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The Effect of Methods Course on Pre-Service Teachers' Awareness and Intentions of Teaching Science, Technology, Engineering, and Mathematics (STEM) Subjects

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Abstract

The purpose of this study was to analyze the impact of participating in a STEM methods course on pre-service teachers' awareness of and intentions to teach STEM subjects. Quantitative analysis was conducted of data gathered from 53 (41 female and 12 male) preservice science teachers from a teacher preparation program in a university in a small western city of Turkey. Data from STEM awareness and STEM teaching intention questionnaires were collected before, immediately after and four months after participants attended a STEM-based science methods course. Data were analyzed via a mixed between-within subjects' analysis of variance. Results indicated that course participation can help modify the awareness of preservice science teachers. Specifically, preservice teachers' STEM awareness and intentions of teaching STEM subjects tended to increase after attending the methods course, showing statistically significant, large effects in teacher awareness and intentions of teaching STEM subjects after attending the course.

Introduction

Preparing pre-service teachers (PTs) to engage diverse groups of students in STEM disciplines in significant and meaningful ways is one of the central goals of STEM teacher education worldwide. Cultural differences between how this challenge is addressed can provide valuable perspective to better understand one's own culture and practice in preparing future STEM educators. This is a challenging, but essential task for preparing STEM educators to develop a scientifically literate populace.

PTs often struggle to effectively reflect on and adapt practices that are different from their own experience in school, methods in which they were successful but their students may find difficult (Lortie, 1975; Yerrick, Parke, & Nugent, 1997). To support lasting change in classrooms, PTs must be guided in thoughtfully considering the outcomes of their pedagogical choices (Yerrick & Hoving, 2003). This is particularly important in considering the goal of engaging diverse students in culturally relevant, authentic STEM practices, however with limited experience and education, PTs may not recognize the value of these practices or simply may not know how to implement them effectively. Preparing and helping teachers to implement STEM practices is challenging, particularly for those with limited knowledge and experience in teaching through inquiry and engineering design-oriented classroom strategies, as pre-service teachers often feel unprepared to teach STEM subjects and practices in the classroom (Anagun & Muhammet, 2010). The knowledge, confidence and awareness that teachers hold regarding integration of STEM subjects and practices play major roles in the successful implementation of STEM in classrooms (Nadelson et al., 2013; Kim & Bolger, 2017).

In particular, a number of researchers have explored beliefs regarding gender and STEM education. Elementary classroom teachers tend believe that mathematics is more challenging for girls than boys, hence girls need to exert more effort than boys to learn the subject (Tiedemann, 2000). In general, teachers tended to believe that mathematics is a subject for boys, while language is a subject for girls (Voyer & Voyer, 2014; Li, 2006). Moreover, research conducted by Pierce and Ball (2009) showed that, although groups of female and male teachers both value using technology for teaching mathematics, female teachers were less confident than male teachers in using technology. Fortunately, research has shown promising results in influencing teachers' classroom practice through teacher education (e.g. professional development workshops and methods courses) in which teachers are exposed firsthand to STEM knowledge and practices (Macalalag, Johnson, & Lai, 2017; Adams, Miller, Saul, & Pegg, 2014). PTs often hold positive views of integrating STEM subjects in their teaching practice (Hacıömeroğlu, 2017) but may simply lack confidence, experience, or training to implement them. Findings such as these reveal a need for researchers to look more deeply at PTs' awareness and intentions regarding STEM integration and how to develop these awareness and intention factors in teacher preparation programs to foster improved STEM education.

The purpose of this study was to analyze the impact of participating in a STEM methods course on PTs' awareness and intentions to teach STEM subjects. Specifically, this study addressed the following research questions:

1. Is there a change in preservice science teachers' awareness of the impact of STEM education on students' knowledge and skills (e.g. critical thinking, problem solving, creativity, innovation, and divergent thinking.) before, immediately after and four months after attending a STEM-based science methods course?
    - **a.** Is there any significant difference in female and male preservice science teachers' STEM awareness scores before, immediately after and four months after attending a STEM based science methods course?
2. Is there a change in preservice science teachers' intentions of teaching STEM subjects and practices to their students before, immediately after and four months after attending a STEM based science methods course?
    - **a.** Is there any significant difference in female and male preservice science teachers' intentions of teaching STEM subjects and practices to their students before, immediately after and four months after attending a STEM based science methods course?
3. Are there any relationships between preservice science teachers' STEM awareness and STEM teaching intentions?

