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Pre-Service Teachers' Attitudes towards STEM: Differences Based on Multiple Variables and the Relationship with Academic Achievement

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Abstract

STEM education has benefits for students, such as increasing achievement and improving attitudes, motivation, interest toward STEM disciplines, and higher-order thinking skills. Teachers' characteristics, perceptions, and attitudes related to STEM influence teachers' implementation of integrative STEM approaches and, as a result, shape the learning environment. This study examined 513 pre-service teachers' attitudes towards STEM in terms of multiple variables (department, class level, gender, having a traineeship, or information about STEM) and investigates the relationship between participants' attitudes and academic grade point averages. Participants were pre-service preschool, classroom, science, and mathematics teachers that can be considered the basis of the STEM pipeline. Data were collected via a survey and were analyzed using descriptive statistics, t-test, ANOVA, and Pearson product-moment correlation. Results show that pre-service science teachers, senior pre-service teachers, and participants who had information or a traineeship about STEM had more positive attitudes towards STEM. There was no relationship between attitudes and grade points. It was also seen that the attitudes towards engineering-technology explain the most variance in the attitudes towards STEM. Therefore, the teacher preparation programs should give more attention to integrate the courses of science, technology, engineering, and mathematics and help the pre-service teachers (regardless of their departments) to realize the connectedness of STEM subjects.

Introduction

We live in a world with significant innovations in science and technology. Achievement in science, technology, and mathematics are closely related to technological innovations and economic growth (NAS, 2006). Individuals are expected to be aware of the roles of science, mathematics, technology, and engineering, realize the importance of these disciplines in society and be familiar with each area's fundamental concepts (Margot & Kettler, 2019). One of the most important points that education systems need to consider is how to equip students with fundamental concepts. Human beings of the digital age should have some necessary competencies such as collaboration, questioning, critical thinking, creativity, and problem-solving to overcome the challenges they face in the global and knowledge-based world (Acar, Tertemiz, & Taşdemir, 2018; Aldahmash, Alamri, Aljallal, & Bevins, 2019; Thibaut, Knipprath, Dehaene, & Depaepe, 2018a; Tseng, Chang, Lou, & Chen, 2013; Yenilmez & Balbağ, 2016). An effective way of dealing with the complex interdisciplinary real-world problems in this digital era is to provide an integrated curriculum that increases learners' academic achievement (Czerniak, Weber, Sandmann, & Ahern, 1999) and improves interest and motivation (Erlandson & McVittie, 2001; Lee, Hsu, & Chang, 2019; Vars, 2001; Weilbacher, 2001). Integrative approaches improve students' content knowledge and promote higher-order thinking (Becker & Park, 2011), and provide students more stimulating experiences (Furner & Kumar, 2007). STEM education is a promising approach for the integrated curriculum.

STEM education is a learning approach that removes the traditional barriers that separate science, technology, engineering, and mathematics from each other and integrates them into students' learning experiences (Vasquez, Sneider, & Comer, 2013). In STEM activities, students are engaged with an engineering design that provides meaningful learning through the integration and application of knowledge and skills of science, technology, and mathematics (Breiner, Harkness, Johnson, & Koehler, 2012; Chia & Maat, 2018; Moore & Smith, 2014; Tseng et al., 2013). STEM helps students to gain the necessary knowledge and skills needed for the future careers (Acar et al., 2018; Becker & Park, 2011; Kinpprath et al., 2018; Wahono & Chang, 2019). STEM education is also related to a nation's economy as STEM disciplines promote scientific and technological innovations (Chen, 2013). Societies need more individuals who choose STEM disciplines as a career. However, interest in engineering and science careers seems to be decreased (Becker & Park, 2011; Dagley, Georgiopoulos, Reece, & Young, 2016). Integrated STEM activities throughout the K-12 curriculum plays a crucial role in increasing students' interest in STEM subjects, and this increased interest also would promote their motivation to choose STEM careers (Sanders, 2009). For example, Karakaya and his colleagues (2020) concluded that STEM activities in which middle-school students engaged were effective in students' career choices.

STEM education includes social, economic, and environmental problems from real-life (Acar et al., 2018). Trying to find solutions to these authentic problems engages students to think critically and creatively, work with peers, justify their own ideas, and judge peers' ideas (Bender, 2017; Karakaya et al., 2020; Morrison, 2006). Integrated STEM education requires (i) the integration of content from different STEM disciplines, (ii) problem-centered learning that refers to using real-world problems, (iii) inquiry-based learning that encourages students to question, discuss, interpret, and explore ideas, (iv) design-based education that emphasizes the use of engineering or technological design, and (v) collaborative learning that allow students to work with peers in small groups (Herdem & Ünal, 2018; Thibaut et al., 2018a). The principles of STEM education, as mentioned above, align with problem-solving, critical thinking, creativity, innovation, communication, and collaboration that are the competencies for the 21st century.

STEM education has benefits for students, such as increasing academic achievement in science and mathematics (Acar et al., 2018; Austin, Hirstein, & Walen, 1997; Becker & Park, 2011; Breiner et al., 2012; Herdem & Ünal, 2018; Hurley, 2001; Wade-Shepherd, 2016), improving attitudes, motivation, and interest toward STEM disciplines (Gutherie, Wigfield, & VonSecker, 2000; Herdem & Ünal, 2018; Karakaya et al., 2020; Lee et al., 2019; Tseng et al., 2013), promoting conceptual understanding (Margot & Kettler, 2019), and improving higher-order thinking skills and technological literacy (Aldahmash et al., 2019; Herdem & Ünal, 2018; Morrison, 2006;

Stohlman, Moore, Roehrig, 2012). STEM education points to using project and inquiry-based teaching rather than traditional teaching (Breiner et al., 2012). Integrating STEM subjects may allow low-achieving students to close the gap between them and high-achieving students by motivating them to learn STEM subjects' content (Becker & Park, 2011). STEM activities require using the tools and materials that low-achieving students may not have previously used and experienced. Such an engagement can create a rich learning environment that improves low-achieving students' conceptual understanding (Cantrell, Pekcan, Itani, & Valesquez-Bryant, 2006) and let them to close the gap.

