledge. This area of knowing is also divided into two dimensions; source of knowledge and justification of knowledge.

Individual epistemological beliefs range from naive to sophisticated (Ryan, 1984; Schommer, 1990; DeBacker & Crowson, 2006). As Kienhues, Bromme, and Stahl (2008) stated that all studies of epistemological beliefs indicated that over time these beliefs changed from the so-called naive epistemological beliefs towards the sophisticated epistemologies. One area of specific research of epistemological beliefs is that of scientific epistemological beliefs (SEB). In its broadest meaning, scientific epistemological beliefs, includes the beliefs of individuals about what science is, what its features and methods are, and how science should be instructed (Deryakulu & Bıkmaz, 2003). In other words, these beliefs regard the nature of science and are generally referred to as the epistemology of science (Tsai & Liu, 2005). Philosophical assumptions, values, developments, and conceptual inventions in science, as well as, consensus making in scientific communities, and the features of scientific knowledge are included in the epistemology of science (Ryan & Aikenhead, 1992; Tsai & Liu, 2005). Furthermore, teachers' SEBs is often considered an important factor that frames their teaching beliefs, and these beliefs may affect their instructional practice (Tsai, 2006; Hammrich, 1997; Hasweh, 1996; Lederman, 1992; Nott & Wellington, 1995). In contrast, there are other studies which have indicated that no relationship exists between teachers' SEBs and their instructional practice (Lederman & Zeidler, 1987).

Tsai (2000) determined the characteristics of constructivist epistemology as the following;

> *"Observations are theory-laden, theories will be retained even when encountering apparent anomalies, science grows through a series of revolutions, the scientific theories between two paradigms are be incommensurable, science does not represent the reality while scientists are producers of the reality, scientific knowledge comes from human imagination, scientific knowledge comes from a series of criticism, validation, consensus and social negotiation in the scientific community, there is no certain 'scientific method' and there is not only one-way to interpret the same natural phenomena and scientific knowledge is the product of a complex social, historical, complex social, historical, cultural and psychological activity"* (pp. 195)

Educational environments and academic practices appear to be an influential factor in the shaping and development of epistemological beliefs. Holding a constructivist view of science is a valuable prerequisite leading to good science teaching (Tsai, 2002). As a result, teacher education programs should assist pre-service teachers in developing sophisticated epistemological understandings of science (Liu & Tsai, 2008).

We know very little about the personal epistemological beliefs held by pre-service teachers', as well as, how their teaching and learning conceptions may change over the course of their teacher education program (Walker, Brownlee, Whiteford, Exely, & Woods, 2012). Studies regarding epistemological beliefs have indicated that these beliefs ultimately influenced one's conception of learning and teaching (Black & Ammon, 1992; Brousseau & Freeman, 1988; Dweck & Leggett, 1988; Qian & Alvermann, 1995). In other studies, it was concluded that students who held a strong belief that knowledge was static were more likely to view learning as a matter of rote memorization (Tsai, 1999, 2000; Windschitl & Andre, 1998).

In this study, the main objective of the research was to better determine what changes occurred to pre-service teachers' beliefs regarding their scientific epistemological beliefs (SEBs) and teaching and learning conceptions (TLCs) as the pre-service teachers progressed through their teacher education program. Therefore, the purpose of the present study is to determine the changes taking place in TLCs and SEBs of pre-service teachers longitudinally, since they started their studies in a teacher education program and to determine whether there is a statistically significant relationship between TLCs and SEBs. In line with the purpose of the study, answers were sought to the following questions:

1. What trend occur in pre-service teachers' TLCs over time?
2. Do pre-service teachers' TLCs mean scores vary significantly over a four-year period?
3. What trend occur in pre-service teachers' SEBs over a four-year period?
4. Do pre-service teachers' SEBs mean scores vary significantly over a four-year period?
5. Are there significant relationships between pre-service teachers' TLCs and SEBs over a four-year period?

Method

The study employed a longitudinal survey methodology in order to collect data from the same sample elements on multiple occasions over time (Lynn, 2009) and a time series design strategy (Keeves, 1997). According to Keeves (1997), these types of studies assume that human development is a process which is on a continuum that can be examined meaningfully through a series of "snapshots" recorded at appropriate moments in time.