Literature Review

There is a growing consensus among member countries of the Organization for Economic Co-Operation and Development (OECD) for the need to educate students in order to develop their 21st century skills. The skill sets such as critical thinking, problem solving, creativity, critical thinking, and decision making are necessary for students to productively participate in the competitive workforce and global market (Ananiadou & Claro, 2009). For instance, manufacturing companies look to hire workers with proficient reading, writing, and communication skills, the ability to work in a team, strong technology-related skills, the ability to translate drawings, diagrams or flowcharts, strong math skills and innovation/ creativity skills (Eisen, Jasinowski, Kleinert, 2005). In the report titled *21st Century Skills and Competences for New Millennium Learners in OECD Countries*, many member countries reported various degrees and ways of integrating these skill sets as part of their educational reform and curriculum. In Turkey, a member of the OECD, the following skill sets were included in the primary and secondary curricula in 2004 and 2005: critical thinking, creativity, communication, research, problem solving, decision making, and information and communications technology. However, there are very few professional development programs and courses to help PTs learn how to foster students' 21st century skills (Ananiadou & Claro, 2009).

It is important to acknowledge the crucial role teachers, who are directly involved in educating and preparing the new generation of students, play in the classroom. According to Shulman (1987), "a teacher knows something not understood by others, presumably the students. Moreover, the teacher can transform understanding, performance skills or desired attitudes or values into pedagogical representations and actions" (p.7). Teachers' disciplinary content knowledge can have an influence on instructional practice (Gess-Newsome & Lederman, 1995) and as such, strong knowledge of STEM content and processes must necessarily be an important part of teacher education programs. Moreover, research studies have shown that teachers were able to use science and engineering education as vehicles to promote certain 21st century skills (Cunningham & Kelly, 2017; Sullivan, 2008). For instance, a study conducted by Kolodner et al. (2003) showed that students in classes that used problem-based learning lessons performed better than those in traditional settings with respect to collaboration, meta-cognition, and science process skills. However, content knowledge alone is insufficient. As Shulman (1987) described, teachers must draw from a unique body of knowledge where knowledge of content and knowledge of pedagogy intersect and are considered as they are situated within the context of learning. This Pedagogical Content Knowledge (PCK) informs important classroom decisions.

Several research studies have pointed to the influence of professional development programs and methods courses in developing pre-service and in-service teachers' PCK as well as their, awareness and intentions to implement STEM disciplinary ideas and practices. In the study conducted by Macalalag and Parker (2016) with 17 elementary classroom teachers in the U.S.A., teachers were able to develop their notions of the engineering design process. However, most teachers identified more practices from the beginning and middle parts of the engineering process (identifying the problem, brainstorming solutions, planning and conducting investigations) and rarely mentioned the latter parts of the engineering process (conducting failure analysis and revising prototypes). This suggested that teachers' learning of engineering design is an incremental process. In another study by Nadelson et al. (2013) with 33 elementary classroom teachers also in the U.S.A., a positive correlation was found for teachers' knowledge of, confidence for, comfort with, and efficacy for teaching engineering design after attending a three-day summer institute. The importance of increasing teachers' notions and awareness of the STEM discipline in order to help improve their confidence and intentions to teach STEM was also confirmed by Adams et al. (2014) when 50 elementary education PTs learned not only content, but also improved their comfort and confidence in teaching after attending a methods course to learn how to teach math, science and social studies.

One of many ways to help teachers improve their awareness and intentions to teach STEM subjects was through lesson design. Kim and Bolger (2017) engaged their 119 elementary PTs, who were enrolled in a methods course in Korea, in lesson planning and design. Their study findings suggested improvements on PTs' awareness, perceived ability, value, and commitment to teach STEM subjects and practices. Moreover, they found increased PTs' positive confidence to create STEM materials for implementation. PTs saw potential of the STEM lessons to help their students develop interest in STEM disciplines and careers. Similarly, in the study conducted by Macalalag et. al., (2017), 24 elementary classroom teachers in the U.S.A. planned and developed lessons as part of a graduate STEM methods course. The lessons showed positive shifts in teachers' notions of cultural practices to reduce carbon footprints and incorporated meaningful context for their students to learn socio-scientific issues in the classroom.

A variety of research studies have been conducted in STEM subjects and humanities that pointed to varying degrees of growth for PTs, in-service teachers, and their students due to differences in gender. In the meta-analysis of published research studies conducted by Voyer and Voyer (2014), they found that there was a consistent advantage of female compared to male students in school marks in all content areas. However, gender differences were largest in language courses in which female performed well and smallest in mathematics courses. In the study conducted by Yuen and Ma (2002), participants revealed gender differences with regards to intentions of using computers in classrooms. In particular, male teachers' intentions to use computers were generally due to perceived usefulness; while female teachers' perceived ease of use often increased the likelihood of using computers. In the study of Minor, Onwuegbuzie, Witcher, and James (2002) with 134 PTs enrolled in several sections of an intro-level education class in a large university in United States of America, the researchers examined the priorities of PTs in teaching their students. They found that both their male and female PTs were equally likely to endorse enthusiasm about teaching. However, male PTs were more likely than female PTs to endorse knowledge of subject as a priority. Minor et al. (2002) explained that it is possible that PTs who are pursuing certification to teach in elementary school are more likely to rate enthusiasm more highly than knowledge as important to instruction because of their awareness of the increase for information covered as students move from lower to higher-grade levels.