STEM Education in Turkey

Most countries have made many endeavors to develop STEM education and help their students meet the technological and engineering demands in the 21st century. Therefore, STEM education has grown to be a new and promising trend (Tseng et al., 2013). Many countries intended and enacted educational reforms to focus on STEM and STEM teaching (Moomaw, 2013). Turkey is one of the countries that need curriculum reforms in STEM disciplines for its economic competitiveness (Corlu, Capraro, & Capraro, 2014). Turkey still needs individuals to be employed in STEM fields. A report by the Turkish Industry and Business Association (TUSIAD) stated that 31% of the number of individuals needed in STEM fields has not yet been met (TUSIAD, 2017). Curriculum reforms in Turkey in 2018 focused on preparing students with 21st-century skills such as communication, mathematical literacy, scientific literacy, technological literacy, problem-solving, and entrepreneurship (MoNe, 2018a). Engineering applications within the context of interdisciplinary teaching constituted the philosophical core in the updated curriculum by the Ministry of National Education (MoNE, 2018a; b) and in Turkey's Education Vision 2023. Only the science curriculum explicitly focuses on the STEM disciplines' skills, such as analytical thinking, creativity, communication, collaboration, and engineering-design skills. It may be implied that only science teachers should integrate STEM disciplines in their teaching, but it is essential to note that mathematics and science teachers should collaborate to integrate STEM disciplines (Corlu et al., 2014).

The goals related to STEM education are still not included in formal education in higher education, especially in teacher training programs. Teachers begin their profession without the integrated teaching knowledge required to provide an active STEM education (Çorlu, 2014). Therefore, more research is needed to understand better how to promote STEM education in Turkey's higher education. Examining teachers' attitudes toward STEM would shed light on the possibility of reaching the objectives of educational reforms (Chia & Maat, 2018). This study aims to investigate pre-service teachers' attitudes toward STEM in terms of multiple variables. The following sections are related to the teacher role in STEM education and teachers' attitudes toward STEM.

Teachers' Attitudes in STEM Education

Learning environments that attempt to integrate STEM subjects into teaching are mainly learner-centered and require students' active participation in the activities based on real-world problems (Acar et al., 2018). STEM learning activities support students to engage in design activities actively, learn from failure, and participate in re-design and finally learn the content through student-centered pedagogy (Moore, Guzey, & Brown, 2014; Moore & Smith, 2014). Besides, student-centered STEM learning environments align with the constructivist approach that encourages students to think critically, explore and construct knowledge, and collaborate with peers (Marlowe & Page, 1998). Therefore, it is possible to say that students in such a learning environment are more likely to construct knowledge instead of receiving it from a teacher or a textbook. Teachers' characteristics, perceptions, and attitudes related to STEM influence teachers' implementation of integrative STEM approaches and, as a result, shape the learning environment. Teachers are significant components of the learning environment as they can promote their students' interests and attitudes towards STEM and guide them to continue with STEM disciplines and choose a STEM career (Regan & DeWitt, 2015; Tseng et al., 2013). Therefore, teachers are at a crucial point in sustaining effective STEM education.

Promoting STEM education is a desirable goal for almost all societies. Many countries have just paid attention to STEM, and many issues need to be overcome. Teachers' unawareness and lack of information about STEM education's effect on students may be a challenge to achieve STEM education goals (Becker & Park, 2011). Teachers should have the essential knowledge, skills, and dispositions to effectively integrate different STEM disciplines in their teaching to prepare the equipped students in this digital era (Yıldız, Alkan, & Cengel, 2019). Teachers should be more open to adapting integrative approaches in STEM (Zubrowski, 2002) and collaborating with other teachers (Al-Salami, Makela, & de Miranda, 2017). Teachers are also expected to relate their content knowledge to other STEM disciplines for effective STEM education (Lin & Williams, 2016). Furthermore, Teacher attitudes have a significant impact on their behavioral intention (Lin & Williams, 2016), instructional practices (Bandura, 1986; Thibaut et al., 2018a), and decision making (Pajares, 1992).

Teacher attitudes play a significant role in implementing new instructional practices such as STEM (Al Salami et al., 2017; Chia & Maat, 2018; Knipprath et al., 2018; Thibaut et al., 2018a; Wahono & Chang, 2019). Teachers may be the ones who either help or hinder their students' mastery experiences related to STEM education (Margot & Kettler, 2019). Teachers' role in their students' interest and achievement in STEM education can be revealed by examining teachers’ attitudes towards STEM. Attitudes toward STEM may be defined as "a disposition to respond favorable or unfavorable to STEM" based on the definition of Ajzen (1988, p.4).

Attitudes towards STEM are also related to the beliefs about the relevance of science, technology, engineering, and mathematics to daily life (Thibaut, Knipprath, Dehaene, & Depaepe, 2018b). Attitudes are closely associated with individuals' career choices and commitment to a career (Tseng et al., 2013). Teachers attitudes towards STEM play a crucial role in teachers' success in integrating the disciplines of STEM in their teaching practices (Aldahmash et al., 2019; Knipprath et al., 2018; Uğraş & Genç, 2018) and relate to their professional attitudes toward teaching STEM (Thibaut et al., 2018b).

Attitudes include emotion, cognition, and intention (Myers, 1993). Teachers with positive attitudes towards STEM have positive feelings, a high level of cognition, and permanence in teaching integrated STEM curriculum. They enjoy STEM disciplines, tend to engage with STEM activities, believe that STEM education is valuable, and feel efficacious in STEM disciplines. Teachers who perceive themselves as having enough knowledge about STEM and feel comfortable with STEM are more likely to have a higher level of self-efficacy in STEM teaching (Margot & Kettler, 2019). They believe that they can effectively teach STEM subjects, and their teaching would positively affect students' STEM learning (Bandura, 1986).

Self-confidence in STEM is necessary for successful implementations of STEM education. Teachers with negative attitudes towards STEM would avoid teaching integrated STEM (Appleton, 2003). Attitudes towards STEM enables us to see what teachers are thinking and feeling about STEM applications (Wahono & Chang, 2019) and helps to identify best practices in STEM education (Chia & Maat, 2018). Therefore, understanding attitudes toward STEM and STEM fields has been investigated by some researchers (Huziak-Clark, Sondergeld, van Staaden, Knaggs, & Bullerjahn, 2015).

