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EXAMINING THE BELIEFS OF PROSPECTIVE ELEMENTARY AND SCIENCE TEACHERS REGARDING REFORMED SCIENCE TEACHING AND LEARNING

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Abstract

Turkey following the footsteps of western education system is nowadays struggling to implement constructivist paradigm in its schools. The success of the integration of constructivist elements into the schools is heavily contingent upon the support of teachers. This necessitates that the ideas advocated in constructivist reform movements should be promoted adequately in the preparation of teacher candidates. Therefore, investigating the beliefs of prospective teachers regarding reformed science teaching and learning becomes crucially important for an accurate portrayal of the current structure of the teacher profiles. This study focuses on the beliefs of prospective elementary and science teachers regarding reformed science teaching and learning. An adapted version of the BARSTL (Beliefs about Reformed Science Teaching and Learning) questionnaire developed originally by Sampson, Grooms and Enderle (2013) was delivered to a total of 393 first-year elementary and science teachers. The reformed science teaching and learning beliefs of prospective teachers with respect to their majors, genders and type of high school from which they graduated was investigated using independent samples t-test statistics and one-way ANOVA statistics. The results of the study indicate that many prospective teachers regardless of their majors adopt traditional perspectives in science teaching and learning. Particularly, prospective elementary and science teachers scored lower on “how people learn about science” and “the nature of the science curriculum” sub-dimensions of the BARSTL questionnaire, which implies that traditional beliefs are more dominant in these two specific sub-dimensions. The mean scores of elementary and science prospective teachers differ statistically significantly in two sub-dimensions of the BARSTL questionnaire (“characteristics of teachers and the learning environment” and “the nature of the science curriculum”). With respect to gender, the mean scores of male teacher candidates are significantly higher than their female peers in two sub-dimensions of the questionnaire (“how people learn about science” and “lesson design and implementation”). No statistically significant difference is present between the mean scores of prospective teachers graduated from different types of high schools. The results obtained from the study indicate the limited acceptance of constructivist reform ideas by pre-service elementary and science teachers.

Constructivist Reform

The history of Western thought might be divided in three consecutive time periods: pre-modern, modern and post-modern (Doll, 1993). Pre-modern worldview that reached its highest level with the exceptional works of influential ancient Greek philosophers like Plato, Socrates and Aristotle was replaced by modernity in sixteenth century with the major contributions of prominent natural philosophers; Copernicus, Galileo, Descartes and Newton just to name a few. The modernity’s success, which was crowned with the

emergence of industrial revolution, permeated to every aspect of life until its death announcement was made by Jürgen Habermas in late twentieth century. The postmodern era in which we currently live makes itself feel in different fields in different ways. Needless to say, the education field is no exception. Although it is quite difficult to give a precise account of the emerging new paradigm accompanying postmodernism, its effects are being felt in education domain with the emergence of contemporary education reform movements (Doll, 1993).

Transitioning from an industrial society to a knowledge driven economy necessitated the renewal of science education standards in 1980s. Fast development of science and technology led to changing relationship between the workforce and production. Preparing the qualified workforce in harmony with the knowledge driven economy triggered a change in the education of students in science. In parallel to the emerging needs of the knowledge driven economy, the influence of the postmodernism manifested itself on science education with constructivism (Schulz, 2007; Sherman, 2000). In other words, the new science education standards in the US rise on the philosophical foundations of constructivism (National Research Council, 1996). Likewise, Turkey following the footsteps of Western education system prepared recently new standards for science education in all levels of schooling, namely elementary, middle and high school (Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı, 2007; Talim ve Terbiye Kurulu Başkanlığı, 2006). Constructivism as an epistemology considers knowledge as a constructed entity by individuals rather than an external agent free from its knower. As such, learning takes place by constructing the meaning from experiences as opposed to acquiring the knowledge directly from the teacher.

Without any doubt, constructivist reform in the education system is fruitful yet a difficult task. That is mainly because the underlying principles advocated in contemporary science education reform efforts are at odds with the traditional foundations of the current education system built on the modernistic worldview. In a most general sense, traditional science education considers students as passive acquirers of information transmitted by their teachers. Traditional education system promotes "the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understandings in context, recitation over argument, reading in lieu of doing" (American Association for the Advancement of Science, 1990). Therefore, in most science classrooms, students are filled with the preexisting information written on the textbooks at the expense of internalizing knowledge constructed from classroom experiences.

