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In-Service and Pre-Service Teachers' Views about STEM Integration and Robotics Applications*

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ARTICLE INFO	ABSTRACT
	Purpose: There are different perspectives about STEM (Science, Technology, Engineering and Mathematics) education. Understanding in-service and pre-service teachers' views plays an important role in supporting K-12 students to choose careers in science, technology and engineering. This research aims to understand science and mathematics in-service and pre-service teachers' views about STEM integration and robotics applications. **Research Methods:** The participants of this study were 240 science and mathematics pre-service teachers and 27 science and mathematics in-service teachers. Participants answered open-ended questions. Data were gathered to find the differences between teachers and future teachers from different disciplines (science and mathematics) with emphasis on their views about STEM and robotics implementation.

Findings: Analysis showed that there were some differences based on disciplines (mathematics and science), but also there are some similarities between in-service and pre-service teachers' views. Mathematics in-service and pre-service teachers provided few details when explaining the effect of STEM and robotics applications. Science in-service and pre-service teachers, on the other hand, presented more ideas about STEM integration while including fewer ideas about robotics applications.

Implications for Research and Practice: There are differences between disciplines in favor of science in-service and pre-service teachers. However, it is hard to say that in-service and pre-service teachers from each discipline were able to present strong examples of STEM implementation. These results suggest the necessity for more interdisciplinary support provided to in-service and pre-service teachers from different disciplines.

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Introduction

STEM (Science, Technology, Mathematics and Engineering) education focuses on students' learning of interdisciplinary relationships (National Research Council [NRC], 2012). Turkey updated the science curriculum with an emphasis on engineering practices in 2018 (MoNE, 2018). However, the recent data released by Higher Education Council (YÖK) in Turkey showed that the youth population does not tend to choose engineering-related majors (Higher Education Council [YÖK] ATLAS, 2018). Akgunduz (2016) found that 83% of the top 1000 students decided to enroll in engineering-related departments after the college placement exam in 2000, and this number decreased to 38% in 2014. In comparison, 40% of the first-year students in Germany enrolled at the STEM-related departments in 2015 when the rate in other countries was lower in other countries: Mexico (32%), South Korea (31%), the United Kingdom (29%), Japan (21%) and Turkey (18%) (Gardner, 2017). Students' lack of interest in STEM-related careers can be found in various studies (Akgunduz, 2016; Honey, Pearson & Schweingruber, 2014; Osborne & Dillon, 2008; Vedder-Weiss & Fortus, 2012). Furthermore, PISA reports released in 2012 demonstrated that Turkish students' performance in problem solving was weaker on interactive and knowledge acquisition tasks (OECD, 2012).

To change this trend, studies focused on understanding students' ideas about science-related careers; however, there is a lack of research revealing teachers' views (Brown, 2012; Honey et al., 2014; Rinke et al., 2016). Departing from this need, we aimed to examine pre-service and in-service teachers' views about STEM as part of their classroom activities. STEM education has many dimensions; among them, we specifically inquired the views from different disciplines about the use of technology and robotics via open-ended questions. The choice of robotics was related to its popularity in Turkey as a STEM application (Yolcu & Demirer, 2017).

Literature review

In the US, the National Science Foundation (NSF) has reported that STEM education plays a central role in training individuals who are technologically advanced and scientifically equipped (Gonzalez & Kuenzi, 2012). Connected with this, NRC aimed to increase advanced education and career opportunities in STEM fields, increasing skilled and equipped workforce in STEM fields and training new generations who have advanced level scientific knowledge (NRC, 2011).

In Europe, countries like England (Morgan, Kirby & Stamenkovic, 2016) and Germany (Gardner, 2011) emphasize STEM to compete with other countries. Similarly, countries with high ranking in international tests in Asia (e.g., South Korea, Japan, China) particularly put emphasis on training teachers for STEM integration (Marginson et al., 2013). These countries have also made some reforms to improve teacher education programs concerning pedagogy and content knowledge to increase the efficiency in science and mathematics teacher education programs, including more problem-solving and research-based practices and encouraging creativity and inquiry (Marginson et al., 2013). Many developed countries, including the US, agreed that starting STEM education at elementary school is more effective in instilling the

attitudes and skills necessary for students to continue their careers in STEM fields (Bagiati et al., 2010; Bybee, and Fuchs, 2006; De Jarnette, 2012; Murphy & Mancini-Samuelson, 2012; Walker, 2012). However, to offer students a learning environment focusing on STEM integration and using technology more efficiently, starting from elementary school, teachers need better support starting from teacher education programs (NASEM, 2019).

STEM in Teacher Education

The acronym of STEM could be interpreted as placing science upfront by many researchers and pave the way for linking the rest to improve science education (English, 2016; Marginson et al., 2013). Science focused STEM education research has proved that the approaches used in those studies fall behind the claim of STEM integration (Shaughnessy, 2013). Although learning mathematics is a key factor for learning other STEM fields, earlier STEM studies have been giving little emphasis on mathematics (English, 2016; Marginson et al., 2013; Shaughnessy, 2013). Likewise, teacher education programs appear to be not giving enough emphasize on the connection among the STEM fields (Greenberg et al., 2013). In a report released about US teacher preparation programs by Greenberg, McKee and Walsh (2013), most of the undergraduate elementary teacher education programs (70%) in the US do not require taking even one science course and do not make strong connections to the other fields of STEM.

Teachers play a significant part in guiding the learning process. Therefore, their knowledge and attitudes toward STEM integration and robotics applications may determines students' achievement in these fields (Turk, Kalayci & Yamak, 2018). However, several studies showed that teachers do not have knowledge about STEM and its applications (Honey et al., 2014; Turk, Kalayci & Yamak, 2018; Wahona & Chang, 2019). Corlu, Capraro and Capraro (2014), on the other hand, examined educational reforms globally and found that teachers' departmentalized expertise in their own disciplines prevents them to successfully implement STEM education. Therefore, they suggest teachers should be prepared for recent reforms, skills and knowledge.