Several research studies have pointed to teachers' awareness and beliefs that influenced their students' achievements. Tiedemann (2000) studied 52 classroom elementary teachers in Northern Germany and found gender-related beliefs while teaching mathematics to 3rd and 4th grade students. In particular, teachers rated mathematics as more difficult for girls compared to boys, and thought that their girls were less logical than boys. Moreover, teachers attributed unexpected failure of girls to low ability and view that girls must exert more effort than boys to achieve certain mathematical performance. In a similar vein, the review of research conducted by Li (2006) regarding gender issues on mathematics education revealed that teachers tend to stereotype mathematics as a male domain.

Specifically, teachers tended to overate male students' mathematical capability, have higher expectations, and more positive attitudes compared to female students. Two research studies, conducted in Turkey and in Taiwan, illustrated the gender differences with regards to PTs' awareness and intentions of teaching STEM subjects. Lin and Williams (2016) found that gender had no effect on Taiwanese PTs' knowledge, values, subjective norms, attitude, and behavioral intention towards STEM teaching. Hacıömeroğlu (2017) saw that Turkish PTs' intentions to teach STEM were more positive, but also found that there was no significant difference between PTs' scores on knowledge, attitude, value, perceived behavioral control, and behavioral intention regarding gender.

In this paper, we describe the changes in PTs' awareness and intentions to teach STEM subjects before and after attending a STEM methods course.

Methods

Participants and Context of Study

A total of 53 (41 female and 12 male) preservice science teachers from the Department of Elementary Science Education in a university located in a small western city of Turkey, participated in the study. Upon completion of their studies, participants will teach elementary science. Due to recent developments (the importance of integrated STEM education, industry 4.0, developments in artificial intelligence etc), the Ministry of Education in Turkey revised science textbooks to include STEM in the science curriculum to keep up with the requirements of modern times. Thus, preservice science teachers' STEM teaching intentions have been found to be important for not only teaching basic science concepts, but also for teaching the synergistic and symbiotic relationships between STEM subjects. Their responses to the STEM teaching intention questionnaire represent their instant intentions (when data was collected) about STEM teaching as future classroom teachers based on their gained experiences in the current STEM methods course.

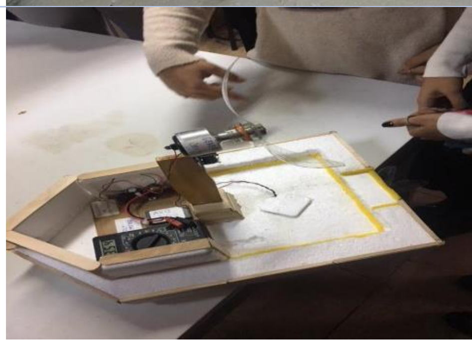
All PTs volunteered to participate and were in the senior year of their program. The age of the participants ranged from 21 to 24 years with an average of 22 years. Eight PTs (15 percent) taught science courses to elementary students to earn money and to get teaching experience before graduation. The majority of the PTs (n=42 or 79%) resided in an urban setting, while the rest of them (n=11 or 21%) lived in agricultural and rural areas. The PTs participated in extra-curricular activities (e.g. conducted seminars, implemented STEM projects, worked in museums, etc.) to enhance their professional practice. The participants are going to teach elementary science when they graduate. Due to the recent developments (the importance of integrated STEM education, industry 4.0, developments in artificial intelligence etc.), Ministry of Education in Turkey revised the science textbooks and included STEM chapter in science curriculum to keep up with the requirements of modern time. Thus, preservice science teachers' STEM teaching intentions are found to be important to determine as they will not be only responsible for teaching basic science concepts but also for teaching the synergistic and symbiotic relationships between STEM subjects. Their responses to the STEM teaching intention questionnaire are their instant intentions (when data was collected) about STEM teaching as future classroom teachers based on their gained experiences in the current STEM methods course.