Participants

The participants of the study were pre-service teachers attending a teacher education program in Elementary Education and data for this study was only accepted from volunteers. The research data was collected from pre-service teachers attending the program on six separate occasions. In the first measure data was collected from 46 pre-service teachers, the second time from 58, third time from 58, fourth time from 57, fifth time from 49 and finally on the sixth occasion from 45 pre-service teachers. The variation in the number of pre-service teachers occurred due to the number of attendees on measurement days, as well as, the voluntary nature of completing the data collection instrument. In the end, data was accepted from a total of 31 female and 10 male (n=41) pre-service teacher participant volunteers. With completion of the data collection process, each participant's completed forms were organized together and analyzed independently from those of the other participants.

The elementary education program requires that pre-service teachers complete a total of 156 credits of coursework including; subject area courses, pedagogy courses, and courses in general culture. During the first two years of study, focus is placed on the instruction of subject area and foundation courses while methodology and teaching practicum courses are provided during the third and fourth year of study. Elementary school pre-service teachers were chosen as study participants because a majority of children in Turkey first encounter with a teacher is in elementary school. Elementary school teachers are not only expected to teach students basic knowledge and skills such as reading, writing, and mathematics but also to teach them in aspects of science, as well as, scientific method and inquiry. Furthermore, due to the significance of science and necessity of teaching scientific reasoning skills to future generations it has become vitally important to fully understand the beliefs and conceptions of elementary school teachers.

Data Collection and Analysis

The data collection period began during the 2008-2009 academic year and ended in the 2011-2012 academic year. Over the four-year data collection period on six occasions the data collection instrument was administered. This occurred at the outset of each school year a total of four times, as well as, occurring a total of two times at the end of the third and fourth year. The reasoning behind administering the data collection twice during the same school year, which occurred in the third and fourth year, was motivated by the methodology and school practice courses being instructed during these final two years. This was important because previous studies had indicated that these courses, methodology and school practices, greatly impacted pre-service teachers' belief formation. The data for this study was collected via two survey instruments; the TLCs scale and the SEBs scale.

TLCs Scale

During this study the TLCs Scale data was collected utilizing a TLCs Scale previously developed by Chan (2001). The validation of the original scale was examined through confirmatory factor analysis, the goodness of fit index and psychometric properties were reported to be satisfactory (GFI= 0.93, AGFI= 0.91, RMSEA= 0.054, RMR= 0.050 ; whole scale Cronbach Alpha = .86, the traditional conception subscale Cronbach Alpha= .84, and the constructivist conception subscale Cronbach Alpha = .84) (Chan, 2001). The original scale is a two-factor scale which includes 30 items and aims to elicit opinions about constructivist and traditional teaching and learning conceptions. For the data collection in this study, Chan's questionnaire (2001) was adapted into to Turkish by Bıkmaz and Demirhan Iscan (2008). According to explanatory factor analysis the TLCs Scale contains two subsacles and consist a total of 29 items including; 17 items which aim to determine Traditional Teaching and Learning Conceptions

(TTLCs), and 12 items which aim to determine Constructivist Teaching and Learning Conceptions (CTLCs). The Cronbach Alpha coefficient for the TTLCs sub-scale was determined to be .83, and for CTLCs, the Cronbach Alpha coefficient was determined to be .88. For the whole scale, the reliability coefficient was determined to be .76. The instrument used for TLCs Scale data collection is comprised of items in six categories including; the meaning of teaching and learning, the role of the teacher and students, the role of peers, individual versus group learning, students' abilities and needs, the ways of teaching and classroom management.

SEBs Scale

The second scale utilized for data collection in this study is the SEBs Scale. The original scale, developed by Pomeroy (1993), was translated into Turkish for use in this study by the Deryakulu and Bıkmaz (2003). The scale is a one-factor scale which includes 30 items and aims to elicit opinions about traditional scientific philosophy, non-traditional science philosophy and traditional science education. The Cronbach Alpha coefficient of the SEBs Scale was found to be .91. The high scores obtained from the scale indicate strong beliefs in traditional scientific philosophy and low scores, on the other hand, indicate strong beliefs in non-traditional scientific philosophy (Deryakulu & Bıkmaz, 2003).

