Preservice Teachers' Awareness About Stem*

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Abstract
This quantitative study examines educational faculty preservice teachers' awareness about STEM in terms of different variables. Students from the departments of mathematics education, science education and computer and instructional technology at Afyon Kocatepe University were the participants. This is a survey study, which used the STEM Awareness Scale (SAS) developed by Buyruk and Korkmaz (2016) to collect the data. Some quantitative data analysis tests were applied on the data obtained. The results show that the preservice teachers had positive perspectives on STEM education.
Key words: *STEM, preservice teachers, awareness*

Introduction

STEM stands for science, technology, engineering and mathematics. The term was first used in 2001 by Dr. Judith Ramaley, the Education and Human Resources Director of the National Science Foundation (NSF) (Chute, 2009), making the NSF the first institution to use the term (NAE & NRC, 2009; Sanders, 2009). According to Morrison (2006), STEM is a new discipline based on the integration of science, technology, engineering and mathematics. Advancements in science and technology make it essential for individuals to acquire the skills to overcome real life problems, use their new knowledge in real life settings, think creatively, and use their knowledge at the appropriate time and place. For these reasons, STEM education is important today (Akgündüz, Ertepınar, Ger, Kaplan Sayı & Türk, 2015; Bybee, 2010).

STEM increases the quality of learning environments in education, makes teaching processes more effective, and gives students opportunities to integrate the disciplines of science, technology, engineering and mathematics. Science is the effort to understand the natural world (NRC, 1996). It examines the natural world and uses inquiry, invention, discovery and scientific methods in courses such as physics, biology, astronomy and geology from primary school to the university level (Dugger, 2010). Technology also uses discovery and scientific methods (Dugger, 2010). Technology changes the natural world based on the desires and needs of humankind (ITEA, 2000). It can be defined as the design, development and production of new materials using natural resources. Processes such as invention, innovation, practical problem solving and design are included in technology (Dugger, 2010). Engineering concerns finding solutions to the needs of humankind using mathematical and scientific knowledge obtained through practice and experience (ABET, 2007). Engineering involves problems that must be solved, understanding problems, asking relevant questions, setting up benchmarks for successful solutions and identifying limitations (Bybee, 2011). Mathematics is defined as the relationships among models, figures and numbers (AAAS, 1993). Mathematics serves as a real language for science, technology and engineering (Dugger, 2010).

STEM education involves activities that can foster students' interests and tendencies in science, technology, engineering and mathematics using the skills they should possess today (Baran, Canbazoğlu Bilici & Mesutoğlu, 2015). STEM education is intended to transform theoretical knowledge into implementation, production and innovative discoveries. It enables students to consider their learning in science, technology, engineering and mathematics as parts of a whole. Many countries have incorporated STEM into their curricula. STEM education enables students to enlarge their physical, intellectual and cultural worlds and fosters their competence in critical thinking and problem solving (Çorlu & Aydın, 2016).

STEM education is an interdisciplinary approach to learning from primary school to graduate school. It offers students an interdisciplinary perspective on problems and some skills and knowledge using a holistic understanding of education (Şahin, Ayar & Adıgüzel, 2014). NSF launched activities to attract attention to the content of STEM education in the 1990s and many international studies have been conducted in this regard (Bracey & Brooks, 2013; Buxton, 2001; Cleaves, 2005; Nadelson, Seifert, Moll & Coat, 2012; Pinnell et al., 2013). However, the Turkish literature has focused on this issue only in the last few years (Baran, Bilici & Mesutoğlu, 2015; Çevik, 2015; Gencer, 2015; Şahin, Ayar & Adıgüzel, 2014; Yamak, Bulut & Dündar, 2014; Yıldırım &

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Altun, 2015). These studies have mostly investigated teachers' or preservice teachers' awareness about STEM, developed scales or adapted international scales into Turkish. For example, Karakaya, Ünal, Çimen, and Yılmaz (2018) investigated science teachers' awareness about the STEM approach in terms of some variables. They found significant differences by gender, professional experience, in-service training and educational level, but no significant difference by classroom size or type. Another study of teachers' perspectives on and awareness about STEM education found that science teachers know the STEM model better than teachers from other disciplines and use it more, that science and mathematics teachers consider their disciplines as an indispensable to the STEM model, but that they restrain themselves from applying the model (Özbilen, 2018). Rather than determining the general situation, studies of preservice teachers have mostly taken the form of scale adaptation.