The success of any reform effort is contingent upon the support of the teachers (Levitt, 2001). If the proposed reform movement comes especially from top to down, the support of the teachers becomes more crucial for the future success of the reform efforts. That is mainly because the innovative ideas adopted at the macro level of education are carried out by teachers at the micro level of classroom. Obtaining wider support from practicing teachers depends partly on providing better education, which is consistent with the central tenets of contemporary science education standards, to them in their university education. Teacher candidates come to the teacher education programs with their preexisting beliefs regarding science teaching and learning. After many years being spent as a student at the K-12 level, prospective teachers develop certain set of beliefs not necessarily aligned with the science education reform ideas. Examining these beliefs is extremely important because they play an important role in teacher candidates' further improvement in teacher education programs. Since beliefs are considered to be the driving force behind the actions, preparing teachers with beliefs inclined more to reform ideas will help actualize the ideas advocated in reform efforts.

In this research study, the reformed science teaching and learning beliefs of prospective teachers were examined with respect to their majors, genders and type of high schools from which they graduated. The following research questions guided this study:

1. Is there a statistically significant difference between the reformed science teaching and learning beliefs mean scores of prospective teachers with respect to their majors?
2. Is there a statistically significant difference between the reformed science teaching and learning beliefs mean scores of prospective teachers with respect to their genders?
3. Is there a statistically significant difference between the reformed science teaching and learning beliefs mean scores of prospective teachers with respect to the type of high school from which they graduated?

Research Design

This research study was conducted at a Turkish university located on the north-west shores of the Aegean Sea. A total of 393 teacher candidates, 204 of whom were preservice elementary teachers and 189 of whom were preservice science teachers, participated in the study. First-year student teachers attending the College of Education were asked to complete a questionnaire entitled "Beliefs about Reformed Science Teaching and Learning (BARSTL)". The questionnaire instrument originally developed by Sampson, Grooms and Enderle (2013) was translated to Turkish language by one of the authors. After the translation was completed, the other author of the paper performed a thorough review of the translation and made some revisions on it. Other than the authors of the paper, the translation process continued through checking the accuracy and appropriateness of the translation by two bilingual (Turkish and English) scholars. The feedback provided by these scholars competent both in English and Turkish languages determined the final shape of the Turkish version of the instrument to be used in this study.

BARSTL was designed for assessing the beliefs of prospective elementary teachers about science teaching and learning. The original instrument included 32 items distributed into the following four sub-dimensions: how people learn about science, lesson design and implementation, characteristics of teachers and the learning environment, and the nature of the science curriculum. Each sub-dimension included eight questions, four of which represented the traditional perspective and four of which represented the reformed perspective. Table-1 below summarizes the traditional and reformed perspectives embedded in each sub-dimensions of the instrument. In the study, prospective elementary and science teachers completed the Turkish version of the questionnaire comprised of a total of 32 items. The data were collected from an online version of the questionnaire prepared specifically for teacher candidates.

Table-1Contrasting Perspectives Represented in the Sub-dimensions of the BARSTL Instrument

BARSTL Sub-dimensions	Traditional Perspective	Reformed Perspective
Factor-1: How people learn about science	Compared with blank slates Learning is accumulation of information.	What students learn is influenced by their existing ideas. Learning is the modification of existing ideas.
Factor-2: Lesson design and implementation	Teacher-prescribed activities Frontal teaching-telling and showing students	Student-directed learning. Relies heavily on student-developed investigations, manipulative

	Relies heavily on textbooks and workbooks.	materials, and primary sources of data.
Factor-3: Characteristics of teachers and the learning environment	The teacher acts as a dispenser of knowledge.	The teacher acts as facilitator, listener, and coach.
	Focus on independent work and learning by rote	Focus on learning together and valuing others ideas and ways of thinking.
Factor-4: The nature of the science curriculum	Focus on basic skills (foundations)	Focus on conceptual understanding and the application of concepts
	Curriculum is fixed.	Curriculum is flexible, changes with student questions and interest.
	Focus on breadth over depth	Focus on depth over breadth