In Turkey, science pre-service teachers (SPSTs) should take courses focusing on mathematics and technology before completing their degrees. Mathematics pre-service teachers (MPSTs) used to take some of the natural science courses, such as physics and chemistry, before the implementation of the updated mathematics teacher education curriculum. These courses were removed from the current curriculum, but algorithm and programming course was added (Higher Education Council, 2018a). In addition, an interdisciplinary science teaching course was added to the science teacher education curriculum (Higher Education Council, 2018b). When looking into the studies published during the previous teacher education curriculum, engineering design process is introduced in courses focusing on designing learning materials or special teaching methods. In parallel with the inclination of STEM education in teacher education programs, researchers started paying more attention to pre-service teachers' understanding and experiences in STEM integration. For example, Delen and Uzun

(2018) examined to what extent elementary mathematics pre-service teachers (MPSTs) implemented STEM education during a semester after they learned STEM integration in a course called Science-Technology and Society. Delen and Uzun found that while MPSTs successfully integrated science and mathematics in the course, they had problems in integrating technology and engineering design process. In another study, Cinar et al. (2016) examined 32 junior SPSTs' perceptions about STEM integration before and after a semester long STEM education. Although their result showed an increment in students' awareness of the interdisciplinary perspective of STEM education, some students believed that natural sciences are the center of STEM and other fields exist to support natural science learning (Cinar et al., 2016). These studies and many more support the arguments about the importance of reinforcing teacher education programs and preparing teachers for the future (Greenberg et al., 2013; NASEM, 2019) since STEM education requires careful planning and integration of different disciplines (Akgunduz et al., 2015; Altan et al., 2016).

Robotics Applications in Educational Settings

Robotics activities are proved to provide a learning environment where students have hands-on learning experience within an interdisciplinary perspective (Nugent et al., 2010; Osborne, Thomas, & Forbes, 2010). Current literature suggests that robotics applications in educational settings are quite effective for different age groups to gain these skills (Almisis, 2013; Benitti, 2012; Kanbul & Uzunboylu, 2017). The "learning by doing" future of robotics increases its importance in STEM since the opportunity of real-life application blending with the concepts of STEM fields (Nugent et al., 2010). Additionally, coding and computational thinking are considered as 21st century skills that every student should have (Kanbul & Uzunboylu, 2017; Monroy-Hernandez & Resnick, 2008). However, teachers seem to have limited skills and knowledge about robotics applications and coding (Guven & Kozcu-Cakir, 2020).

Although the positive effects of robotics applications are proved, there are quite few studies that focus on training teachers on robotics in educational settings (Kim et al., 2015). One of these studies was conducted by Kim et al. (2015) with sixteen elementary pre-service teachers who were trained with robotic-related activities in a three-week program. As a result, the researchers concluded that these activities increased PSTs attitudes toward STEM education. On the other hand, there are fewer studies focusing on ISTs. Guven and Kozcu-Cakir (2020), for example, examined 30 elementary ISTs' perspectives after they completed a robotic coding training program. Based on the result of this study, ISTs stated that they need more organized and efficient training.

When looking into how researchers in Turkey used robotics in discipline-based studies, there was a big emphasis on science teaching (Yolcu & Demirer, 2017). For instance, Korkmaz et al.(2014) implemented LEGO sets and various activities with 48 high school students in three different schools and only examined students' ideas about science. Turkish science curriculum that was updated in 2018 has emphasized engineering practices, high-level thinking, creativity and real-life problem solving (MoNE, 2018). While the science education curriculum was putting more emphasis on

scientific and engineering practices (MoNE, 2018), coding oriented course was added to the mathematics teacher education curriculum (Higher Education Council, 2018a). Our goal in this paper is to offer a snapshot of the existing situation by looking into the views of PSTs and ISTs who did not take specific courses for STEM integration or robotics during their teacher education training. As stated by NASEM (2019), it is important to understand how teachers and future teachers integrate science, technology, engineering and mathematics as part of their instructional design. Departing from this need, the following research questions were created for the present study:

1. What are the examples of educational technology tools and robotic applications listed by elementary mathematics and science pre-service teachers?

2. What are the examples of educational technology tools and robotic applications listed by elementary mathematics and science in-service teachers?

3. What are the similarities and differences between elementary mathematics and science pre-service teachers' views about STEM integration and robotic applications in the classrooms?

4. What are the similarities and differences between elementary mathematics and science in-service teachers' views about STEM integration and robotic applications in the classrooms?

Researchers who studied human behaviors and beliefs argue that perceptions toward a phenomenon determine how individuals make a decision and take action (Dewey, 1933; Nisbett & Ross, 1980; Pajares, 1992). On the other hand, there is a lack of support during teacher training programs with an emphasis on STEM (NRC, 2012; NASEM, 2019) although how teachers implement STEM plays an important role for students (NASEM, 2019). Therefore, it is quite crucial to identify teachers' views toward relatively new concepts. Based on the current literature showing in-service and pre-service teachers' limited knowledge about STEM education while putting an emphasis on robotics applications, we started our inquiry with the use of technology, then shifted to STEM and robotics applications.

Method

Research Sample

We used a convenience sampling method to reach our participants. 240 PSTs (111 mathematics PSTs [MPSTs] and 129 science PSTs [SPSTs]) from three Turkish public universities in three different regions voluntarily participated in this study. Elementary teacher education programs concentrate on pedagogy courses after the 2nd semester, and we selected PSTs starting from sophomore level. In addition, 27 in-service teachers voluntarily answered open-ended questions (11 mathematics teachers

[MTs] and 16 science teachers [STs]) working in elementary schools. Main questions targeted PSTs' and ISTs' perspectives on integrating STEM and robotics applications in the classrooms. To understand the role of technology-supported STEM, we asked participants to make two lists: (1) the educational technology used in the classrooms and (2) robotics applications. These open-ended questions were prepared based on previous studies and revised by expert researchers.

Teachers' gender, subject area and educational level are presented in Table 1. On average, MTs had 5.8 years of teaching experience, and STs had nine years of teaching experience.