The Motivation of This Study

STEM education is an integrated approach in kindergarten through 12th grades (Bybee, 2010; Knipprath et al., 2018). STEM education should be started in elementary school, as it is more effective for increasing mathematics and science achievement and interest in STEM careers in elementary education (Acar et al., 2018; Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013). Early STEM exposure may lead to higher academic achievement (Becker & Park, 2011) and provide opportunities for children to increase their knowledge and skills and to improve their dispositions that they would need in their STEM-related careers (Kurup, Li, Powell, & Brown, 2019; Park, Dimitrov, Patterson, & Park, 2017).

It is also crucial to introduce children to STEM activities in their kindergarten education (Tao, 2019). This will support them in gaining essential skills in the 21st century (Uğraş & Genç, 2018) and increase the interest in the choice of careers related to STEM (Dejonckheere, Wit, Keere & Vervaet, 2016). Therefore, early childhood and primary education may be considered as essential as science, technology, and mathematics education in STEM education. Teacher preparation programs have an important place for countries to achieve the objectives they set for the future (Tekerek & Karakaya, 2018; Yenilmez & Balbağ, 2016) and are expected to train pre-service teachers with the ability to deal with STEM in their future teaching (Kurup et al., 2019).

Furthermore, pre-service teachers' attitudes toward STEM would determine the extent to which they tend to implement STEM teaching in the future (Lin & Williams, 2016). We firstly should focus on pre-service teacher education to avoid the leaks of the STEM pipeline. Describing pre-service teachers' attitudes towards STEM would reveal their behavioral intention in the future and would also help to understand who needs more support to integrate STEM education. Negative attitudes towards STEM hinder teachers from teaching STEM disciplines (Appleton, 2003). Pre-service teachers with negative attitudes may be considered as the primary group that needs more scaffolding. Attitudes towards STEM have been broad research interest in recent days because it is known that teachers' attitudes related to STEM also influence their students' attitudes towards STEM (Tseng et al., 2013). Table 1 briefs the literature that examines teacher attitudes towards STEM.

Table 1. Summary of the Studies Associated with Teacher Attitudes towards STEM

Authors	N	Participants	Aim	Instruments	Demographics
Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013	33	Elementary teachers	To examine the impact of a 3-day professional development institute on changes in attitudes, confidence, and efficacy for teaching STEM	✓ Confidence for teaching STEM. ✓ Efficacy for teaching STEM. ✓ Attitudes toward engineering	Age, gender, ethnicity, education, years of teaching, years in the present position, class level of instruction, and prior participation in STEM professional development.
Shahali, Halim, Rasul, Osman, Ikhsan, & Rahim, 2015	35	Post graduate students of STEM fields	To examine the impact of the professional development program on participants' knowledge, beliefs, attitudes, and efficacy of integrated STEM teaching	✓ Attitudes of Integrated STEM Teaching ✓ Beliefs of Integrated STEM Teaching ✓ Integrated STEM Teaching Efficacy ✓ Knowledge of Integrated STEM Teaching	-
Lin & Williams, 2016	139	Pre-service science teachers	To explore the impact of knowledge, values, subjective norms, perceived behavioral controls, and attitudes on the behavioral intention toward STEM education	✓ Knowledge ✓ Values ✓ Attitude ✓ Subjective norms ✓ Perceived behavioral control ✓ Behavioral intention	Gender Majors (physics, chemistry, life sciences, earth sciences, non-science disciplines)
Yenilmez & Balbağ, 2016	128	Pre-service science and mathematics teachers (freshmen)	To investigate the STEM attitudes of prospective science and middle school mathematics teachers	✓ STEM attitude scale	Gender, department

Al Salami et al., 2017	29	Middle school and high school teachers	To examine the change in attitudes to interdisciplinary teaching of teachers who participated a PD workshop and in delivering a 12–15-week interdisciplinary teaching and design problem unit that spanned multiple STEM subjects	✓ Attitudes towards interdisciplinary teaching ✓ Attitude toward teamwork ✓ Teaching satisfaction ✓ Resistance to change	School level, gender, education level, discipline taught
Chia & Maat, 2018	55	Secondary teachers (STEM related subjects and non-STEM subjects)	To identify the level of attitudes towards the integration of STEM among secondary school teachers in Malaysia	✓ A-STEM survey	Gender, level of education, years of teaching experience and subject teaching in school
Kan & Murat, 2018	193	Pre-service science teachers	Examine the relationship between pre-service science teachers' 21st century skills and attitudes towards STEM	✓ 21st Century Skills Competencies Perception Scale for Teacher Candidates ✓ STEM Attitude Scale	Gender
Thibaut et al., 2018a	244	STEM teachers	To examine the influence of teachers' attitudes and school context on reported instructional practices in integrated STEM	✓ Attitudes toward teaching integrated STEM ✓ Instructional practices ✓ School context	
Thibaut et al., 2018b	135	Secondary teachers in the fields of mathematics, engineering, science and technology	To investigate the relationship between secondary school teachers' professional attitudes towards teaching integrated STEM and teacher background	✓ Personal background characteristics ✓ Personal attitudes towards STEM ✓ School context ✓ Professional attitudes towards	

			characteristics, personal attitudes and school context variables	teaching integrated STEM	
Aldahmash et al., 2019	48	Science and mathematics teachers'	To examine teachers' attitudes towards integrating STEM before and after a professional development program	✓ Instrument for Teachers' Attitudes Toward Teaching Integrated STEM.	
Lee et al., 2019	220	High school teachers who teach science, mathematics, or technology	To examine teachers' perceived self-efficacy in STEM knowledge and attitudes towards STEM education	✓ Scientific Inquiry Knowledge ✓ Technology Use Knowledge ✓ Engineering Design knowledge ✓ Mathematical Thinking Knowledge ✓ Synthesized Knowledge of STEM ✓ Attitudes towards STEM education	Gender Teaching subject
Tao, 2019	430	Kindergarten teachers	To examine teachers' attitudes toward and confidence with implementing integrated STEM education in early childhood classroom settings	✓ Attitudes toward STEM Education ✓ Confidence with Implementing STEM Education	Gender Years of Teaching Level of Education Type of Kindergarten Region
Wahono & Chang, 2019	197	Secondary school science teachers	To develop a valid instrument to measure attitude, knowledge, and application of STEM (AKA) by science teachers	✓ Survey of Science Teachers' Attitude, Knowledge, and Application (AKA) of STEM.	