The data collection scales were administered to pre-service teachers six times over a four-year period beginning at the outset of each year, as well as, at the end of each of the third and fourth years. As a result, the data collection was completed and the final analysis performed during the 2011-2012 academic year. A Kolmogorow-Smirnov's test ($p>.05$) and a visual inspection of the related histograms, normal Q-Q plots and box plots revealed that almost all data obtain from two scales had an approximately normal distribution with acceptable Skewness and Kurtosis values. However, it was determined that the data obtained from CTLCs did not present a normal distribution but its Mauchly's sphericity result was significant. Due to the lack of both normality assumptions and homogeneity of variances, the obtained data from CTLCs were analyzed with the Friedman test. In order to determine the source of the difference, Wilcoxon test was used and binary comparisons were made. Arithmetic mean was used in order to answer the first and the third research questions. Repeated measures of ANOVA were used for the second (for TTLC scores) and the fourth questions. For the fifth question the simple (Pearson and Spearman Correlation Coefficient) correlation analysis was conducted. Post-hoc comparisons of data, on which ANOVA was performed, was made through Bonferroni test due to the homogeneity of variance and the small amount of data.

Results

In order to address any trend of pre-service teachers' TLCs and SEBs over the duration of the study, the pre-service teachers were asked to rate their acceptance of items regarding the TLCs and SEBs. Tables 1, 2, and 3 provide descriptive statistics for the TLCs (CTLCs and TTLCs) and SEBs.

Table 1. Descriptive Statistics for CTLCs

Measurements	N	$\overline{x}$	ss	Minimum Score	Maximum Score
CTLCs 1	41	53.00	3.94	45.00	60.00
CTLCs 2	41	51.93	4.47	45.00	60.00
CTLCs 3	41	54.15	4.44	46.00	60.00
CTLCs 4	40	55.50	5.29	36.00	60.00
CTLCs 5	41	56.18	4.26	47.00	60.00
CTLCs 6	41	56.58	4.65	41.00	60.00

When pre-service teachers' CTLCs mean scores were analyzed, it can be seen that except CTLCs 2, these mean scores increased over the research period. In this context, the lowest CTLCs mean scores for pre-service teachers were seen at the beginning of the second year ($\overline{x}$=51.93) and the highest score was seen at the end of the fourth year ($\overline{x}$=56.58).

Table 2. Descriptive Statistics for TTLCs

Measurements	N	$\overline{x}$	ss	Minimum Score	Maximum Score
TTLCs 1	41	46.41	8.44	28.00	70.00
TTLCs 2	41	46.66	7.57	28.00	63.00
TTLCs 3	41	37.83	7.47	24.00	61.00
TTLCs 4	41	35.73	9.59	21.00	59.00
TTLCs 5	41	34.73	7.79	22.00	52.00
TTLCs 6	41	33.88	8.96	17.00	62.00

When pre-service teachers' TTLCs mean scores were analyzed based, it can be seen that except TTLCs 2, these mean scores decreased over the research period. In this context, the highest TTLCs mean scores for pre-service teachers were seen at the beginning of the second year ($\overline{x}$=46.66) and the lowest score was seen at the end of the fourth year ($\overline{x}$=33.88).

Table 3. Descriptive Statistics for SEBs

Measurements	N	$\overline{x}$	ss	Minimum Score	Maximum Score
BEİ 1	41	105.22	6.99	88.00	119.00
BEİ 2	41	103.83	5.44	92.00	119.00
BEİ 3	41	105.98	5.08	98.00	117.00
BEİ 4	41	107.07	6.78	95.00	122.00
BEİ 5	41	106.63	7.19	89.00	119.00
BEİ 6	41	107.66	7.34	84.00	123.00

When pre-service teachers' SEBs mean scores were analyzed, it can be seen that except for SEBs 2 and SEBs 5 these mean scores increased over the research period. In this context, the lowest SEBs mean scores for pre-service teachers were seen at the beginning of the second year ($\overline{x}$=103.83) and the highest score was seen at the end of the fourth year ($\overline{x}$=107.66).