Table 1

Demographic Information about Participants

PSTs	Gender		Class Level			
	Female	Male	2nd Year	3rd Year	4th Year	Total
SPSTs	100	29	60	31	38	29
MPSTs	77	34	42	45	24	11
Teachers	Gender		Education Level			
	Female	Male	BA*	Continuing Master Degree	Completed Master Degree	Total
STs	6	10	11	3	2	16
MTs	10	1	6	4	1	11

BA: Bachelor degree, **SPSTs**: science pre-service teachers, **MPSTs**: Mathematics pre-service teachers

Our research team reached the participants using in-class announcements and e-mails. We also sent out open-ended questions to teacher groups. When questions were distributed, we ensured that participants were informed about confidentiality. None of the questions addressed their identity or any personal information. We asked them to reflect on their true opinions and information about themselves without having apprehension due to their grades or anything else.

Data Analysis

This study was conducted using the qualitative research method (Strauss & Corbin, 1990), and as a methodological approach, we used Hermeneutic phenomenology (Creswell, 2007). Unlike phenomenology, "Hermeneutic research is interpretive and concentrated on historical meanings of experience and their developmental and cumulative effects on individual and social levels" (Laverty, 2003, p. 27). Hermeneutic phenomenology requires a bunch of skills that allows the reading text of transcript,

verbal agents of personal experiences, as well as extracting the meaningful themes (van Manen, 1997). Initially, first and second authors read through all participants' responses that reflected their experiences and break them down into pieces using open coding (Strauss & Corbin, 1990). Then, authors identified the most predominant ideas to generate categories for each particular subject (e.g., technology, STEM education, robotics applications). The categories were determined based on common themes that ISTs and PSTs gave for each question (see Table 2). When the responses, such as saving time, effective teaching and teaching materials, they were categorized under Teaching. When responses focused on meaningful or active learning, they were placed under Learning. Finally, the responses, such as supporting entrepreneurship and providing interdisciplinary perspective, were categorized under Nature of STEM. When creating the codes and categories, the authors worked together in the entire process and solved all disagreements through discussion.

Table 2

Codes and Categories for STEM Integration and Robotics Applications

Codes and categories for STEM integration		
Teaching	**Learning**	**Nature of STEM**
Facilitates Teaching	Increases individuals' motivation.	Supports entrepreneurship/ critical thinking
Effective and efficient teaching	Provides meaningful learning	Innovative thinking
Provides visual/ tangible cues	Encourages active learning	Relates to daily life
Improves science teaching		Enables practice and producing
		Emphasizes interdisciplinary connections
Facilitates teaching / useful / interactive teaching	Attracts interest / attention. Motivates students.	Promote entrepreneurialship, critical thinking / raise creative, Productive and scientifically literate individuals.
Accelerates teaching / saves time.	Provides effective, permanent and meaningful learning & understanding / helps pedagogical development	Improves motor & computer skills
It provides visuality, audibility. Helps to give concrete examples.	Provides active learning / learning by doing	STEM application
Improves science education teaching		Associates daily life with other areas
		Practical / Product oriented Innovative

We also analyzed examples of technology and robotics tools/applications given by the participants and listed only the top 10 frequently mentioned responses given by PSTs (Table 3 and 5) and ISTs (Table 4 and 6). While participants were able to provide many examples for technology, there were fewer examples given for robotics applications. As some educational researchers emphasized, qualitative research analysis is not necessarily a linear process (Khandkar, 2009). Therefore, we tried to infer data by looking one participant's responses from a complete perspective instead of looking into individual questions.

Results

The results were presented under three aspects as follows: technology tools used in classroom, STEM integration and robotic applications in sequence. The goal of this section is to reveal similarities and differences between IST and PSTs from different disciplines under each aspect.

Educational Technology Tools Used in Classrooms

This section presents the analysis for PSTs' and ISTs' views about frequently used technologies in classrooms. We asked PSTs and ISTs to list five main tools/applications based on their experiences.

PSTs' List of Educational Technology Tools in Classrooms. As presented in Table 3, top three technology tools/applications listed by SPSTs and MPSTs were computers, projection and smart boards. In addition, MPSTs mentioned some applications, such as GeoGebra (9.1%), Cabri 3D (4.1%) and HotPotatoes (3%). There were also eight MPSTs mentioning another application called Illumination. On the other hand, SPSTs listed LearningApps (11 SPSTs) and also included Kahoot! (8 SPSTs), Code.org (7 SPSTs), Arduino (8 SPSTs) and mBlock (2 SPSTs).

Table 3

Technology Examples Given by PSTs

Science Pre-Service Teachers (SPSTs)		Mathematics Pre-Service Teachers (MPSTs)	
Categories	**f / %**	**Categories**	**f / %**
Computers	101 (22%)	Smartboards	65 (17.9%)
Projection	63 (13%)	Computers	58 (16%)
Smart board	61 (13%)	Projection	43 (11.8%)
Smart phone	53 (11%)	Smart phone	38 (10.5%)
Tablets	37 (8%)	Geogebra	33 (9.1%)
LearningApps	11 (2%)	Tablets	29 (8%)
EBA	10 (2%)	Cabri 3D	15 (4.1%)
Microscope	10 (2%)	MS Office	11 (3%)
Google Classroom	10 (2%)	HotPotatoes	11 (3%)
Scratch	9 (2%)	EBA	10 (2.8%)
		YouTube	10 (2.8%)

ISTs' List of Educational Technology Tools in Classrooms. When we looked at ISTs' examples, we came across similar tools/apps but in different order. Table 4 presents ISTs' answers. Smart boards and computers are ranked as top tools/applications in STs answers. Similar to SPSTs, the tools/application examples, given by the STs were not different, and they only included few technological tools such as computer, smartboards and tablets. MTs, on the other hand, provided more examples connected with the examples provided by MPSTs.

Table 4

Technology Examples Given by ISTs

| Categories for SISTs	f	Categories for MISTs	f
Smarboards	13 (22%)	Smarboards	9 (26%)
Computers	7 (12%)	Geogebra	4 (15%)
Tablets	4 (7%)	Cabri 3D	3 (9%)
EBA	4 (7%)	Smart phones	3 (9%)
Smart phones	4 (7%)	Computer	3 (9%)
z-book*	3 (5%)	Tablets	2 (6%)
Projection	3 (5%)	Projection	2 (6%)
4D applications	2 (3%)	Social Media (e.g. Facebook)	2 (6%)
		z-book*	1 (3%)

: Enriched digital books

STEM Integration in the Classrooms

Similar to other countries, Turkey put an effort to legislate STEM integration by adding engineering design and entrepreneurship skills into recent curriculum (MoNE, 2018). Therefore, science (Higher Education Council, 2018b) and mathematics teachers (Higher Education Council, 2018a) are expected to know how to integrate STEM fields to be able to manage this process well. Here, we first analyzed PSTs' views about STEM integration as a classroom application and then continued with ISTs. The codes given in Table 2 were used to plot the graphs in Figure 1, Figure 2 and Figure 3.