Table 1 demonstrates that most of the studies examined teacher attitudes towards STEM. These studies mostly measured teachers' attitudes towards STEM education or teaching STEM. It may be challenging to measure pre-service teachers' attitudes towards STEM teaching because of their lack of teaching experience. However, examining pre-service teachers' attitudes towards STEM may give an insight into their attitudes towards teaching STEM subjects (Thibaut et al., 2018b). Pajares (1992) highlighted that pre-service teachers make their decisions about teaching in their preparation programs. It may be difficult to change attitudes and beliefs after graduation. Teacher preparation programs should consider preparing pre-service teachers with positive attitudes (Woodcock, 2011). The limited research examining pre-service teachers' STEM attitudes is an essential motivation for this study. Besides, studies conducted with pre-service teachers included pre-service science and/or mathematics teachers and examined the attitudes in terms of gender and department. Little is known about the differences in pre-service teachers' attitudes towards STEM. Identifying the variables that lead to differences in attitudes would help teacher educators to arrange teacher preparation programs to prepare pre-service teachers with positive attitudes towards STEM (Rimm-Kaufman & Sawyer, 2004). This study is different from the existing studies as pre-service teachers from various departments participated in the study. Pre-service preschool, classroom, science, and mathematics teachers that may be considered the STEM pipeline's scaffolders participated in the study. This study's findings would allow comparing departments and giving valuable suggestions for future STEM education. This study aims to investigate the STEM attitudes of pre-service teachers who enroll in preschool, primary, science, and mathematics education in terms of multiple variables. The following research questions were addressed to achieve the purposes:

- What are the pre-service teachers' attitudes towards STEM?
- Do pre-service teachers' attitudes towards STEM differ by
    - Gender?
    - Class level?
    - The department?
    - Whether they have a traineeship such as a course/education related to STEM education?
    - The level of information related to STEM education?
- Is there a relationship between pre-service teachers' attitudes towards STEM and their grade point averages?

Method

This study aims to describe pre-service teachers' attitudes in terms of different variables and to reveal the relationships between pre-service teachers' attitudes and GPAs and other variables (gender, department, class level, having a traineeship about STEM, level of information about STEM). Therefore, the correlational survey design that aims to determine the relationships between two or more variables without manipulating them was utilized in this study (Creswell, 2012; Creswell & Plano Clark, 2015; Fraenkel, Wallen, Hyun, 2011). Correlational research design helps explain human behavior or predicting likely outcomes (Fraenkel et al., 2011) and determines the extent to which two or more factors are related. The results of this study would help to determine the extent to which changes in demographics and GPA are reflected in changes in STEM attitudes (Cresswell, 2012).

Participants

To be recruited as a teacher in Turkey, pre-service teachers enroll in a 4-year faculty of education and get a national exam after graduation. The study sample is pre-service teachers who study in a Faculty of Education in the middle of Anatolia in the 2018-2019 academic year. It is possible to assume that the results of the accessible population can be generalized to the population because of the same curriculum in the faculties and the similar exam-based requirements to enter the faculty. Five hundred thirteen pre-service teachers from different departments (Science Education, Mathematics Education, Classroom Teaching, and Preschool Education) were selected randomly and participated in the data collection. The departments in which participants were enrolled were chosen because they are supposed to have knowledge and experience about STEM. Due to this context, the accessible population was divided into two layers (department and class level), and pre-service teachers representing the population were selected from these layers.

Table 2 demonstrates that most of the participants (80.3%) are female. A little (19.7%) had a traineeship about STEM and a little more than half (51.7%) had no information about STEM.

Table 2. Demographics of Participants

Independent Variables	Category	f	%
Gender	Female	412	80.3
	Male	101	19.7
Department	Science Education	86	16.8
	Mathematics Education	149	29.0
	Classroom Education	128	25.0
	Preschool Education	150	29.2
Class Level	1st Grade	89	17.3
	2nd Grade	146	28.5
	3rd Grade	122	23.8
	4th Grade	156	30.4
Traineeship about STEM	Yes	101	19.7
	No	412	80.3
Having information about STEM	Yes	78	15.2
	Partly	170	33.1
	No	265	51.7

Five hundred fifty data collection tools were administered, and 513 of them appropriate for the data input were included in the data analysis. The return rate that should be in the range of 70%-80% to make valid interpretations, was calculated as 93.2% (Creswell, 2012). Before determining the sample of the study, the sample size and Power (Power) analysis were computed using G Power statistical software (Faul, Erdfelder, Lang, & Buchner, 2007). In this context, The Attitude towards STEM Scale has been evaluated as primary outcome parameters, and the sample size was calculated as 510 for the effect size (0.4), Alpha (0.05), and Power

(0.95) values obtained in previous studies (Al-Salami et al., 2017; Chia & Maat, 2018; Kan & Murat, 2018; Lee et al., 2019; Özcan & Koca, 2019; Yenilmez & Balbağ, 2016). Five hundred thirteen PSTs are enough to generalize the findings of this study to the accessible population of the study.

Besides, for the allocation ratio (N2 / N1 = 4) for two independent group t-tests, the sample size was calculated as 102 for the first group and 408 for the second group. Within the scope of the study, the number of samples in terms of gender is 412 for female and 101 for male. Considering these results, the sample size of the study shows that enough pre-service teachers were reached in accordance with the G power analysis.

Data Collection Tools

Three different measurement tools were used within the scope of this research.