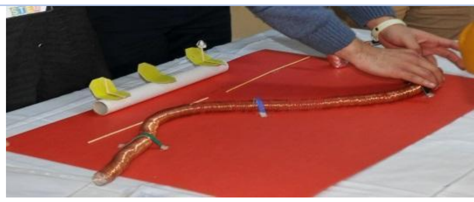
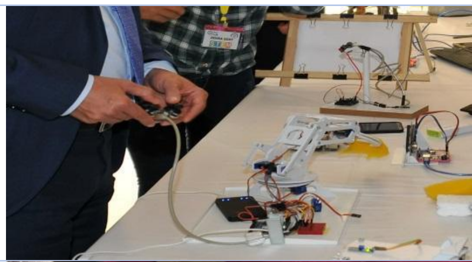
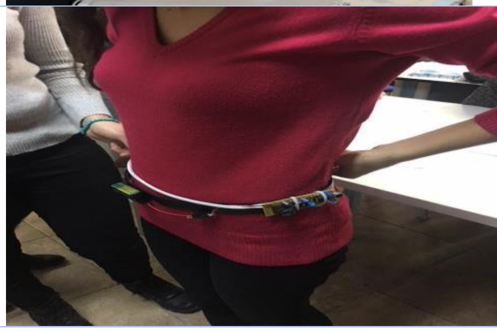
The STEM methods course was an undergraduate, interdisciplinary, inquiry- and problem-based course designed to introduce PTs to the synergistic and symbiotic relationships between STEM subjects. The course was taught by the first author for 12 weeks in the Fall Semester of 2017. Students came together twice per week: two hours of lectures and group-based problem solving activities and two hours of classroom-based work. During the first week of the course, the instructor administered a pre-test and introduced the course's framework, objectives, activities, and assignments. In one of the assignments, PTs were asked to adapt, redesign or develop a unit of study that integrated at least three of the STEM fields. The PTs formed twelve groups (four to five students per group). Each group was responsible for choosing the topic to integrate STEM subjects and practices for grade bands K-5 or K-8 classrooms. The instructor of the course reviewed and provided feedback on the PTs' lesson plans before PTs teaching of their lessons to elementary or middle school students. PTs used the rubric that we adapted from Jacobs, Martin, & Otieno's (2008) *A* Science *Lesson Plan Analysis Instrument* as a guide in creating their unit of study. Each lesson plan included the following components: title, grade bands, duration, appropriate science standards, learning goals and objectives, anticipated students' prior knowledge, STEM practices (e.g. asking a question or defining a problem, planning and conducting investigations, developing and testing a model, argumentation from evidence, etc.), detailed description of instructional activities, strategies for inclusion, assessments and hand-outs of the course activities.

The group-based problem solving consisted of instructional activities that engaged PTs in solving real-world problems. Examples included creating technologies to support a person who is blind or deaf, developing tools to water plants that are unattended during a family vacation, and developing a mode of transportation that does not rely on fossil fuels. The PTs worked collaboratively in groups with minimal support from the course instructor. They used the engineering design process—identifying the problem and constraints; developing, testing and revising engineering models; planning and conducting investigations; and collecting and analyzing data—in solving the problems (Katehi, Pearson, & Feder, 2009; Peterson, Crow, Macalalag, 2016). Each group was given two hours to finish their designs and ten minutes to present their work. These engineering design challenges, class' discussions and individual reflections aimed to support the development of PTs' PCK and awareness toward teaching integrated STEM subjects and practices, which can potentially contribute to the development of their students' 21st century skills. In Table 1 below, we provide a complete list of our course's instructional activities and real-world problems solved by students.

Table 1. Overview of the weekly instructional activities from the STEM methods course

Weeks	Methods Course's Activities	Photos
1	PTs' completed the pre-tests	
2	Designing a sustainable tap water system Engineering design challenge: A citizen who lives in a metropolitan city is concerned about climate change and water shortages, she wants to save wasted cold water while waiting for hot water to flow from the tap. In this activity, *PTs were asked what would you do if you were that citizen? Design a system that blocks the tap system and saves wasted cold water.* PTs aimed to collect cold water in an alternative tank, and block the water flow system until it becomes hot. They used temperature sensitive sensors to unblock the system. Their design, seen in the photograph, worked properly. They were able to integrate their science knowledge (temperature and heat) to engineering design solution (using sensors and some simple materials and making a product), mathematics (measurements and calculating the flow rate and volume of water during filtration), and technology (temperature sensitive sensors, alternative tank) because of this activity.	
3	Light and sound: Designing a jacket to assist deaf and blind people Engineering design challenge: PTs where asked, *how can we make life easier for blind or deaf people by using our knowledge of STEM?* PTs used Ardiuno Uno, an open-source microcontroller board developed by Ardiuno company, for this activity. They aimed to convert electric energy to light and sound energy. The jacket has sensors that vibrate when it faces an obstacle for someone who is deaf and creates a sound signal for a person who is blind. The sound frequency increases when the distance of the sensor to the object decreases to help determine the distance to the obstacle. The STEM connections included light and sound energy (science), measurement of distance to sensors, velocity of sound waves and time (mathematics), understanding how the jacket will function to assist a deaf and/or blind person (engineering), and understanding the function and limitations of the sensors (technology).	