Differences observed in pre-service teachers' TLCs and SEBs scores over a four-year period are provided in Figure1. The mean scores of TLCs are presented separately as CTLCs and TTLCs.

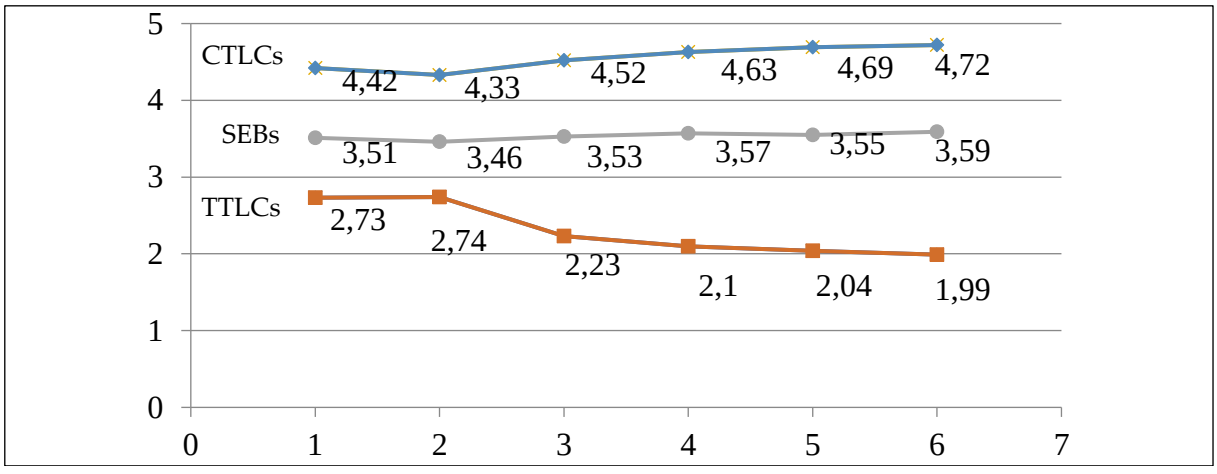

Figure 1. Mean Scores of SEBs, CTLCs and TTLCs

When the pre-service teachers entered the Faculty of Education and agreed to participate in this study the first data collected regarding their CTLCs and TTLCs was during the first semester of study. The initial mean score for the CTLCs was 4.42, which indicated that these pre-service teachers had strong CTLCs when they entered their teacher education program. The mean scores for virtually all

items' increased slightly for each subsequent year of grade level increase. While at the outset of the teacher education program the TTLCs mean scores at the beginning of the first year was 2.73 and increased to 2.74 in the beginning of the second year. Conversely, the mean scores of the TTLCs continuously decreased each year when the grade level increased. As a result, the trend indicates that the teacher education program has a stronger effect on pre-service teachers' TTLCs.

Again, at the outset of the program the pre-service teachers SEBs mean scores were 3.51. At the start of the second year the mean score had decreased to 3.46 but then increased during the third year to 3.53 and then 3.57 by the end of the third year. The same trend was observed in in the mean scores during the fourth year, 3.55 in the beginning of the year and 3.59 with the year-end data collection. High SEBs mean scores indicate that pre-service teachers' hold strong traditional scientific epistemological beliefs. Further analysis of the mean scores clearly indicates that pre-service teachers hold strong traditional scientific epistemological beliefs and that the teacher education program has little effect on the pre-service teachers' SEBs.

Table 4. Friedman Analysis of CTLC

N	χ^2	df	p
40	61.538	5	.000

The mean scores of pre-service teachers' CTLCs scores statistically significantly varied ($\chi^2_{(5,40)}$ = 61.538, p= .000). In order to determine the source of the difference, the Wilcoxon test for bilateral comparisons was used. There were statistically significant differences between measurements in the first and fourth (1-4), the first and fifth (1-5), the first and sixth (1-6), the second and fourth (2-4), the second and fifth (2-5), the second and sixth (2-6), the third and fourth (3-4), the third and fifth (3-5), and the third and sixth (3-6) ($p<0.05$).