There is a limited number of studies in the literature that examine preservice teachers' awareness about STEM in terms of various variables. Therefore, this study can contribute to the literature because it examines educational faculty preservice teachers' awareness about STEM in terms of different variables. It sought answers to these research questions:
1. What is the level of preservice teachers' awareness about STEM?
2. Is there a significant difference between the levels of preservice teachers' awareness about STEM by department?
3. Is there a significant difference between the levels of preservice teachers' awareness about STEM by gender?
4. Is there a significant difference between the levels of preservice teachers' awareness about STEM by grade level?

Method
The participants in this study were students in the departments of mathematics education, science education and computer and instructional technologies at the educational faculty of Afyon Kocatepe University. This quantitative study was designed as a survey. According to Karasar (2014), researchers should use survey study design if they intend to describe a case as it exists, whether it is an event, individual or object. The STEM Awareness Scale (SAS) developed by Buyruk and Korkmaz (2016) was used to collect data. The data were analyzed using IBM SPSS 18 software. The Kolmogorov-Smirnov test was done to analyze the normality of the data distribution and showed ($p<0.05$) that the data did not have a normal distribution. Therefore, non-parametric tests were used. The Mann-Whitney U test was used to make a pairwise comparison, and the Kruskal-Wallis test was used to make multiple comparisons.

Findings
Table 1 shows the descriptive analysis of the preservice teachers' scores on the STEM Awareness Scale.

Table 1. Descriptive analysis of the STEM Awareness Scale scores

Department	Positive perspective			Negative perspective			Overall Scale		
	N	Mean	sd	N	Mean	sd	N	Mean	sd
Mathematics Education	115	3.99	.875	115	4.03	.683	115	4.01	.736
Science Education	113	3.78	1.07	113	3.53	1.21	113	3.70	.947
Computer and Instructional Technologies Education	87	3.81	.778	87	3.41	1.14	87	3.69	.707
TOTAL	315	3.87	.930	315	3.68	1.06	315	3.81	.821

Table 1 shows that the mean scores on the positive perspective sub-dimension ($\bar{X} = 3.87$), on the negative perspective sub-dimension ($\bar{X}$=3.68) and on the overall scale indicated that all of the preservice teachers had positive perceptions about STEM education ($\bar{X}$=3.81).

Table 2 shows the mean scores on the scale by department.

Table 2. Kruskal-Wallis test results for the comparison of the mean scores on the STEM Awareness Scale

Scale	Group	N	Mean Rank	sd	Chi-Square	p	Significant Difference
Positive	Math Edu.	115	163.96	2	2.013	.366	-
	Science Edu.	113	160.85				
	Comp. Edu.	87	146.43				
Negative	Math Edu.	115	182.96	2	14.964	.001	1-2 1-3
	Science Edu.	113	149.99				
	Comp. Edu.	87	135.41				
Total	Math Edu.	115	178.70	2	10.734	.005	1-2 1-3
	Science Edu.	113	152.72				
	Comp. Edu.	87	137.51				

Table 2 shows that, even though no significant was found in the positive perspective sub-dimension, the mathematics education preservice teachers had a higher mean score (163.96) than the science education and computer education and instructional technologies preservice teachers.

The variance of the preservice primary mathematics teachers' mean scores by gender is shown in Table 3.

Table 3. Mann-Whitney U test results for the comparison of the preservice primary mathematics teachers' mean scores by gender

Scale	Group	N	Mean Score	Rank Total	U	p
Positive	Female	78	64.26	5012.00	955.000	.003*
	Male	37	44.81	1658.00		
Negative	Female	78	62.06	4841.00	1126.000	.056
	Male	37	49.43	1829.00		
Total	Female	78	64.06	4996.50	970.500	.005*
	Male	37	45.23	1673.50		

Table 3 shows that the female preservice teachers had significantly more positive perceptions of STEM in the positive perspective sub-dimension and the overall scale. However, no significant difference was found by gender in the negative perspectives sub-dimension.

Table 4 shows the mean scores of the primary mathematics education preservice teachers by grade level.