4	Simple machines: Building a winch Engineering design challenge: *How can you move objects by designing a mechanical device?* Each group designed different types of model winch (e.g. tow truck, steam shovel, and elevators) by using simple machines. A tow truck can be seen on the right figure that works using a hydraulic fluid. The STEM connections included understanding and application of fluid mechanics (science), measurement and calculations of force, pressure and area (science and mathematics), and designing a hydraulic system (technology and engineering).	
5	Energy conversion: Designing your own fan Engineering design challenge: *How can you keep cool when it is warm outside?* PTs designed their own fan. In this activity, they used electric motor to convert electric energy to kinetic and mechanical energy. The STEM connections included electrical and mechanical energies (science), measurement and calculations of Ohm's Law (mathematics), and designing a fan (engineering and technology).	
6	Designing a boat powered by a wind turbine. Engineering design challenge: *How can you develop an airboat to reduce fossil fuel usage in transportation?* PTs designed a model boat using a fan to propel itself by using the power from a windmill. The windmill can rotate 360° in order to catch the wind and for the boat to sail in any direction. The STEM connections included forces, motion, and electrical energy (science), measurement and calculations involving Newton's and Ohm's Laws (mathematics), designing a boat using a wind turbine (engineering), and understanding the function and limitations of the boat and its wind turbine (technology).	
7	Creating an automated houseplant watering system. Engineering design challenge: *How can you design a system to water your plant during your extended vacation?* PTs used Ardiuno Uno and breadboard to design a system that monitors the dampness of soil using a sensor to detect the appropriate time for watering the plant. The STEM connections included understanding of soil composition, irrigation, capillary action of plants, type of plant, and electricity (science), measurement of rate of water disbursement (mathematics), designing the automated watering system (engineering), and	

	understanding the function and limitations of the watering system (technology).	
8	Maglev train Engineering design challenge: *How can you design a model train that uses magnets to propel and stop it?* This activity introduced PTs to alternative transportation systems by using environmentally friendly mechanism such as magnets. PTs lifted, propelled and stopped the train by using super-conducting magnets. The STEM connections included understanding the forces of magnets (science), calculation of speed (mathematics), investigating the efficiency of maglev (engineering), and understanding the function and limitations of maglev design (technology).	
9	Robotic arm Engineering design challenge: *How can you create a model robotic arm that mimics the functions of a human arm?* PTs developed and investigated the successes and limitations of a model robotic arm.	
10	Sound: a belt for people who are deaf. Engineering design challenge: *How can we help people who are deaf by using a belt including sound and vibration producing technology?* PTs used the Internet to find ways to solve this problem. Their solution was to design a belt that vibrates in certain sound intensity so that the deaf people be able to realize their environment.	
11	PTs completed the post-test 1	
	PTs completed the post-test 2 (Four months after the end of course)	

Data and Analysis

In order to answer our research questions, we created and conducted pre- and post-tests in order to study the effects of our STEM-based methods course on PTs' STEM awareness and intentions to implement STEM subjects. The questionnaires were administered at the beginning (pre-test), at the end of the 12-weeks course (post-test 1), and four months after the course (post-test 2). We believe that this design is better than the pre- and post- tests only study, but it is still weak experimental design because of the lack of a control group (Fraenkel and Wallen, 2005). We aimed to investigate the one group pre- and post-tests design by including repeated measurements (collecting follow-up data).

STEM Awareness Questionnaire

The STEM awareness questionnaire, developed by Buyruk and Korkmaz (2016), is a five-point Likert-type instrument (1: strongly disagree, 5: strongly agree). It consists of 17 items and two subscales including positive (12 items) and negative (5 items) factors to measure PTs' STEM awareness and intentions. The lowest score that can be obtained from the scale was 17 (17 x 1) whereas the highest score was 85 (17 x 5). One positive item from the instrument is "STEM education improves students' problem solving skills" and one negative item from the instrument is "STEM activities distracts students interest and motivation to the lessons." Fifteen minutes were devoted to the administration of each test. Table 2 shows the reliability analysis scores of the pre-, post- and follow-up tests. Cronbach alpha values ranged between .73 to .90, which indicates the scores obtained from the three tests were valid and reliable.

Reliability Analysis

Table 2. Cronbach alpha values of STEM perception questionnaire

Subscale	α (Original scale)	α (Present study: pre-test)	α (Present study: post-test 1)	α (Present study: post-test 2)
Positive	.92	.76	.79	.90
Negative	.80	.73	.85	.76
Overall	.92	.82	.86	.90

STEM Teaching Intention Questionnaire

The STEM teaching intention questionnaire, a seven point Likert type instrument (1: strongly disagree, 7: strongly agree) developed by Lin and Williams (2016) and adapted into Turkish by Hacıömeroğlu and Bulut (2016), was used to measure PTs' STEM teaching intentions. The overall scale has 31 items and five subscales which are: Knowledge (4 items), Value (5 items), Attitude (6 items), Subjective norms (6 items), Behavior control (10 items). The lowest score to be obtained from the scale is 31 (31 x 1) whereas the highest score is 217 (31 x 7). Twenty minutes were devoted to testing administration. Sample items for each subscale are shown in table 3.