PSTs' Views about STEM Integration. When the PSTs were asked about STEM integration, surprisingly, almost half of the MPSTs (53.2%) did not present an idea, while 9.3% of SPSTs said they did not have any knowledge about STEM. On the other hand, 24.8% of SPSTs and 18.9% of MPSTs failed to provide why they believed STEM

makes a difference in education. Under this category (no explanation in Figure 1), participants stated a positive impact but did not provide any tangible examples. The responses of all PSTs who gave some details showed that STEM integration was linked with science teaching. Especially, MPSTs missed connections of STEM integration with their subject area: "*STEM education had a broad application in science education. I think it is a great opportunity to teach information by relating with daily life.*" [MPST6]; "*I think that STEM will help to increase interest in science and will help to achieve original projects as a result of the integration of science into similar fields*" [MPST40].

SPSTs, on the other hand, perceived that STEM integration has a positive effect on education; however, almost one fourth of them (24.8%) did not have a comprehensive understanding to detail in what extend STEM education benefits learning: "*I cannot say anything precisely, but it can be very helpful since it includes some activities related to science education.*" [SPTS87]. "*I think it will be very beneficial because STEM is mentioned in science courses now.*" [SPST117].
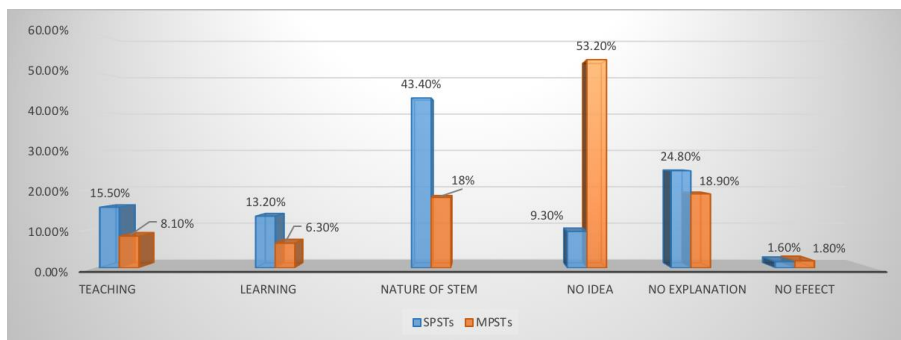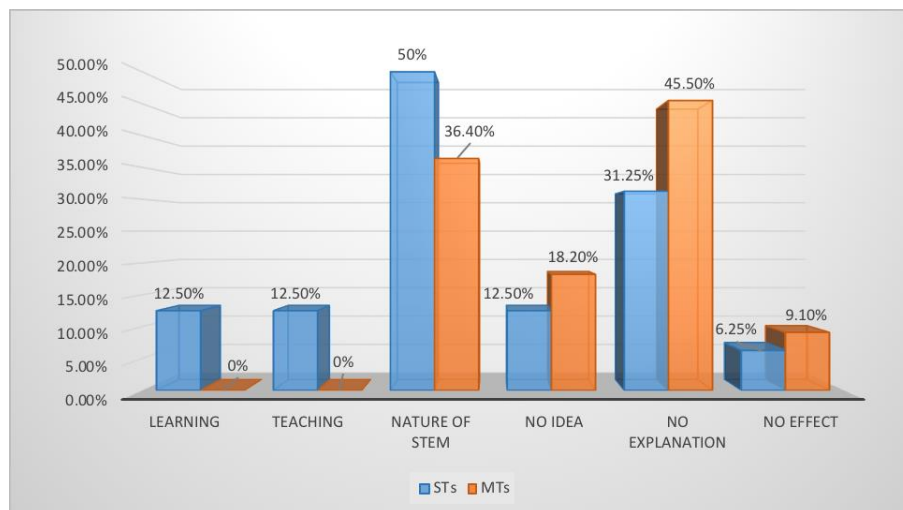

Figure 1. *PSTs views about STEM integration (the total of percentages in the graphs are higher than 100% since some quotes were linked to multiple categories).*

As indicated in Figure 1, SPSTs stated more ideas about the nature of STEM (e.g., emphasizing interdisciplinary connections, supporting entrepreneurship, innovative and critical thinking,) and its benefit on learning process when compared with MPSTs. On the other hand, several PSTs stated that STEM would not make a difference. The focus on teaching and learning was at a comparable level for both groups. SPSTs more frequently (SPTSs: 28.7% vs. MPSTs: 14.4%) focused more on teaching and learning related examples (combination of teaching and learning categories). Several SPSTs stated the role of providing a different learning environment and encouraging students to be active learners under *Learning* category: "*It makes learning more meaningful and didactic*" [SPST7]. "*Science learning would not be just based on memorizing. Students would become more curious and active*" [SPST93].

Another salient aspect of the PSTs' responses was that they conceptualize STEM education as an additional activity rather than viewing it from an integrated

perspective. "It *benefits the technology education. For example, lots of activities and presentations could be done via the smart boards used in classrooms*" [SPST 30]. "*It [STEM] could be used in the cases where the direct observation is not possible, e.g., topics related to space*" [SPST34].

ISTs' Views about STEM Integration. The analysis of ISTs' views about STEM education shows that STs have more knowledge and willingness of the use STEM education in their classrooms compared to MTs. While MTs did not mention learning and teaching aspect of STEM education, 25% of the STs (combination of teaching and learning categories) stated that STEM integration helps them to teach easier, effective and enriched content as well as encouraging students to learn by doing. "*Thanks to STEM integration, students would develop their creativity, problem solving skills using their basic knowledge and skills and at the same time, it provides self-confidence, which will increase the academic success by saving the course from being rote*" [ST1]. Similar to MPSTs, there were MTs missing connections to include mathematics and engineering as part of STEM integration "*Science education becomes more understandable with the help of technology integration*" [MT10].