Table 4. Kruskal-Wallis test results for the comparison of the preservice primary mathematics teachers' mean scores by grade level

Scale	Groups	N	Mean Score	sd	χ^2	p	Significant Difference
Positive perspective	1st year	30	43.13	3	8.33	.040	1-2
	2nd year	30	62.48				1-3
	3rd year	30	65.50				1-4
	4th year	25	61.46				
Negative perspective	1st year	30	51.37	3	2.46	.483	-
	2nd year	30	62.98				
	3rd year	30	61.88				
	4th year	25	55.32				
Total	1st year	30	43.92	3	8.04	.045	1-2
	2nd year	30	64.20				1-3
	3rd year	30	65.75				
	4th year	25	58.16				

Table 4 shows that the sophomore, junior and senior preservice teachers in the primary mathematics education department had significantly more positive perspectives on STEM in the positive perspective sub-dimension than the freshmen. Although no significant difference was observed in the negative perspective sub-dimension, the sophomore, junior and senior preservice teachers had more positive perspectives in the negative perspectives sub-dimension than the freshmen.

Table 5 shows the preservice science teachers' mean scores by gender.

Table 5. Mann-Whitney U test results for the comparison of the preservice science teachers' mean scores by gender

Scale	Group	N	Mean Score	Rank Total	U	p
Positive	Female	93	59.97	5577.00	654.00	.037*
	Male	20	43.20	864.00		
Negative	Female	93	59.85	5566.00	665.00	.045*
	Male	20	43.75	875.00		
Total	Female	93	60.45	5622.00	609.00	.016*
	Male	20	40.95	819.00		

Table 5 shows that the female preservice teachers had significantly more positive perceptions of STEM in the sub-dimensions and the overall scale.

Table 6 shows the mean scores of science education preservice teachers by grade level.

Table 6:. Kruskal Wallis test results for the comparison of the preservice science teachers' mean scores by grade level

Scale	Groups	N	Mean Score	sd	χ^2	p	Significant Difference
Positive	1st year	27	39.65	3	11.543	.009*	1-2
	2nd year	32	68.13				1-3
	3rd year	26	59.69				1-4
	4th year	28	58.52				
Negative	1st year	27	46.07	3	14.276	.003*	1-2
	2nd year	32	73.19				2-4
	3rd year	26	60.19				
	4th year	28	46.07				
Total	1st year	27	39.67	3	15.994	.001*	1-2
	2nd year	32	73.19				1-3
	3rd year	26	59.56				2-4
	4th year	28	52.84				

Table 6 shows that compared to the freshmen, the sophomore, junior and senior preservice teachers in the science education department had significantly more positive perspectives on STEM in the positive perspective sub-dimension. On the negative perspective sub-dimension of the scale, the sophomore preservice teachers had less negative perspectives on STEM than the freshmen and seniors. On the overall scale, the sophomore and junior preservice teachers had more positive perspectives on STEM than the freshmen, and the senior preservice teachers had more negative perspectives on STEM than the sophomores.

Table 7 shows the preservice computer and instructional technologies teachers' mean scores by gender.

Table 7: Mann-Whitney U test results for the comparison of the preservice computer and instructional technologies teachers' mean scores by gender

Scale	Group	N	Mean score	Rank total	U	p
Positive	Female	48	49.98	2399.00	649.000	.014*
	Male	39	36.64	1429.00		
Negative	Female	48	50.98	2447.00	601.000	.004*
	Male	39	35.41	1381.00		
Total	Female	48	51.47	2470.50	577.500	.002*
	Male	39	34.81	1357.50		

Table 7 shows that the female computer and instructional technologies preservice teachers had significantly more positive perspectives on STEM in the sub-dimensions of the scale and the overall scale.

Table 8 shows the mean scores of the computer and instructional technologies preservice teachers by grade level.

Table 8. Kruskal Wallis test results for the comparison of the preservice computer and instructional technologies teachers' mean scores by grade level

Scale	Groups	N	Mean Score	Sd	Chi-square	P	Significant Difference
positive perspective	2nd year	30	37.10	2	9.893	.007	2-4
	3rd year	30	39.57				
	4th year	27	56.59				
Negative perspective	2nd year	30	42.73	2	0.119	.942	3-4
	3rd year	30	44.50				
	4th year	27	44.85				
Total	2nd year	30	38.78	2	4.868	.088	2-4
	3rd year	30	41.33				
	4th year	27	52.76				

Table 8 shows that, compared to the sophomores, the senior preservice teachers had significantly more positive perspectives on STEM education in the positive perspective sub-dimension of the scale and the overall scale. In the negative perspectives sub-dimension, the senior preservice teachers had less negative perspectives than the juniors.