Personal Information Questionnaire

Researchers developed this questionnaire to determine the participants' demographic characteristics (gender, department, class level, having a traineeship about STEM, and level of STEM knowledge). The literature was reviewed, and independent variables that were thought to influence STEM attitudes were determined (Al Salami et al., 2017; Chia & Maat, 2018; Knipprath et al., 2018; Lee et al., 2019; Wahono & Chang, 2019). Then, the measurement tool was transformed into a classification question format.

The Attitude towards STEM Scale

The Attitude towards STEM Scale was developed originally by The Friday Institute for The Educational Innovation (2012) to identify students' attitudes towards STEM. The validity and reliability of the scale and its adaptation into Turkish were carried out by Özcan and Koca (2019). The reason for using this instrument is that this instrument measures the attitudes towards STEM disciplines. It may be more appropriate to measure pre-service teachers’ attitudes toward STEM disciplines than attitudes towards teaching STEM. Besides, it is known that personal attitudes towards STEM are related to professional attitudes towards teaching STEM subjects (Thibaut et al., 2018b). This study's findings would reveal the pre-service teachers’ attitudes towards STEM and STEM disciplines and give an insight into their attitudes towards teaching STEM subjects.

The scale has four factors and 37 items in the Turkish version. The first factor is related to the attitudes towards mathematics (8 items, Cronbach's α=.86), the second is related to the attitudes towards science (9 items, Cronbach's α =.87), the third is Engineering-Technology (9 items, Cronbach's α=.86), and the last factor is related to the 21st-century skills (11 items, Cronbach's α=.88). 21st-century skills are essential learning and career skills needed for a workforce and citizenship in the information-rich century. They include critical thinking, complex communication skills, problem-solving, and self-management skills (Unfired, Faber, Stanhope, & Wiebe, 2015, p.624). Therefore, researchers consider 21st-century skills an essential new variable to understand students’ interest in STEM-related careers. It is also worthy to note that this subscale includes self-efficacy measurements related to these skills (Unfried et al., 2015). The total score from the instrument shows the attitudes towards STEM. The sample items for each subscale are given as follows.

Sample items for "Mathematics" Subscale:

I am sure I could do advanced work in math.

I can get good grades in math.

Sample items for "Science" Subscale:

I am sure of myself when I do science.

I would consider a career in science.

Sample items for "Engineering-Technology" Subscale:

I like to imagine creating new products.

If I learn engineering, then I can improve things that people use every day.

Sample items for "21st Century Skills" Subscale:

I am confident I can produce high quality work.

I am confident I can help my peers.

Özcan and Koca (2019) performed the Confirmatory Factor Analysis and confirmed that the adapted scale has four factors as is in the original form. Two expert teacher educators were asked to evaluate if items are appropriate to measure pre-service teachers' attitudes towards STEM subjects. Besides, ten pre-service teachers were asked to read and answer the items aloud (think aloud) to see whether items are understandable for pre-service teachers.

General Academic Grade Point Averages

End-of-year academic grade point averages (GPAs) were used to determine the academic achievement of PSTs. The academic grade point averages of PSTs were obtained by taking legal permissions from the Faculty of Education, where the study was conducted.

Data Analysis

Descriptive and relational analyses were used. The mean scores and standard deviation of participants' attitudes towards STEM were calculated to analyze data descriptively. We first investigated whether data has a normal distribution before examining STEM attitudes in terms of independent variables. Mean scores, mod, and median values of pre-service teachers' responses to items are close (see Table 3). Furthermore, the value of the skewness is -.221, and the kurtosis is .262. Tabachnick and Fidell (2013) suggested that skewness and kurtosis should be in the range of +1.5 and -1.5, while George and Mallery (2010) proposed that the range should be +2.0 and -2.0. Mean, mod, and median should be equal as the normal distribution is also symmetric (Kalaycı, 2010). The closeness of the mean, mod, and the median seen in Table 2 may show that the measures approximated a normal distribution. In other words, parametric tests can be used to analyze data obtained in this study.

Table 3. Normal Distribution Statistics

	Attitudes towards STEM
Mean	3.56
Median	3.59
Mod	3.70
Skewness	-.221
Kurtosis	-.262

To determine the STEM attitude levels of PSTs, a one-sample t-test was conducted to determine the difference between the average of PSTs' scores on the scale and the expected average. To calculate the expected average, one is added to the Likert point and divided by two. Then this value is multiplicated by the number of items. For example, The Attitude towards STEM Scale is a five-point Likert type and consists of 37 items (([5+1]/2)*37); the expected average is calculated as 111. We performed an independent t-test to examine attitudes in terms of variables with two categories (gender, department, class level, having a traineeship about STEM, level of information about STEM) and ANOVA to examine attitudes in terms of variables with three or more than three categories (class level, program, etc.). A Scheffe test was performed to determine the source of significance. Cohen's d was calculated for the effect size of the significant differences found in t-tests and eta-square for the effect size of the significant differences found in one-way variance analysis. Pearson product-moment correlation coefficient was also computed to reveal the relationship between participants' attitudes towards STEM and GPAs.

Results

Pre-service teachers' STEM attitudes

The first research question deals with the pre-service teachers' STEM attitudes regardless of department, class level, and gender. Table 4 reports the findings of whether the scores of PSTs differ significantly from the expected average.

Table 4. One-Sample t-Test that Shows the Differences between PSTs Means and Expected Means

Subscales	N	Mean	SD	Expected Mean	Mean Difference	t	p
Overall Scale- Attitudes towards STEM	513	132.05	16.431	111	21.05	29.027	.000
Sub-scale 1. Mathematics	513	25.33	7.094	24	1.33	4.257	.000
Sub-scale 2. Science	513	29.81	6.539	27	2.81	9.74	.000
Sub-scale 3. Engineering-Technology	513	32.36	5.928	27	5.36647	20.501	.000
Sub-scale 4. 21st century skills	513	44.54	5.960	33	11.54	43.87	.000

According to Table 4, there is a significant difference between the STEM attitude scores of the PSTs and the expected average in the overall scale (t513=29.027; p<.00). This result shows that means of PSTs' attitudes towards STEM are over the expected mean. In other words, participants have more positive attitudes than expected. When the sub-scales are examined, it is determined that the highest level of significant difference occurred in 21st-century skills (t513=43.87; p<.00) and engineering-technology (t513=20.501; p<.00). PSTs had the highest scores in the 21st -century skills-subscale ($\bar{\chi}$=44.54), and the lowest in the mathematics ($\bar{\chi}$=25.33) and science ($\bar{\chi}$=29.81) subscales. Participants had lower attitudes towards science and mathematics while having higher attitudes towards engineering-technology and 21st -century skills.