Figure 2. *ISTs' views about STEM integration (the total of percentages in the graphs are higher than 100% since some quotes were linked to multiple categories).*

Half of the STs talked about nature of STEM, while 36.4% of MTs stated the nature of STEM aspects "*As a teacher who thinks that science is not subject that should be taught as monotonous, by integrating different disciplines, I think that students would have an important effect in terms of addressing learning areas in different ways*" [ST2]; "[STEM integration] *helps to design efficient projects*" [MT5]. Although MT5 mentioned about "designing efficient project", we cannot conclude that this teacher fully understand the nature of

STEM since he did not give enough detail. Furthermore, the percentage of MTs who did not present an idea about STEM was more than the number of STs. Moreover, many STs and MTs did not include detailed explanations, although they had positive views about STEM integration.

Robotics Applications

In this section, we presented what PSTs and ISTs think about robotics applications. Then, for each group, we reported the robotics applications that they had already used or would potentially use.

PSTs' Views about Robotics Applications. Figure 3 summarizes PSTs' views about the robotics applications in education. While more than half (52.3%) of the MPSTs did not know about the applications of robotics in education, almost one third (31%) of SPSTs had not heard about robotics: "*I do not have any knowledge about it* [robotics applications in education]" [MPST23]. The most highlighted feature of robotics applications by SPSTs (34.9%) was related to teaching and learning categories: "*Instead of memorizing an information and getting bored in class, they could have fun and learn via robots that they develop by themselves*" [SPST93]. 21.6% of the MPSTs, on the other hand, emphasized on how robotics activities help teachers under teaching and learning categories: "*I believe robotic coding is directly related with science teaching. When teaching forces in physics, a simple robotic car could be designed*" [MPST96].
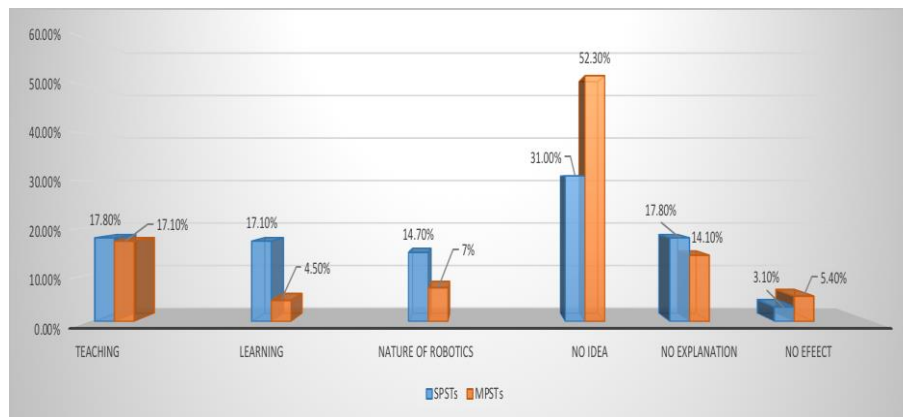
Figure 3. *PSTs views about robotics applications (the total of percentages in the graphs are higher than 100% since some quotes were linked to multiple categories).*

The findings also showed that the nature of robotics (e.g., promoting entrepreneurship, improving motor and computer skills and product oriented), and what makes robotics different than other instructional activities and tools were rarely mentioned by both groups (14.7% of SPSTs and 7% of MPSTs). There were also PSTs who argued that the robotics in education has limitations: "*I do not think robotic activities*

should be given place in classrooms, because it decreases the effect of permanent learning by making learning easier" [SPST80]. Unfortunately, SPST80 did not provide further information about what makes "learning easier".

PSTs' Examples of Robotics Applications. To better understand PSTs' views about robotics applications, we also asked them to list five robotic applications they use in their daily life. This question was not specifically asking about educational experiences, but some PSTs provided examples focusing on Scratch and Arduino. As presented in Table 5, the most popular categories under this section were home appliances and robotic learning sets.

Table 5

Robotics Examples Given by PSTs

Categories for SPSTs	f	Categories for MPSTs	f
No Answer	62 (39%)	No Answer	83 (59%)
Robotic learning sets (Arduino, Mblock\Lego)	22 (14%)	Unrelated (Education projects, videos, etc.)	6 (4%)
Home Appliances (Dishwasher, Washing Machine, Remote Control)	14 (9%)	Robotic learning sets (Arduino, Mblock\Lego)	5 (4%)
Smartphone	9 (6%)	Smartphone	6 (4%)
Computer	9 (6%)	Siri	5 (4%)
Unrelated (Education projects, robotic with no other explanation)	9 (6%)	Home Appliances (Dishwasher, Washing Machine, Remote Control)	4 (3%)
Smarthome	5 (3%)	Tablet	5 (4%)
Smartboard	5 (3%)	Computer	4 (3%)
Tablet	5 (3%)	Scratch	4 (3%)
Siri	3 (2%)		

As it is seen in Table 5, MPSTs seemed to have less awareness about robotic applications than SPSTs. Drones, card readers and 3D printers were also listed by less than 1% of SPSTs. Students who gave unrelated examples seemed to be clueless about

robotics applications as well: "*Teaching 3D atom models with tablets*" [MPST12]; "*Showing students videos about a concept from smart boards in the classroom*" [SPST41].