Table 3. Sample items of STEM Teaching Intention Questionnaire

Subscale	Sample Item
Knowledge	I am familiar with the Science knowledge in the middle school level (e.g. Newton's laws of motion
Value	I think it is important to help students in learning how to use STEM-related data during the design process
Attitude	I will implement integrative STEM teaching if my university professors ask me to do this
Subjective Norms	I think I know how to propose STEM-based suggestions to students during the design process
Behavior	I will try to collaborate with other teachers in STEM fields for implementing integrative STEM teaching

Table 4 provides the reliability analysis scores of the pre-, post-, and follow-up tests. Cronbach alpha values ranged between .93 to .96 which indicates the scores obtained from the three tests were valid and reliable. Cronbach alpha values for each subscale were also reliable except for one: knowledge (α = .50). However, overall scale reliability was found to be .93 which indicates that the scale is reliable.

Table 4. Cronbach alpha values of STEM Teaching Intention Questionnaire

Subscale	α (original scale)	α (pre-test)	α (post-test 1)	α (post-test 2)
Knowledge	.93	.50	.85	.82
Value	.86	.91	.87	.92
Attitude	.87	.86	.77	.83
Subjective Norms	.69	.87	.86	.87
Behavior	.86	.91	.90	.93
Overall	.94	.93	.93	.96

Results

A mixed between-within subjects' analysis of variance (ANOVA) was used to investigate the effects of the STEM Methods course on PTs' STEM awareness and STEM Teaching Intentions to determine whether there was a change in PTs' understanding of STEM across the three time periods: on the first day of the course (pre-test), on the last day of the course (post-test 1), and four months after the end of the course (post-test 2).

Table 5 shows that female PTs' STEM awareness scores (M=4.45, SD= .42) are higher than male PTs' awareness (M=4.29, SD=.52) before and immediately after (M=4.79, SD=.24) (M=4.57, SD=.41) attending the STEM methods course. The post-test 2 results also revealed the same findings that female PTs' scores (M=4.78, SD= .22) are higher than male PTs' scores (M=4.60, SD= .46).

Table 5. Descriptive statistics of STEM awareness

Subscale	Gender	Pre-Test		Post-Test 1		Post-Test 2	
		M	SD	M	SD	M	SD
Positive	Female	4.49	.37	4.78	.25	4.74	.29
	Male	4.25	.47	4.61	.33	4.54	.54
Negative	Female	4.38	.77	4.82	.30	4.90	.21
	Male	4.38	.81	4.48	.77	4.75	.40
Overall	Female	4.45	.42	4.79	.24	4.78	.22
	Male	4.29	.52	4.57	.41	4.60	.46

Table 6 shows that female PTs' STEM Teaching Intentions scores (M=3.76, SD= .48) are higher than male PTs' scores (M=3.71, SD=.38) before and immediately after attending the STEM based science method course (female: M=6.58, SD=.39; Male: M=6.54, SD=.36). The post-test 2 results also revealed the similar findings that is female PTs' scores (M=6.53, SD= .40) are higher than those of male PTs' scores (M=6.29, SD= .79).

Table 6. Descriptive statistics of STEM TIQ

Subscale	Gender	Pre (Time 1)		Post (Time 2)		Follow Up (Time 3)	
		M	SD	M	SD	M	SD
Knowledge	Female	4.03	.52	6.39	.62	6.31	.62
	Male	3.93	.56	6.60	.52	6.33	.62
Value	Female	3.55	.52	6.70	.43	6.63	.45
	Male	3.48	.57	6.54	.39	6.37	1.1
Attitude	Female	3.52	.58	6.65	.44	6.59	.44
	Male	3.58	.52	6.63	.40	6.18	.80
Subjective Norm	Female	4.34	.79	6.41	.65	6.25	.67
	Male	4.60	.77	6.35	.73	6.15	.63
Perceived behavioral control and behavioral intention	Female	3.65	.61	6.62	.45	6.67	.34
	Male	3.40	.45	6.56	.42	6.38	.91
Overall	Female	3.76	.48	6.58	.39	6.53	.40
	Male	3.71	.38	6.54	.36	6.29	.79

The STEM awareness of PTs was measured before, immediately after, and four months after attending the STEM methods course. In order to test the gender and time effect on PTs' STEM awareness scores, a 3x2 ANOVA design was run. The analysis revealed a main effect for time factor Wilks' Lambda=.79, F (2. 50)= 6.53, p= .003. partial eta square = .21 in the predicted direction. PTs' STEM awareness scores tended to increase after attending the course.