One of this study's focuses is to reveal the factors that lead to a significant difference in participants' attitudes towards STEM. Table 5 demonstrates the comparisons of pre-service teachers' attitudes based on their departments.

Table 5. The ANOVA Results Based on Participants' Departments

	Department	SS	df	MS	F	p	Source of the difference	η^2
Overall scale-Attitudes towards STEM	[1]Science (M=3.70)	2.316	3	.772	3.983	.008	1>2.4	0.022
	[2]Mathematics (M=3.55)	98.664	509	.194				
	[3]Classroom teacher (M=3.58)	100.980	512					
	[4]Preschool (M=3.49)							
Subscale 1 Attitudes towards Mathematics	[1]Science (M=2.93)	84.804	3	28.268	45.268	.000	3>1.4 2>1.4	0.211
	[2]Mathematics (M=3.26)	317.852	509	.624				
	[3]Classroom Teacher (M=3. 75)	402.656	512					
	[4]Preschool (M=2.69)							
Subscale 2 Attitudes towards Science	[1]Science (M=3.87)	36.053	3	12.018	26.108	.000	1>2.3.4	0.133
	[2]Mathematics (M=3.24)	234.293	509	.460				
	[3]Classroom Teacher (M=3.07)	270.346	512					
	[4]Preschool (M=3.26)							
Subscale 3 Attitudes towards Engineering-Technology	[1]Science (M=3.82)	7.539	3	2.513	5.959	.001	1>2.3	0.033
	[2]Mathematics (M=3.52)	214.647	509	.422				
	[3]Classroom Teacher (M=3.47)	222.186	512					
	[4]Preschool (M=3.64)							
Subscale 4 21st Century Skills	[1]Science (M=4.00)	2.740	3	.913	3.150	.025	4>3	0.018
	[2]Mathematics (M=4.03)	147.600	509	.290				
	[3]Classroom Teacher (M=3.97)	150.340	512					
	[4]Preschool (M=4.15)							

Respondents' scores on the overall scale and subscales significantly differed based on the departments in which pre-service teachers enroll. However, significant differences have small effect sizes. Pre-service science teachers' mean scores of attitudes towards STEM are significantly higher than pre-service mathematics and pre-school teachers' attitudes.

Based on the results in the subscales, it is seen that pre-service mathematics and classroom teachers have more positive attitudes towards mathematics. Pre-service science teachers' attitudes towards science and engineering-technology are more positive than pre-service mathematics and classroom teachers. Lastly, pre-service preschool teachers had scored more in the 21st-century subscale than pre-service classroom teachers. These findings could mean that pre-service teachers other than pre-service science teachers need to develop more positive STEM attitudes.

Gender is another variable of interest in this study. Table 6 reveals the differences in attitudes in terms of gender.

Table 6. The t-Test Results Based on Gender

	Gender	N	M	Sd	t	p	Cohen's d
Overall scale- Attitudes towards STEM	Female	412	3.56	.442	-.156	.876	-
	Male	101	3.57	.451			
Subscale 1 Attitudes towards Mathematics	Female	412	3.15	.889	-.474	.635	-
	Male	101	3.20	.878			
Subscale 2 Attitudes towards Science	Female	412	3.33	.720	1.242	.215	-
	Male	101	3.23	.750			
Subscale 3 Attitudes towards Engineering-Technology	Female	412	3.54	.658	-3.328	.001	0.375
	Male	101	3.78	.627			
Subscale 4 21st Century Skills	Female	412	4.07	.527	2.058	.040	0.221
	Male	101	3.95	.588			

The difference based on gender in pre-service teachers' mean scores on the overall scale is not statistically significant (t=-.156;p<.05). In other words, participants' STEM attitudes did not differ based on gender. This finding is promising, given the under-representation of women in STEM. However, there are significant differences in the attitudes towards engineering-technology and in the 21st-century skills subscales. Male pre-service teachers had more positive attitudes towards engineering-technology than females (t=-3.328;p<.05). Female pre-service teachers scored themselves more in the 21st-century skills than males t=2.058;p<.05). Significant differences have small effect sizes. Engineering design is an essential characteristic of STEM education. Even though male and female pre-service teachers' attitudes towards STEM did not significantly differ, female pre-service teachers may need scaffolding, especially in engineering-design, to feel more confident in teaching STEM subjects.

Table 6 indicates the ANOVA results based on the respondents' class levels.

Table 7. The ANOVA Results Based on Participants' Class Levels

	Class Level	SS	df	MS	F	p	The source of difference	η^2
The overall scale Attitudes towards STEM	1st class (M=3.50)	2.715	3	.905	4.687	.003	3>2 4>1.2	0.026
	2nd class (M=3.48)	98.266	509	.193				
	3rd class (M=3.59)	100.980	512					
	4th class (M=3.66)							
Subscale 1 Attitudes towards Mathematics	1st class (M=3.30)	5.580	3	1.860	2.384	.068	1>2 4>2	0.013
	2nd class (M=3.05)	397.076	509	.780				
	3rd class (M=3.08)	402.656	512					
	4th class (M=3.25)							
Subscale 2 Attitudes towards Science	1st class (M=3.10)	11.269	3	3.756	7.380	.000	3>1.2 4>1.2	0.041
	2nd class (M=3.19)	259.078	509	.509				
	3rd class (M=3.37)	270.346	512					
	4th class (M=3.49)							
Subscale 3 Attitudes towards Engineering-Technology	1st class (M=3.49)	6.935	3	2.312	5.466	.001	4>1.2	0.031
	2nd class (M=3.47)	215.252	509	.423				
	3rd class (M=3.61)	222.186	512					
	4th class (M=3.75)							
Subscale 4 21st Century Skills	1st class (M=4.00)	1.224	3	.408	1.393	.244	-	-
	2nd class (M=4.04)	149.116	509	.293				
	3rd class (M=4.13)	150.340	512					
	4th class (M=4.01)							

Senior pre-service teachers rated themselves as having the most positive attitudes towards STEM, and sophomore pre-service rated as having the least positive attitudes towards STEM. ANOVA results revealed significant differences in mean scores ($F = 4.687$; $p < .05$) and showed that junior pre-service teachers have more positive attitudes towards STEM than sophomores, and seniors have more positive attitudes than first-year students and sophomores. The difference has a small effect size ($\eta^2 = 0.026$). These results show that the classroom levels of the pre-service teachers are a factor on their STEM attitudes. Pre-service teachers may develop more positive attitudes towards STEM as they proceed in their teacher preparation programs.