Conclusions

The results indicate that the preservice teachers from the departments of mathematics, science, and computer and instructional technologies have positive perspectives towards STEM, which is corroborated by many studies of preservice teachers and STEM education (Akaygun & Aslan-Tutak, 2016; Yenilmez & Balbağ, 2016; Yıldırım & Selvi, 2015). This also underlines that preservice teachers had positive awareness about STEM. Studies have shown that individuals with high awareness about STEM also have more positive perceptions of and perspectives on it (Guzey, Harwell & Moore, 2014; Schmidt & Kelter, 2017).

The preservice teachers in the department of mathematics education had more positive perceptions of STEM. Yenilmez and Balbağ (2016) reported that preservice science teachers have more positive attitudes. This may stem from preservice teachers' learning backgrounds or the difference between their undergraduate courses.
The females' mean scores on the STEM Awareness Scale were higher than the males in all departments. This result is corroborated by those of Yenilmez and Balbuğ (2016). Çevik, Danıştay and Yağcı (2017) investigated teachers' awareness about STEM by gender and found no significant difference by gender. Therefore, the effect of the gender variable on the awareness about STEM may differ in preservice or in-service training courses.

By grade level, the sophomore, junior and senior preservice teachers from the department of mathematics education had more positive perspectives on STEM than the freshmen. This may imply that courses in mathematics education positively influence their perceptions of STEM. The sophomore, junior and senior preservice science teachers had significantly higher mean scores on the positive perspective sub-dimension of the scale than the freshman. However, the senior preservice science teachers had less negative perceptions of STEM in the other sub-dimensions of the scale and the overall scale than the sophomores. The reasons for this can be investigated in further qualitative research. On the other hand, the senior preservice computer and instructional technologies education preservice teachers had more positive perceptions of STEM than the sophomores and juniors.

References

AAAS. (1993). Benchmarks for science literacy. New York, NY: Oxford University Press.

ABET (2007). The Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology. Accreditation handbook online. Available at: http://www.abet.org.

Akaygun, S., & Aslan-Tutak, F. (2016). STEM images revealing stem conceptions of pre-service chemistry and mathematics teachers. *International Journal of Education in Mathematics, Science and Technology, 4*(1), 56-71. DOI:10.18404/ijemst.44833