The PTs' intentions of teaching STEM subjects and practices to their students was also measured and analyzed. In order to test the gender and time effect on PTs' STEM Teaching Intentions a 3x2 ANOVA design was run. Our analysis revealed a main effect for the time factor Wilks' Lambda=.06, F (2, 50) = 346.603, p= .000, partial eta square = .93 in the predicted direction. As shown in Table 7, PTs' intentions of teaching STEM subjects tended to increase after attending the methods course. Our results also suggested that there is no main effect for gender F (1, 51) = 1.54, p= .22, partial eta square= .03, and no significant interaction between time and gender, Wilks' Lambda=.97, F (2, 50) = .73, p= .48 partial eta square= .03. The effect size indicated that attending the methods course had a large effect on PTs' intentions of teaching STEM (Cohen. 1988 [.01 low, .06 medium, 0.14 large]).

Table 7. ANOVA results for test of between subject effects

Source	SS	df	F	Sig.	Partial Eta Squared
Intercept	3461.730	1	15960.324	.000	.997
Gender	.335	1	1.546	.021	.029
Error	11.062	51			

We also analyzed any relationships between PTs' STEM awareness and intentions of STEM teaching. We conducted a Pearson product-moment correlation coefficient to test what relationship, if any, existed between PTs' STEM awareness and intentions of STEM teaching. Table 8 shows that there was a medium, positive correlation between the two variables (r=.38, n=53, p<.005). The coefficient of determination was calculated (R^2 =0.15) and only 15% of the PTs' intentions of STEM teaching can be explained by their STEM awareness. Table 8 below summarizes this result.

Table 8. Correlation between Intentions of STEM Teaching and STEM Perception

		Awareness	Teaching Intentions
Awareness	Pearson Correlation	1	.387**
	Sig. (2-tailed)		.004
	N	53	53
Teaching Intentions	Pearson Correlation	.387**	1
	Sig. (2-tailed)	.004	
	N	53	53

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion

This study explored the influence of a 12-weeks interdisciplinary, inquiry- and problem-based STEM methods course designed to introduce PTs to the synergistic and symbiotic relationships between the STEM disciplines. Our findings highlighted that participating in the STEM methods course for a semester developed PTs' awareness and intentions to teach STEM subjects, which in turn has the potential to influence their students' learning experiences and skill sets (e.g. critical thinking, problem solving, creativity, innovation, and divergent thinking). Results revealed that not only PTs' STEM awareness scores but also their intentions of teaching STEM subjects tended to increase after participating in STEM related coursework. These findings are consistent with the previous studies conducted in similar contexts (Gibson, 2012; Hacıömeroğlu, 2017; Ring, Dare, Crotty, & Roehrig, 2017). Similar to our design, Breiner, Harkness, Johnson, and Koehler (2012) recommended integration of the STEM concept in ways that involve more inquiry and problem-based learning approaches. Gibson (2012) highlighted the importance of the preservice teachers of today who will be the aspiring classroom practitioners of tomorrow. She shed light on the importance of PTs being given opportunities to develop appropriate knowledge, understanding and skills in STEM contexts. She stated the effect of short periods of STEM-related industrial placement on PTs' awareness of engineering and technology. It is obvious that the success of improving the quality and integration of STEM in K–12 classrooms depends on teachers' associated knowledge and awareness.

A previous study have indicated that understanding the conceptions teachers hold regarding integrated STEM education is an important first step (Ring et. al, 2017). Their participants felt confident about their science knowledge at the middle school level, implementing integrative STEM teaching, proposing STEM-based suggestions to students during the design process. They also admitted that it is important to help students in learning how to use STEM-related data during the design process and to collaborate with other teachers in STEM fields for implementing integrative STEM teaching. The work of Haciomeroglu (2017) with 401 elementary pre-service teachers who were enrolled in two public universities revealed that PTs' integrative STEM intentions were positive in general. Our study findings with 53 PTs in the Department of Elementary Science Education showed similar result. In particular, our PTs' intentions of teaching STEM subjects tended to increase after attending the methods course Regarding the influence of STEM education on participants' STEM awareness, Gokbayrak and Karisan (2017a) revealed that there was a significant difference between their experimental group (participating in the STEM-based science laboratory activities) and control group students (participating inductive science laboratory applications) in STEM teaching intention scores in favor of the experimental group. In another study, Gunbatar, Tarkin, Kutucu, Kıran (2018) revealed that pre-service chemistry teachers' participating in a 12-weeks, design-based elective STEM course increased the participants content knowledge, STEM conceptions, and engineering design views through the training. Likewise, Kaya, Newley, Deniz, Yesilyurt, Newley (2017) allowed PTs engage in a real-world problem context and focused on the application of the engineering design process. Similar to our study, Kaya et al. (2017) stated that introducing engineering design to a science teaching methods course through educational robotics changed preservice science teachers' views about integration of robotics into their elementary science curriculum.