The class level also led to significant differences in the subscales related to mathematics, science, and engineering-technology. Senior pre-service teachers seem to have the most positive attitudes towards mathematics, science, and engineering-technology. The results in Table 7 may mean that progressing through the teacher preparation programs promoted pre-service teachers' attitudes towards STEM and STEM subjects.

Pre-service teachers were asked whether they had a traineeship about STEM. Traineeship referred to a course, a professional development program, or a workshop. Table 8 reports the t-test results of whether traineeship leads to a significant difference in STEM attitudes.

Table 8. The t-Test Results Based on the Participants' Traineeship about STEM

	Having a traineeship about STEM	N	M	Sd	t	p	Cohen's d
The overall scale	Yes	101	3.66	.381			
Attitudes towards STEM	No	412	3.54	.455	2.466	.014	0.288
Subscale 1	Yes	101	3.34	.792			
Attitudes towards Mathematics	No	412	3.12	.903	2.300	.022	0.265
Subscale 2	Yes	101	3.42	.620			
Attitudes towards Science	No	412	3.28	.748	1.665	.097	-
Subscale 3	Yes	101	3.73	.539			
Attitudes towards Engineering-Technology	No	412	3.56	.681	2.332	.020	0.277
Subscale 4	Yes	101	4.04	.491			
21st Century Skills	No	412	4.05	.554	-.095	.924	-

Pre-service teachers who had a traineeship about STEM had higher scores than those who had not. The mean difference is found to be statistically significant ($t=2.466; p<.05$). The effect size of the significant difference is small ($d=0.288$). Having a traineeship about STEM also led to significant differences in pre-service teachers' attitudes towards mathematics ($t=2.300; p<.05$) and engineering-technology ($t=2.332; p<.05$) with small effect sizes. The effect of traineeship about STEM on attitudes towards STEM may be explained by that traineeship also led to a significant difference in engineering-technology which is an essential component of STEM education.

The level of information that participants have about STEM is asked in the personal information questionnaire. participants were asked to choose one of the options titled "I Know STEM," "I partially know STEM," or "I do not know STEM" to determine the level of their STEM knowledge. We investigated whether the level of information about STEM differed pre-service teachers' STEM attitudes. Table 9 demonstrates the ANOVA results based on the participants' information level about STEM.

Table 9. The ANOVA Results Based on the Participants' Information Level about STEM

	Level of information about STEM	SS	df	MS	F	p	The source of the difference	η^2
The overall scale Attitudes towards STEM	[1]Yes (M=3.71)	2.426	2	1.213	6.277	.002	1>3	0.024
	[2]Partially (M=3.58)	98.555	510	.193				
	[3]No (M=3.51)	100.980	512					
Subscale 1 Attitudes towards Mathematics	[1]Yes (M=3.34)	2.973	2	1.487	1.897	.151	-	-
	[2]Partially (M=3.14)	399.683	510	.784				
	[3]No (M=3.13)	402.656	512					
Subscale 2 Attitudes towards Science	[1]Yes (M=3.56)	7.739	2	3.869	7.515	.001	1>3	0.029
	[2]Partially (M=3.35)	262.607	510	.515				
	[3]No (M=3.21)	270.346	512					
Subscale 3 Attitudes towards Engineering-Technology	[1]Yes (M=3.78)	6.236	2	3.118	7.364	.001	1>3 2>3	0.028
	[2]Partially (M=3.66)	215.950	510	.423				
	[3]No (M=3.49)	222.186	512					
Subscale 4 21st Century Skills	[1]Yes (M=4.03)	.024	2	.012	.042	.959	-	-
	[2]Partially (M=4.04)	150.316	510	.295				
	[3]No (M=4.05)	150.340	512					

Pre-service teachers who had information about STEM had higher scores than those who had no information or partially knew about STEM in the overall scale and subscales. ANOVA results demonstrate that having knowledge about STEM affected pre-service teachers' attitudes towards STEM ($F=6.277; p<.05$), science ($F=7.515; p<.05$), and engineering-technology ($F=7.364; p<.05$). It is important to note that the differences have small effect sizes. It is seen that pre-service teachers who have information about STEM have more positive attitudes towards STEM, science, and engineering-technology than those who have no information about STEM. This finding is consistent with the findings that showed that progressing through teacher education programs or having a traineeship about STEM led to significant differences in STEM attitudes.

The Relationship between Pre-Service Teachers' Attitudes and General Academic Grade Point Averages

This study dealt with the relationships between pre-service teachers' attitudes and general academic grade point averages. Table 10 indicates the Pearson coefficients that reveal the relationships among pre-service teachers' GPAs, attitudes towards STEM, mathematics, science, engineering-technology, and 21st-century skills.

Table 10. The Correlations among Participants' Attitudes and Grade Point Averages

		Attitudes towards STEM	Attitudes towards Mathematics	Attitudes towards Science	Attitudes towards Engineering-Technology	21st century Skills
General Academic Grade Point Averages	r	.004	-.058	.044	-.058	.090
	p	.922	.186	.315	.190	.040
	N	513	513	513	513	513
Attitudes towards STEM	r	1	.548	.679	.734	.630
	p		.000	.000	.000	.000
	N	513	513	513	513	513

Table 10 points out a weak positive relationship (r=.004) between pre-service teachers' attitudes towards STEM and their GPAs. However, the relationship is not statistically significant. This finding shows no correlation between PSTs' STEM attitudes and the cognitive grades taken by PSTs within the scope of outcome evaluation. Participants' GPAs are significantly correlated with only their attitudes towards 21st-century skills.