Based on the available data collected from the prospective teachers, some psychometric properties of the instrument were investigated to ensure the validity and reliability of the results. Construct validity of the instrument was tested using Principal Component Analysis (Table-2). The value of Kaiser-Meyer-Olkin (KMO) as a measure of sampling adequacy was found as 0.75. KMO value over 0.5 is generally considered to be adequate for performing the Principle Component Analysis (Field, 2009). Bartlett's Test of Sphericity [χ^2 (120) = 1575.38, $p < 0.001$] indicated that the correlations between the items were sufficiently large for conducting the Principle Component Analysis. Adopting Kaiser's criterion of 1, four factors whose eigenvalues were over 1 were extracted. The extraction of these four factors was confirmed with an analysis of the scree plot. These four factors explained 54.51 % of the total variance in the data set. 14.70, 22.26, 8.54 and 9.01 % of the variance was attributable to factor-1, factor-2, factor-3 and factor-4 respectively. Only those items with higher factor loadings than 0.33 were considered to have adequate relationship with a specific factor, which explains approximately 10 % of variance in a specific item. Therefore, the inconsistent items loading more than one factor and that having lower factor loadings than 0.33 were eliminated from the instrument. Hence, in the Turkish version of BARSTL, sixteen of the items representing the four factors were retained based on the results obtained from the factor analysis. The items kept in the instrument and their respective factor loadings are displayed in Table-2 below.

Table-2 Principle Component Analysis (Rotated Component Matrix via Varimax Method)

Items	Factor 1	Factor 2	Factor 3	Factor 4	Eigenvalues	% of Variance
Item 03	0.77				2.35	14.70
Item 04	0.49					
Item 06	0.76					
Item 07	0.75					
Item 09		0.83			3.56	22.26
Item 10		0.85				
Item 11		0.81				
Item 13		0.43				
Item 18			0.80		1.37	8.54
Item 19			0.79			
Item 20			0.68			
Item 26				0.59	1.44	9.01
Item 27				0.65		
Item 29	0.41			0.55		

Item 30	0.57	
Item 31	0.58	

As a measure of internal consistency of the Turkish version of the scale, Cronbach Alpha reliability coefficients were calculated for each one of the four sub-dimensions of the instrument. The following reliability coefficients, each one of which corresponds to one of the four sub-dimensions, were found as: 0.77, 0.68, 0.61 and 0.68. The overall reliability coefficient of the scale was obtained as 0.75. These values are considered to be acceptable for social science research purposes (Kent, 2001).

The items in BARSTL instrument were scored using 5-level Likert Scale, ranging from "strongly agree" to "strongly disagree". While an item marked as "strongly agree" was given 5 points, an item marked as "strongly disagree" were given 1 point. However, items representing the traditional perspectives were reverse scored, in that, 5 points were given to items marked as "strongly disagree" and 1 point was assigned to items marked as "strongly agree". The comparisons of the mean scores of the teacher candidates with respect to their majors and genders were made using "2-tailed independent samples t-test" statistics. The analysis of the mean scores of prospective teachers in regard to the type of high school from which they graduated was performed using "one way ANOVA (Analysis of Variance)" statistics. The results of the statistical analyses are presented in the next section.

Findings

Turkish education system is currently undergoing a process of change. There is no doubt that the teachers play the major role in this change process. Teachers who hold beliefs aligned with the reform ideas will contribute positively to this change process. Therefore, preparing reform minded teachers is a must for the future success of the reform movements. Investigating the beliefs of teacher candidates regarding teaching and learning process has a strategic importance for educating the next generation teachers supporting the central tenets of reform ideals. In this study, the science teaching and learning beliefs of prospective teachers were investigated with respect to their majors, genders and high schools from which they graduated.

Answering the first research question of whether the mean scores of the prospective teachers differ significantly from one to another with respect to their majors (elementary and science education), "independent samples t-test" statistics were adopted. Levene's Test for Equality of Variances produced insignificant results in all sub-dimensions of BARSTL instrument, which indicated the homogeneity of variance across two groups of teacher candidates, namely elementary and science. Thus, t-test values corresponding to "equal variances assumed" row were used in analyzing the effect of major on prospective teachers' beliefs of reformed science teaching and learning (Table-3).

Table-3 Comparison of Mean Scores of Prospective Teachers with Respect to Their Majors

Sub-dimensions	Major	N	Mean	SD	Mean Difference	t-test (2-tailed)
Factor-1	Elementary Teachers	204	1.69	0.58	-0.06	t(391) = -0.929, p=0.354
	Science Teachers	189	1.75	0.65		
	Combined	393	1.72	0.61		