Table 5. Analysis of Variance and Effect Size for TTLCs

Source of Variance	*Sum of the square*	*df*	*Mean of the squares*	*F*	*p*	*Partial Eta Squared*
Between Groups	8475,927	40	211,898			.46
Measure/intercept	6964,963	5	1392,993	33,919	.000	
Error	8213,537	200	41,068			
Total		245				

[F(5-200)= 33,919, p<.0001]

According to the analysis of variance, there was a statistically significant difference among the pre-service teachers' TTLCs mean scores [F(5-200)= 33,919, p<.0001]. The Partial Eta Squared was calculated to .46 and addressing a difference in mean scores of TTLC measurements. Post-hoc comparisons using the Bonferroni test indicated that in terms of TTLCs' mean scores there were also significant mean differences between the first and third measurement (1-3), first and fourth measurement (1-4), first and fifth measurement (1-5), first and sixth measurement (1-6), the second and third measurement (2-3), second and fourth measurement (2-4), second and fifth measurement (2-5), second and sixth measurement (2-6).

Table 6. Analysis of Variance and Effect Size for SEBs

Source of Variance	*Sum of the square*	*df*	*Mean of the squares*	*F*	*p*	*Partial Eta Squared*
Between Groups	5265,293	40	131,632			
Measure/intercept	393,642	5	78,728	3,167	,009	.07
Error	4972,024	200	24,860			
Total		245				

[F(5-200)= 3,167, p<.0001]

There were statistically significant differences among the SEBs mean scores of pre-service teachers [F(5-200)= 3,167, p<.0001]. The Partial Eta Squared was calculated to be .07, addressing a very small difference which existed for mean scores between measurements. Post-hoc comparisons using the Bonferroni test revealed a significant mean difference in terms of SEBs' mean scores between the second and fourth (2-4) measurement and the second and sixth (2-6) measurement.

Moderate and positive significant relationships were found among the scores obtained from the sixth measurement of the pre-service teachers' TLCs and SEBs. For the first two measurements of TTLCs and SEBs, there were moderately significant positive relationships found, r= .32 and r= .39. While a moderately significant negative relationship was found between last measurements of TTLCs and SEBs, r= -.36. Moreover, between all measurements of CTLCs and SEBs, positive and moderate significant relationships were found, r_s = .57, r_s= .55, r_s = .31, r_s= .34, r_s = .38 and r_s= .44.

Discussion, Conclusion and Suggestions

The purpose of the present study is to determine what changes occurred in the TLCs and SEBs of pre-service teachers after they began their studies in education. Based on these research findings it can be stated that pre-service teachers entered their first year of education with strong CTLCs and that mean scores increased slightly as their grade level increased. This can be interpreted as pre-service teachers starting their teacher education programs with high CTLCs; having a more teacher-centered education approach in the formal education system and pre-service teachers who experience such practices find student-centered education more meaningful. This finding is in agreement with Lamote and Engels' (2010) and Doyle's (1999) studies which had determined that students' entering teacher education programs with strong student-centered beliefs towards pedagogy tended to have mean scores for student-centered pedagogic beliefs that continued to increase over the academic years.

Findings also revealed that throughout the period of the teacher education program while the CTLCs mean scores were increasing, conversely, the TTLCs mean scores were decreasing. Following the first year and second year measurements there were no significant differences were found between the CTLCs and TTLCs mean scores. During the first two years of the teacher education program the pre-service teachers were receiving instruction in foundational and subject area courses. Measurements at the completion of the third year, as well as, at both the outset and completion of the fourth year of teacher education program revealed that the CTLCs mean scores differed significantly from first and second year mean score measurements. These findings were also valid for the TTLCs mean scores from the third, fourth, fifth and sixth measurements' which also significantly differed from the first and second year mean score measurements. During the third and fourth years of the teacher education program the pre-service teachers received instruction in teaching methodology and teaching practice which can explain the significant divergence in the mean score measurements (Lofstrom & Poom-Valickis, 2013; Tang et al., 2012; Clift & Brady, 2005; Richardson, 1996). In the teacher education program the pre-service teachers received instruction in teaching practice during their sixth, seventh and eight semesters. As a result, it can be expected that changes would occur in their conceptions regarding teaching and learning. A significant difference was indicated between the second and third measurements of TTLCs mean scores. The significant difference in mean scores may be explained by the instruction in the teacher education program during these semesters of courses in pedagogy including; teaching methodology, teaching technologies and material design. Another important finding was that the SEBs' mean scores obtained from each measurement were very analogous and virtually all SEB mean scores corresponded with the agree category. In other words, pre-service teachers starting their college education with high TSEB did not significantly change these beliefs over the four years of education. In formal education programs, teaching science primarily as theoretical, and having closed-ended science experiments in laboratory studies may cause powerful TSEBs. In this research, it can be argued that courses involved in teacher education programs such as physics, life science, chemistry, laboratory science I-II and teaching science I-II did not lead to a change in pre-service teachers' understandings of TSEBs. Other studies have indicated that epistemological beliefs do not