Akgunduz, D., Ertepinar, H., Ger, A. M., Kaplan Sayi, A., & Turk, Z. (2015). The report of STEM education workshop: An assessment on STEM education in Turkey. *Istanbul Aydın University: STEM Centre and Faculty of Education*.
Baran, E., Canbazoğlu-Bilici, S., & Mesutoğlu, C. (2015). Fen, Teknoloji, Mühendislik ve Matematik (FeTeMM) spotu geliştirme etkinliği. *Araştırma Temelli Etkinlik Dergisi,* 5(2), 60-69
Bracey, G., Brooks, M., Marlette, S., & Locke, S. (2013). Teachers' training: Building formal STEM teaching efficacy through informal science teaching experience. In *ASQ Advancing the STEM Agenda Conference, Grand Valley State University, Michigan*.
Buxton, C. (2001). Exploring science-literacy-in-practice: Implications for scientific literacy from an anthropological perspective. *Electronic Journal in Science and Literacy Education*, 1(1).Retrieved from http://sweeneyhall. sjsu.edu/ejlts/
Buyruk, B., & Korkmaz, Ö. (2014). FeTeMM farkındalık ölçeği (FFÖ): geçerlik ve güvenirlik çalışması. *Journal of Turkish Science Education*, *11*(1), 3-23.
Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, *70*(1), 30.
Bybee, R. W. (2011). Scientific and engineering practices in K-12 classrooms. *Science Teacher*, *78*(9), 34-40.
Çevik, M. (2017). Content analysis of stem-focused education research in Turkey. *Journal of Turkish Science Education (TUSED)*, *14*(2).
Çevik, M., Danıştay, A., & Yağcı, A. (2017). Ortaokul öğretmenlerinin Fetemm (fen-teknoloji-mühendislik-matematik) farkındalıklarının farklı değişkenlere göre değerlendirilmesi. *Sakarya University Journal of Education, 7*(3), 584-599.
Chute, E. (2009). Lack of diversity part of equation in STEM fields. Colleges try to increase numbers of women, minorities in science and engineering. *Pittsburgh Post-Gazette*. Retrieved 2/21/10 from http://www.post-gazette.com/pg/09041/947952-298.stm#ixzz0g1ceZiGK
Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education*, 27(4), 471–486.
Corlu, M. A., & Aydin, E. (2016). Evaluation of learning gains through integrated STEM projects. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 20-29.
Dugger, W. E. (2010, December). Evolution of STEM in the United States. In *6th Biennial International Conference on Technology Education Research in Australia retrieved from http://www. iteea. org/Resources/PressRoom/AustraliaPaper. pdf*.
Gencer, A. S. (2015). Fen eğitiminde bilim ve mühendislik uygulaması: fırıldak etkinliği. *Araştırma Temelli Etkinlik Dergisi*, 5(1), 1-19.
Guzey, S. S, Harwell, M. ve Moore, T. (2014). Development of an Instrument to assess attitudes toward Science, Technology, Engineering, and Mathematics (STEM). *School Science and Mathematics, 114* (6), 271-279.
ITEA. (2000). Standards for technological literacy: Content for the study of technology. Reston, VA: Author.
Karakaya, F., Ünal. A., Çimen, O., & Yılmaz, M. (2018) Fen bilimleri öğretmenlerinin stem yaklaşımına yönelik farkındalıkları. *Eğitim ve Toplum Araştırmaları Dergisi/JRES*, 5(1), 124-138.
Karasar, N. (2014). *Bilimsel Araştırma Yöntemi*, Ankara: Nobel Yayın, 26.
Morrison, J. (2006). TIES STEM education monograph series, attributes of STEM education. *Baltimore, MD: TIES, 3*.
Nadelson, L. D., Seifert A., Moll, A. J. & Coat, B. (2012). I-STEM Summer Institute: An integrated approach to teacher professional development in STEM. *Journal of STEM Education*, 13(2), 69-83.
National Academy of Engineering and National Research Council [NAE & NRC]. (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington: National Academies Press.
National Research Council (NRC). (1996). National science education standards. Washington, DC: National Academy Press.
ÖZBİLEN, A. G. (2018). Stem eğitimine yönelik öğretmen görüşleri ve farkındalıkları. *Scientific Educational Studies*, *2*(1), 1-21.
Pinnell, M., Rowley, J., Preiss, S., Franco, S., Blust, R. ve Beach, R. (2013). Bridging the gap between engineering design and PK-12 curriculum development through the use of the STEM education quality framework. *Journal of STEM Education*, 14(4), 28-35.
Şahin, A., Ayar, M. C., & Adıgüzel, T. (2014). Fen, teknoloji, mühendislik ve matematik içerikli okul sonrası etkinlikler ve öğrenciler üzerindeki etkileri. *Kuram ve Uygulamada Eğitim Bilimleri*, *14*(1), 1-26.
Sahin, A., Ayar, M. C., & Adiguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory and Practice*,*14*(1), 309-322.
Sanders, M. (2009). STEM, STEM education, STEM mania. *Technology Teacher*, 68(4), 20–26.
Schmidt, K. M.ve Kelter, P. (2017). Science Fairs: A Qualitative Study of Their Impact on Student Science Inquiry Learning and Attitudes toward STEM. *Science Educator, 25*(2), 126-132.

Yamak, H., Bulut, N., & Dündar, S. (2014). 5. Sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FeTeMM etkinliklerinin etkisi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *34*(2).

Yenilmez, K ve Balbağ, M. Z. (2016). Fen bilgisi ve ilköğretim matematik öğretmeni adaylarının STEM'e yönelik tutumları. *Journal of Research in Education and Teaching, 5*(4), 301-307.

Yıldırım, B. ve Selvi, M. (2015). Adaptation of STEM attitude scale to Turkish. *Turkish Studies, 10*(3), 1107-1120.

Yıldırım, B., & Altun, Y. (2015). Investigating the effect of STEM education and engineering applications on science laboratory lectures. *El-Cezerî Journal of Science and Engineering*, *2*(2), 28-40.