ISTs' Views about Robotics Applications. As depicted in Figure 4, while STs emphasized more about learning (18.75%) and teaching (62.5%) aspect of robotics, MTs provided examples focusing on the nature of robotics (36.4%) (e.g., improving motor and computer skills, product oriented association with daily life). Similar to PSTs' result, MTs appeared to have limited understanding about the effects of robotics in teaching/learning (36.4%) compared to the STs (18.75%). Although almost half of the MTs (45.5%) have positive views about including robotics applications in education, they did not give any supporting argument to explain why. 25% of the STs, on the other hand, stated that including robotics applications in education might have positive impact without providing further details. "*I think that the positive effects will be seen through such applications since they are designed based on consideration of needs and conditions.*" [MT1]; "*I think it has positive effects*" [ST10].
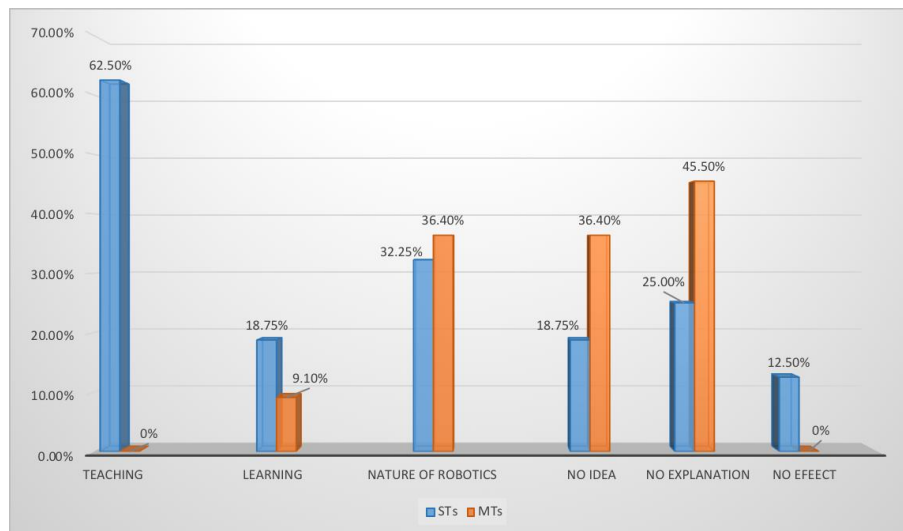
Figure 4. *ISTs views about robotics applications (the total of percentages in the graphs were higher than 100% since some quotes were linked to multiple categories).*

ISTs' Examples of Robotics Applications. MTs' lack of knowledge continued when they were listing five robotics applications. STs also followed a similar pattern. Since there were not many different examples, we presented only four different robotic examples given by teachers on Table 6. 45% of the STs could not list any example while 67% of the MTs failed to do so. Although the given examples appeared to be almost the same, STs seemed to provide relatively more examples related to education such as Scratch (20%) and robotic learning sets (30%) in comparison to the MTs.

Table 6

Robotics Examples Given by ISTs

Categories for SISTs	f	Categories for MISTs	f
No Idea	9 (45%)	No Idea	8 (67%)
Robotic learning set (Arduino, Mblock/Lego)	6 (30%)	Home appliance	2 (17%)
Scratch	4 (20%)	Robotic learning set(Arduino, Mblock/Lego)	1 (8%)
Navigation systems	1 (5%)	Navigation systems	1 (8%)

Discussion

Researchers in STEM fields studied how science, technology, engineering and mathematics can be integrated into well-structured ways to increase the meaningful understanding and awareness of interdisciplinary connections to date. We need to raise qualified teachers who are competent in all STEM fields and confident to show these interdisciplinary connections to teach their subjects (Honey et al., 2014). In our study, MPSTs and MTs provided fewer details when explaining the effects of STEM and robotics applications in learning and teaching. SPSTs and STs, on the other hand, appeared to have more knowledge about STEM integration and less awareness about robotics applications. As Pimthong and Williams (2018) indicated, PSTs have perceptions of STEM integration being a new teaching approach; therefore, we need to pay more attention to how to make STEM education more perceptible and practical for PSTs in order for them to comprehend the fundamentals of STEM integration. Some MPSTs in our study linked STEM to improving science teaching.

To support teachers' understanding of the various components included in STEM education (NRC, 2012), all teachers in STEM fields need to be persuaded to internalize STEM integration with an emphasis on students' development. Although we worked with limited sample size, our findings showed the differences between science and mathematics PSTs' and ISTs' views. If we want to achieve interdisciplinary links, understanding and overcoming these differences are crucial for a better STEM implementation. In this section, we focused on why these deeper connections were missing for PSTs and ISTs, who did not take specific courses for programming and interdisciplinary connections.

In our study, all participants took the courses from the previous curriculum, so we could not observe how the new curriculum may bring on a change for mathematics PSTs and ISTs, rather we tried to provide a snapshot of the existing situation. By looking at PSTs' and ISTs' examples of technology, we identified that both groups listed smart boards, computers, and projectors as part of the technology used in the

classroom. Similar to Lei (2009), PSTs and ISTs tend to use the most convenient and easy to use technology, such as smartphones, computers and smart boards. When we consider PSTs' knowledge and experience they gained in teacher education program, it is not surprising that they listed only basic technological tools could be used in education (Doering et al. 2003). Technology is now seen as a part of pedagogy and there may be a mismatch between what teachers know about technology and how they use it in specific occasions or contexts in their classrooms; therefore, there should be specific knowledge and skills, as well as creativity involved in using technology as part of the curriculum (Koehler & Mishra, 2009). Once we looked at the examples provided by different groups, MPSTs and MTs provided examples of applications more than SPSTs and STs. However, we observed this trend changing when focusing on STEM integration and robotics applications.

While MPTS presented a lack of understanding about STEM, SPTSs provided more examples of STEM integration. These findings are in line with the results of Pimthong and Williams (2018) who reported a similar result about STEM being perceived differently by major. Pimthong and Williams found that although most PSTs had knowledge of what STEM stood for, they could not make an explicit explanation to reveal its nature. Likewise, particularly MPSTs, in this study, put little emphasis on the nature of STEM while emphasizing contextualizing STEM education to teach science concepts. Almost none of the MPSTs explained how STEM integration could be implemented by providing examples. Similarly, Wang et al. (2011) experienced MTs did not think that they could address math standards via STEM integration and believe that STEM integration helps better for science teaching.

Research revealed that there are different types of STEM integration. Becker and Park (2011) conducted a meta-analysis focusing on these types and reported that integrating science and technology leads to better student achievement compared to including mathematics. In addition to that, they reported that four out of eight integration types included technology. When thinking about the dominance of science in STEM integration (English, 2016; Marginson et al., 2013; Shaughnessy, 2013) with adding the role of technology (Becker & Park, 2011), we focused on technology-supported applications with an emphasis on STEM in this paper. Robotics is evaluated as part of STEM in previous studies published in Turkey (Donmez, 2017). Analysis of PSTs' and ISTs' views showed that SPSTs and STs provided more information compared to MPSTs and MTs. However, robotics applications in education were a big unknown for PSTs and ISTs from both disciplines. Since they had heard about commercialized robotics education (e.g., LEGO sets, Arduino) but not actually experienced it, the responses were limited to either its positive effect without further explanation or no explanation at all. This result is consistent with Khanlari's (2016) study that argues that teachers have a lack of knowledge about educational robotics and proper software/hardware that they can use in the classroom.