We agree with Lin and Williams (2016) when they suggested that the “lack of gender differences and limited disciplinary influences among PTs related to their STEM intention should inform teacher education and recruitment efforts” (p.12). In their study of 144 PTs who are preparing to teach science and technology to junior high school students in Taiwan, they found that gender had no effect on knowledge, values, subjective norms, attitude, and behavioral intention toward STEM teaching. Similarly, our current research findings suggest that there is no main effect of gender on PTs’ intentions of teaching STEM subjects. However, it is also worth noting that gender had a medium effect on PTs’ STEM awareness. This present research builds upon the earlier work of Bakirci and Karisan (2018) in which they found that gender was not a factor on the participants’ STEM awareness for 558 PTs at the Department of Mathematics and Science Teacher Education program in Turkey. Our findings also support the results from the study of Hacıömeroğlu (2017) who saw that PTs seemed to hold positive views for integrating STEM teaching and there was no significant difference between PTs’ scores on knowledge, attitude, value, perceived behavioral control, and behavioral intention regarding gender. Our results also suggested that there is no main effect for gender and no significant interaction between time and gender.

Changes in STEM awareness can have powerful influence on what someone will do (Hasna & Clark, 2009). Thus, findings of the present study indicate that engaging PTs in real world problems which increase their understanding of how to integrate STEM disciplines into their lessons have the utmost importance. Having a positive attitude towards integrative STEM teaching is thought to be helpful for preservice teachers to adopt an integrative teaching approach to their future classes (Hacıomeroğlu, 2017). Using STEM activities in the classroom environment provides opportunities for pre-service teachers to become effective elementary teachers. In the present study, engaging in real life problems through participating in the STEM method course increased PTs’ STEM awareness as well as their intentions of teaching STEM subjects.

A number of studies have been conducted investigating teacher STEM awareness and intentions regarding change in teaching practice. Studies have pointed out the necessity of determining preservice teachers’ STEM awareness as a means of understanding the knowledge and skills they bring to teaching STEM (Bakirci and Karisan, 2018; Buyruk and Korkmaz 2016; Faber et al., 2013). As described above, this knowledge of STEM content is an important component of the PCK that informs teachers’ pedagogical decisions (Shulman, 1987), further describing how “the teacher can transform understanding, performance skills or desired attitudes or values into pedagogical representations and actions” (p.7). Lumpe, Haney, and Czerniak (1998) found that attitude toward behavior constructs held the greatest influence for Ohio teachers in their intent to implement all inquiry, knowledge, conditions, and applications strands of state level science education reform. Lumpe et al. (1998) also found that teachers’ attitudes towards the behavior, subjective norm, and perceived behavioral control are significant influences of their intent to integrate Science-Technology-Society issues into their classrooms. Crawley (1990) found that attitude toward the behavior was the greatest predictor of teachers’ intent to use inquiry-based teaching methods in their classrooms.

In the current study, we analyzed the relationship between preservice science teachers’ STEM awareness and intentions regarding STEM teaching through a Pearson product-moment correlation. As table 8 shows, there was a medium, positive correlation between the two variables ($r=.38$, $n=53$, $p<.005$), awareness and intentions. This is consistent with the previous literature described above (Peterson et al., 2016; Adams et al., 2014; Nadelson et al., 2013) . For our participating teachers, as with previous studies in other areas, their awareness did influence their intentions in regard to STEM teaching. Unlike the prior studies described, the extent to which intentions were influenced by awareness was lower than expected. The coefficient of determination was calculated ($R2 =0.15$) and only 15% of the PTs’ intentions of STEM teaching can be explained by their STEM awareness. In our study, it is possible that teachers’ awareness changed and developed during and after the completion of the methods course. Awareness and intentions were still closely related, but perhaps this flux mitigated some of the influence awareness had on teachers’ STEM teaching intentions.

Conclusion

The purpose of our study was to analyze the impact of participating in a STEM methods course on PTs’ awareness and intentions. Our work provides evidence to support the results of Luft and Roehrig (2007) that showed pre-service and professional develop programs can help modify the awareness of science teachers. Specifically, in our study, PTs’ STEM awareness and intentions of teaching STEM subjects tended to increase after attending the methods course. More importantly, our PTs’ intentions of teaching STEM subjects tended to increase after attending the methods course. Our results also suggested that there is no main effect for gender and no significant interaction between time and gender. The effect size indicated that attending the methods course had a large effect on PTs' intentions of teaching STEM.

Recommendations

While the findings of this study are interesting and can inform STEM teacher preparation, further study is recommended. Specifically, an experimental study comparing the results found to a more traditional setting may illuminate specific differences between the programs that target awareness and intentions. The findings of this study will be further explored along with similar data gathered from a STEM teacher preparation program in the north Eastern United States. Such international comparisons will allow the exploration of the impact of culture on STEM teacher development. In particular, we have collected and will be analyzing the similarities and differences of two classes of elementary science PTs: one in Turkey and another one in the United States with respect to their implementation of STEM disciplinary core ideas and practices in lesson/unit plans.

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