Factor-2	Elementary Teachers	204	3.24	0.50	0.10	t(391) = 1.827, p=0.069
	Science Teachers	189	3.14	0.54		
	Combined	393	3.19	0.52		
Factor-3	Elementary Teachers	204	3.54	0.43	0.19*	t(391) = 3.984, p=0.001
	Science Teachers	189	3.35	0.47		
	Combined	393	3.45	0.46		
Factor-4	Elementary Teachers	204	2.15	0.35	-0.07#	t(391) = -2.140, p=0.033
	Science Teachers	189	2.22	0.38		
	Combined	393	2.18	0.37		
BARSTL	Elementary Teachers	204	2.65	0.25	0.03	t(391) = 1.397, p=0.163
	Science Teachers	189	2.62	0.26		
	Combined	393	2.64	0.25		

*significant at α=0.01
#significant at α=0.05

According to Table-3, the overall mean scores of prospective teachers indicate a moderate support of reform ideas (mean=2.64). Teacher candidates received lowest mean scores in the following two sub-dimensions of the scale: how people learn about science (mean=1.72) and the nature of the science curriculum (mean=2.18). In comparison to other two sub-dimensions ("lesson design and implementation" and "characteristics of teachers and the learning environment"), traditional views of prospective teachers are more dominant in these two sub-dimensions ("how people learn about science" and "the nature of the science curriculum"). Teacher candidates hold more reform-oriented beliefs in the following two sub-dimensions: lesson design and implementation (mean=3.19) and characteristics of teachers and the learning environment (mean=3.45). When it comes to the comparison of elementary and science prospective teachers, the mean scores of elementary and science prospective teachers differ statistically significantly in the following two sub-dimensions: characteristics of teachers and the learning environment [$t(391) = 3.984$, $p<0.01$)] and the nature of the science curriculum [$t(391) = -2.140$, $p<0.05$]. The mean scores of elementary teachers (mean=3.54) are significantly higher than science teachers (mean=3.35) in "characteristics of teachers and the learning environment" subdimension. In "the nature of the science curriculum" sub-dimension, the mean scores of prospective teachers are significantly different in favor of science teachers. On the other hand, in addition to factor-1 and factor-2, the difference between overall mean scores of elementary and science teachers does not yield a statistically significant result [$t(391) = 1.397$, $p>0.05$].

Answering the second research question of whether the mean scores of the prospective teachers are significantly different from one to another with respect to their genders (female and male), "independent samples t-test" statistics were used. Due to the insignificant results of Levene's Test for Equality of Variances in all sub-dimensions of BARSTL instrument, t-test values corresponding to "equal variances assumed" row were used in analyzing the effect of gender on prospective teachers' beliefs of reformed science teaching and learning (Table-4).

Table-4 Comparison of Mean Scores of Prospective Teachers with Respect to Their Genders

Sub-dimensions	Gender	N	Mean	SD	Mean Difference	t-test (2-tailed)

Factor-1	Female	288	1.67	.61	-0.17#	t(391) = -2.401, p=0.017
	Male	105	1.84	.61		
Factor-2	Female	288	3.15	.53	-0.18*	t(391) = -3.062, p=0.002
	Male	105	3.33	.47		
Factor-3	Female	288	3.44	.46	-0.04	t(391) = -0.785, p=0.433
	Male	105	3.48	.45		
Factor-4	Female	288	2.17	.37	-0.04	t(391) = -0.917, p=0.360
	Male	105	2.21	.37		
BARSTL	Female	288	2.61	.26	-0.10*	t(391) = -3.780, p=0.001
	Male	105	2.71	.21		

*significant at α=0.01
#significant at α=0.05

The results in Table-4 indicate that the overall mean scores of male prospective teachers are statistically significantly higher than the mean scores of female prospective teachers [t(391) = -3.780, p<0.01]. In a similar fashion, males scored significantly higher than their female counterparts in the following two sub-dimensions: how people learn about science [t(391) = -2.401, p<0.05] and lesson design and implementation [t(391) = -3.062, p<0.01]. Having a higher score in a specific sub-dimension means to be inclined more to the reformed beliefs of science teaching and learning. In other two sub-dimensions ("characteristics of teachers and the learning environment" and "the nature of the science curriculum"), no statistically significant difference was found between the mean scores of female and male prospective teachers. Regardless of their genders, the mean scores of prospective teachers are lower in "how people learn about science" and "the nature of the science curriculum" sub-dimensions, which implies a more traditional view of science teaching and learning.

Investigating the effect of the type of high school graduated on prospective teachers' beliefs of science teaching and learning, one way ANOVA (Analysis of Variance) statistics was utilized. Insignificant results of Levene Statistics in all of the sub-dimensions of the scale can be acknowledged as an indicator of the fulfillment of homogeneity of variances assumption of ANOVA statistics.