LEGO, Arduino and Scratch are commonly used in Turkey. Grover and Pea (2013) define them as programming tools. Therefore, when we look at the examples provided by ISTs and PSTs, it is seen that graphical programming environments (e.g., Scratch) and robotic learning kits (e.g., Arduino) were mentioned in both disciplines. Departing

from this finding, one can assume that teachers focused primarily on programming. However, to support students' deeper understanding, coding itself is not enough (Grover, 2013). Moreover, several PSTs and ISTs stated that robotic applications do not facilitate students to reach targeted goals. This result is also in-line with Khanlari's (2016) findings. He interpreted this result as teachers' concern about length of the time invested on the robotics application. Additionally, we believe that PSTs and ISTs lack of knowledge may cause the reluctance about the benefit of using robotics activities in classrooms. Especially MPSTs and MTs provided limited examples and ideas about the benefit of robotic activities in mathematics education. MPSTs' and MTs' limited knowledge about robotics might be acknowledged with the studies primarily focusing on science education (Korkmaz et al., 2014; Yolcu & Demirer, 2017).

Research confirmed that teachers who have negative dispositions toward STEM education rather prefer not to integrate STEM in their curriculum (Appleton, 2003) and teachers' position towards STEM could be transferred to their students who may develop similar attitudes against STEM fields and interdisciplinary integration (Srikoom, Hanuscin & Faikhamta, 2017). Deemer (2004) argues that teachers' attitudes toward classroom practices are linked to their students' attitudes. Although we did not encounter many negative opinions about STEM integration and robotics application, we believe ISTs and PSTs limited number of examples about these topics may raise a little concern. Additionally, strong links between STEM, technology, robotics and classroom activities have yet to be established (Land, 2013). Babacan and Sasmaz-Oren (2017) argued that PSTs feel more confident using the technology that they learn during their undergraduate programs. We believe with the recent updates in teacher education programs (Higher Educational Council, 2018a; Higher Educational Council, 2018b) would be beneficial for future PSTs becoming competent about STEM integration and robotics applications.

Conclusion, Limitation and Recommendations

All developed countries put an effort for not losing their positions in competing with other countries in STEM fields (Wang et al., 2011). Therefore, the concern of raising future scientists, technologists, engineers and mathematicians leads educators to develop programs to reinforce relations between these disciplines. Since qualified teachers, particularly at the K-12 level, are a significant key to increase students' achievement (Darling-Hammond, 2003), we, as educators, should pay more attention to what our future teachers perceive and know about integrating STEM in different educational contexts. Mathematics and science teachers are the most likely group to implement STEM in the K-12 curriculum since they are two core subjects that are offered in most programs in many countries. In this study, we tried to identify the similarities and differences between elementary mathematics and science PSTs' and ISTs' views and examples about using technology, STEM integration and robotics applications in their classroom. Since we worked with volunteer participants, this created an unequal distribution between participant groups, and may cause some limitations to interpreting the results. However, the number of participants in both

disciplines helped us to analyze qualitatively and conclude their views and make some assertions. Despite the limited number of ISTs, we found similar patterns between ISTs and PSTs based on the disciplines.

Identifying teachers' knowledge and perspectives about STEM integration and robotics applications will help us to find out (1) the readiness of future's and today's teachers to STEM integration and (2) how we can reformulate courses in teacher education programs as well as providing professional development opportunities (Honey et al., 2014). We cannot abnegate the importance of preparing experienced and qualified teachers who are aware of the robotics applications and their place in education. Since robotic courses and projects received considerable financial support in recent years, teachers' likelihood to integrate STEM and robotics applications in their classes will increase with the changes made in the teacher education curriculum (Higher Educational Council, 2018a; Higher Educational Council, 2018b). To support this positive trend, we need further studies depicting similarities and differences between teachers' preparedness about STEM integration and robotics applications.

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Öğretmenlerin ve Öğretmen Adaylarının STEM Entegrasyonu ve Robotik Uygulamaları Konusundaki Fikirleri

Atıf:

Özet

Problem Durumu: Öğrencilerin fen bilimleri ve matematikteki performanslarının artması, gelişmiş ve gelişmekte olan ülkelerde birincil hedeflerden biri olmuştur. Bu nedenle, birçok araştırmacı STEM (Bilim, Teknoloji, Mühendislik ve Matematik) eğitimi hakkında farklı bakış açılarına yönelmiştir. Öğrencilerin STEM alanları ilgili kariyerlere ilgilerinin düşmesi, tüm dünyada bir sorun olarak görülmektedir. Son zamanlarda, STEM eğitiminin bu sorunun üstesinden gelmenin önde gelen yollarından biri olduğu ileri sürülmüştür. Bu nedenle gelişmiş ülkeler STEM alanlarında donanımlı bireyler yetiştirmek için ilk ve ortaöğretim düzeyindeki ders programları ve içeriğinde değişikliğe gitmiştir. Buna bağlı olarak, öğretmenlerin ve öğretmen adaylarının bu değişikliklere ne kadar hazır olduklarını incelemek önemlidir. Bu çalışma, fen bilimleri ve matematik öğretmenlerinin ve öğretmen adaylarının eğitimde kullanılan teknolojik araçlar, STEM entegrasyonu ve STEM'in uygulama alanlarından biri olan robotik hakkındaki bilgi ve algılarını incelemeyi amaçlamaktadır. Matematik ve fen bilimleri STEM eğitiminin birbirleri içerisine en fazla geçmiş alanlarıdır. Bu iki disiplinin mühendislik ve teknoloji ile de yakın bağlantıları vardır. Bu alanlarda görev yapan ya da yapacak olan öğretmenler gelecekteki bilim adamları, mühendisler ve programcılar olarak kabul edilecek öğrencileri yetiştireceğinden, onların STEM entegrasyonuna ilişkin bakış açıları ve inançların tespit edilmesi çok önemlidir.