often change quickly or easily (Richardson, 1996), and the means of pre-service teachers' SEBs in this research were consistent with these other study findings. Following examination of this tendency it can be stated that the teacher education program had little effect on pre-service teachers SEBs. Furthermore, it was also revealed that pre-service teachers hold TSEBs. This finding is also consistent with studies that indicated that TSEBs are common among university students in Turkey (Meral & Çolak, 2009; Terzi, 2005).

Another important finding is the positive and moderate significant relationships revealed between all measurements of the CTLCs and SEBs. What this indicates is that while CTLCs mean scores were increasing the TSEBs were also increasing. Green (1971) addressed this phenomenon postulating that beliefs are organized into isolated clusters that allow for contradictory central beliefs to be clustered. In this research group pre-service teachers hold CTLCs but also simultaneously hold TSEBs. In fact, there was an expectation that in pre-service teachers' belief system the TLCs and SEBs would form a coherent network. Green's concept of "isolated cluster" can explain this phenomenon of contradictory beliefs being clustered.

The fact that there was little change in SEBs mean scores over the duration of the teacher education program indicates there is a need to reevaluate and revamp the teaching approach used in the teacher education program. In fact, *"young adults begin college holding primarily naive epistemological beliefs, and evolve toward higher-level ones throughout their postsecondary education, provided adequate opportunities to develop their beliefs"* (Schraw, Bendixen, & Dunkle, 2002; Baxter Magolda, 1996; Schommer, 1994). A strong constructivist view of science is seen by many to be almost a prerequisite for quality science teaching (Chinn & Malhotra, 2002; Tsai, 2002). As a result, it can be argued that teacher education programs should support pre-service teachers in developing sophisticated epistemological beliefs of science. Furthermore, a more thorough understanding of pre-service teachers' beliefs may further assist teacher educators in better developing and implementing instruction that can enhance pre-service teacher's epistemological development (Liu & Tsai, 2008). Pre-service teachers' epistemological beliefs can be cultivated during their teacher education by implementing more inquiry-oriented, conceptual change, cooperative science activities, as well as, utilizing more elements in the instructional process from the areas of history and philosophy of science (Abd-El-Khalick & Lederman, 2000; Palmquist & Finley, 1997).

Without self-reflection of one's own beliefs and also the critical examination of these existing beliefs in light of new possibilities, then pre-service teachers may ultimately ignore and/or distort the new ideas and practices that they gain during the teacher education process. For that reason alone, teacher educators should work to create a variety of new opportunities that can enhance pre-service teachers' awareness of their own beliefs in hopes of forming a more consistent network of beliefs. In particular, pre-service teachers should be asked to critique, discuss, evaluate, and think about their own, as well as, their peers' preferred practices regarding practical courses, teaching practicum courses, and proposed teaching-learning experiences. As a result of this process of reflection the introspective and self-awareness skills of pre-service teachers may be further developed and enhanced.

Finally, there is continued need to conduct further research in this area in order to more fully examine the beliefs and conceptions of pre-service teachers from a variety of disciplines and subject areas. Further research can aid in bettering determining which experiences affect pre-service teachers, observe changes and/or trends which occur in the beliefs and conceptions of teachers during service, as well as, to investigate how their beliefs and conceptions are transferred into their teaching.

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