Table-5 Comparison of Mean Scores of Prospective Teachers with Respect to Their Schools

Sub-dimensions	Type of School Graduated	N	Mean	SD	ANOVA
Factor-1	Regular High School	219	1.75	.62	F(3,386) = 2.079, p=0.103
	Anatolian High School	140	1.68	.59	
	Anatolian Teacher High School	16	1.42	.62	
	Vocational High School	15	1.90	.59	
Factor-2	Regular High School	219	3.21	.53	F(3,386) = 0.980, p=0.402
	Anatolian High School	140	3.15	.52	
	Anatolian Teacher High School	16	3.36	.52	
	Vocational High School	15	3.18	.49	
Factor-3	Regular High School	219	3.41	.48	F(3,386) = 1.301, p=0.274
	Anatolian High School	140	3.49	.44	

	Anatolian Teacher High School	16	3.52	.40	
	Vocational High School	15	3.53	.37	
Factor-4	Regular High School	219	2.19	.37	F(3,386) = 0.529, p=0.662
	Anatolian High School	140	2.18	.36	
	Anatolian Teacher High School	16	2.07	.41	
	Vocational High School	15	2.23	.27	
BARSTL	Regular High School	219	2.64	.25	F(3,386) = 0.668, p=0.572
	Anatolian High School	140	2.63	.26	
	Anatolian Teacher High School	16	2.59	.23	
	Vocational High School	15	2.71	.21	

Reviewing the figures in Table-5 reveals that the overall mean scores of prospective teachers do not differ statistically significantly from one to another depending on the type of high school from which they graduated [$F(3,386) = 0.668$, $p>0.05$]. The situation is no different in the specific sub-dimensions of the scale. In other words, the difference between the mean scores of the prospective teachers graduated from different types of high schools yield a statistically significant result in none of the sub-dimensions. This finding implies that the type of high school from which prospective teachers graduated does not have significant effect on their beliefs of science teaching and learning.

Statistically significant results found in the study should be scrutinized further in terms of their practical importance. That is because having significant difference is not necessarily meaningful in real life. In the next section of the paper, the practical implications of the statistical results will be discussed holistically in connection with the relevant literature.

Conclusions and Implications

The new standards in science education deserve wider support from teachers in order to maintain its success. This is ultimately dependent on the preparation of future teachers having inline beliefs with the central tenets of science education reform movement. However, according to the specific results acquired from this study, the current situation among prospective teachers seems to be quite the reverse. Many prospective teachers regardless of their majors have limited support of constructivist reform ideas. The overall mean scores of pre-service teachers represent a moderate level of acceptance rate of reformed beliefs of science teaching and learning. In terms of the sub-dimensions included in the instrument, prospective teachers scored lower on sub-dimensions “how people learn about science” and “the nature of the science curriculum” in comparison to the other two sub-dimensions, namely “lesson design and implementation” and “characteristics of teachers and the learning environment”. Prospective teachers’ lower mean scores in these specific sub-dimensions of the BARSTL questionnaire indicate that most of the teacher candidates are not in favor of reform oriented ideas in science teaching and learning. This result is not unexpected considering the K-12 school structure built primarily on the traditional foundations of education. The inference to be made from this finding might be that the recent science education standards based on the constructivist paradigm failed to permeate to the Turkish schools sufficiently yet. Teacher candidates starting their university education with traditional beliefs of education should be supported to feel more inclined to the reform ideas. That is because the conflict between teachers’ traditional beliefs of education and the ideas advocated in reform documents constitute one of the

biggest impediments in front of reforming education system.

The analysis of the data with respect to the majors of the prospective teachers denote that the mean scores of the teacher candidates differ statistically significantly in two out of the four sub-dimensions included in the instrument. While elementary teachers' mean scores were significantly higher than science teachers on "characteristics of teachers and the learning environment" sub-dimension, science teachers scored significantly higher on "the nature of the science curriculum" sub-dimension. Based on the genders of the teacher candidates, the mean scores of male student teachers were found to be statistically significantly higher than their female peers on the following two sub-dimensions: "how people learn about science" and "lesson design and implementation". The type of high school from which prospective teachers graduated does not have a significant effect on their reformed beliefs of science teaching and learning. This finding seems to be reasonable considering the similar programs followed in all types of Turkish high schools. Despite being graduated from different high schools, teacher candidates start the teacher education programs with similar beliefs about science teaching and learning.

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