Araştırmanın Amacı: Bu çalışma, görev yapmakta olan fen bilimleri ve matematik öğretmenleri ile ilköğretim matematik ve fen bilimleri öğretmenliği bölümlerinde öğrenimlerine devam eden öğretmen adaylarının eğitimde kullanılan teknolojik araçlar, STEM entegrasyonu ve robotik uygulamaları hakkında ne kadar bilgi sahibi olduklarını ve bu konuların eğitimdeki yeri hakkındaki görüşlerini belirlemek amacı ile yapılmıştır. Çalışmaya yön veren araştırma soruları: *1) İlk öğretim matematik ve fen bilimleri öğretmen adaylarına göre derslerde en fazla kullanılan teknolojik araçlar ve robotik uygulamalar nelerdir? 2) İlk öğretim matematik ve fen bilimleri öğretmenlerine göre derslerde en fazla kullanılan teknolojik araçlar ve robotik uygulamalar nelerdir? 3)İlk öğretim matematik ve fen bilimleri öğretmen adaylarının derslere STEM ve robotik uygulamaları dahil etme konusundaki görüşleri nelerdir? 4) İlk öğretim matematik ve fen bilimleri öğretmenlerinin derslere STEM ve robotik uygulamaları dahil etme konusundaki görüşleri nelerdir?*

Araştırmanın Yöntemi: Araştırmanın katılımcıları, Türkiye'deki üç farklı devlet üniversitesinde ilköğretim matematik ve fen bilimleri bölümlerinde öğrenimlerine devam eden 240 öğretmen adayıdır. 27 fen bilimleri ve matematik öğretmeni de

çalışmaya katılmıştır. Katılımcıların eğitimde kullanılan teknolojik araçlar, STEM ve robotik uygulama ile ilgili fikirleri, açık uçlu soruları vasıtası ile alınmıştır. Toplanan veriler nitel araştırma yöntemi ile hem öğretmen ve öğretmen adayı bazında hem de farklı disiplinler (fen bilimleri ve matematik) bazındaki farklılıkları bulmak için analiz edilmiştir.

Araştırmanın Bulguları: Araştırmanın sonuçları, disiplinlere (matematik ve fen bilimleri) dayalı bazı farklılıklar olduğunu, ancak öğretmen adayları ve öğretmenler arasında bazı benzerlikler olduğunu ortaya koymuştur. Her iki disiplindeki öğretmen ve öğretmen adayları eğitimde kullandıkları (ya da kullanabilecekleri) teknoloji destekli materyal olarak akıllı tahta, bilgisayar ve projeksiyon cihazı gibi kolay ulaşılabilen ve kullanımı kolay olan cihazları listelemişlerdir. Ayrıca çoğu öğretmen ve öğretmen adaylarının STEM entegrasyonu ve robotik uygulamalarının eğitimdeki yeri konularında bilgilerinin yetersiz olduğu öne çıkan bir başka bulgudur. Ayrıca ilköğretim matematik öğretmen adayları ve öğretmenleri STEM ve robotik uygulamalarının öğrenme ve öğretmedeki etkisini açıklarken fen bilimleri öğretmen adayı ve öğretmenlerine oranla daha az ayrıntı verdiği tespit edilmiştir. Bunun yanında fen bilimleri öğretmenlerinin ve öğretmen adaylarının STEM hakkında daha fazla bilgiye sahip olmalarına karşın, robotik uygulamaları hakkında daha az farkındalıkları olduğu görülmüştür. Sonuçlar fen bilimleri öğretmen ve öğretmen adaylarının ilköğretim matematik öğretmen ve öğretmen adaylarına kıyasla STEM entegrasyonu hakkında daha fazla bilgi sahibi olduklarını göstermiştir. Bu farklılığa rağmen, her iki grubun STEM uygulaması hakkında sınırlı sayıda detaylı örnekler ve açıklamalar sunabildikleri gözlenmiştir.

Araştırmanın Sonuçları ve Önerileri: Bu çalışma ile farklı fen bilimleri ve matematik gibi iki temel disiplindeki öğretmen ve öğretmen adaylarının bu uygulamalara hazır olup olmadıklarına ışık tutulmaya çalışılmıştır. Araştırmanın bulguları, öğretmen ve öğretmen adaylarının STEM'in doğasına yönelik kısıtlı cevaplar verdiklerini göstermektedir. STEM entegrasyonu ve eğitimde robotik uygulama hakkında pek fazla olumsuz görüşle karşılaşmamamıza rağmen, öğretmen ve öğretmen adaylarının bu konularla ilgili sınırlı sayıda verdikleri örneklerin bu alandaki eksikleri işaret etmektedir. Bu nedenle özellikle öğretmen adaylarının STEM entegrasyonunun temellerini kavramaları için STEM eğitiminin daha anlaşılabilir ve uygulamalı olarak öğrenilmesi önerebilir. Ayrıca, STEM entegrasyonu disiplinler arası bağlantıların güçlendirilmesini savunmaktadır. Farklı öğretmen ve öğretmen adayı gruplarının bu konu hakkındaki farkındalıklarının arttırılması, disiplinler arası bağlantıların daha güçlü yapılmasına yardımcı olacaktır.

Son zamanlarda hızla yaygın hale gelen robotik kurslar ve projeler önemli finansal destekler aldığını göz önünde bulundurursak, öğretmenlerin STEM entegrasyonu ve robotik uygulamalar konularında daha fazla bilgi ve deneyim sahibi olmaları beklenecektir. Özellikle ilköğretim matematik öğretmen ve öğretmen adaylarının robotik uygulamalar hakkında daha fazla bilgi ve deneyim sahibi olması için çalışmaların yapılması önerilmektedir. Bunun içinde öğretmen yetiştirme ve de hizmet içi eğitim programlarının öğretmen ve öğretmen adaylarının bu beklentileri

karşılayacak düzeye gelebilmelerine destek sağlayacak şekilde bir eğitim vermeleri gerekmektedir.

Anahtar sözcükler: Öğretmen Adayları; İlköğretim Matematik ve Fen Bilimleri Öğretmenleri; STEM Entegrasyonu; Robotik Uygulamaları.