The subscales of the STEM attitudes scale are found to have significant and strong relationships with the overall scale. The strongest relationship occurred between the attitudes towards STEM and attitudes towards engineering-technology (r=.734). The determination coefficient (r^2) was calculated as 0.539. The attitudes towards engineering-technology explain approximately 53.9% of the variance in the attitudes towards STEM. In other words, the attitudes towards engineering-technology play a significant role in predicting pre-service teachers' attitudes towards STEM.

Conclusion and Discussion

This study aimed to investigate pre-service teachers' STEM attitudes in terms of multiple variables and reveal the relationship between STEM attitudes and GPAs. The research was designed as a correlation survey. Five hundred thirteen pre-service teachers participated in the study. The research questions were interested in the pre-service teachers' STEM attitudes and the differences in STEM attitudes in terms of gender, department, class level, having a traineeship about STEM, and the level of STEM knowledge. The last research question focused on the relationship between pre-service teachers' STEM attitudes and their GPAs. The results are discussed in the two following sections that also correspond to research questions.

Pre-Service Teachers' STEM Attitudes

Results show that pre-service teachers have positive attitudes toward STEM consistently with the findings of Herdem and Ünal (2018). The Attitude towards STEM Scale has four subscales: mathematics, science, engineering technology, and 21st-century skills. Participants' scores in the attitudes towards engineering-technology and 21st-century skills are higher, while scores in mathematics and science attitudes are lower than in other subscales. Higher mean scores in engineering-technology and 21st-century skills are promising.

However, the lower mean scores in the science and mathematics attitudes may need to be considered, although all participants get basic mathematics and science lessons. The department at which participants study seems to lead to significant differences in the overall scale and subscales. Pre-service science teachers have more positive attitudes toward STEM, science, and engineering-technology than other pre-service teachers. Similar to this result, there are studies in the literature showing a significant difference in favor of pre-service science teachers (Lee et al., 2019; Yenilmez & Balbağ, 2016; Yıldız et al., 2019). Furthermore, pre-service classroom teachers' attitudes toward mathematics and pre-service preschool teachers' attitudes toward 21st-century skills are more positive than other pre-service teachers.

Early years of schooling are crucial for students' views about STEM and support them in choosing STEM careers (Park, Dimitrov, Patterson, & Park, 2017; Regan & DeWitt, 2015). Acar and her colleagues (2018) found that STEM activities improved fourth-grade students' science and mathematics achievement and made them interested in STEM careers. Moreover, STEM studies that integrate mathematics are limited (Becker & Park, 2011). These results emphasize that it is not enough that only science teachers should have positive attitudes towards STEM education. Instead, pre-school, classroom, and mathematics teachers who can be considered the STEM pipeline supporters should also develop positive attitudes towards STEM. It is worth noting that self-reported measures do not give accurate information about participants' actual practices; however, we can see how they feel about STEM and STEM disciplines with these measures.

Figure 1 demonstrates the participants' mean scores on the overall scale and subscales and may help us envisage the STEM pipeline's strength supported by the participants of this study. Teachers with positive attitudes are supposed to like STEM disciplines, engage with STEM activities, and consider STEM activities valuable (Ma & Kishor, 1997). Pre-service teachers' attitudes toward STEM would also affect how they teach integrated STEM (Thibaut et al., 2018b). It is seen that participants mostly feel confident about STEM. We can say that the participants' future students are expected to incline to STEM-related careers, and the leaks in this pipeline would likely decrease.

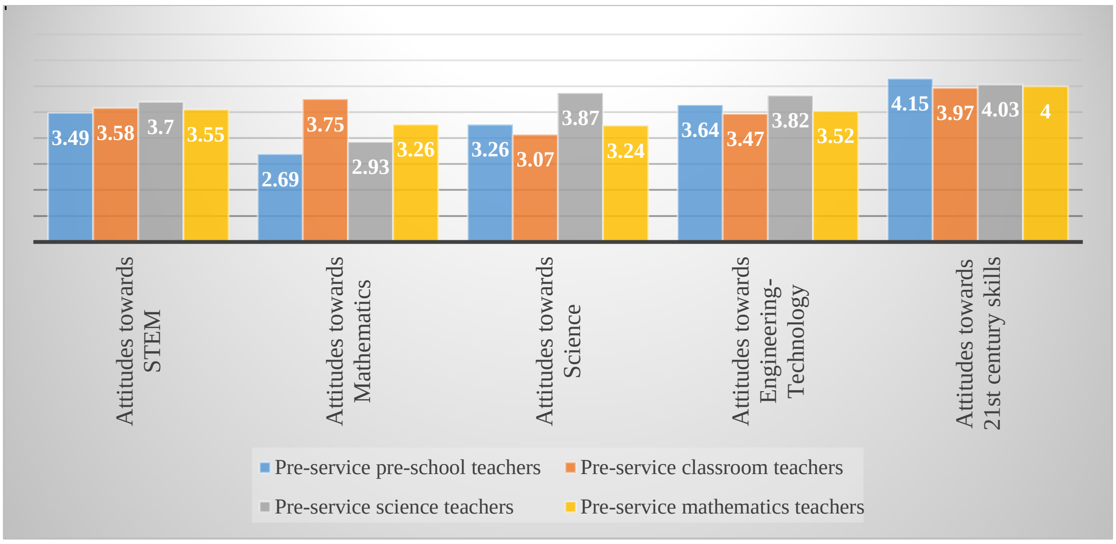

Figure 1. Pre-Service Teachers' Mean Scores in the Overall Scale and Sub-Scales

Especially STEM experience in early childhood promotes students' knowledge, skills (such as collaboration, create and discuss scientific relationships), and dispositions related to STEM (Moomaw & Davis, 2010). The increased knowledge and skills about STEM would make students feel prepared for future jobs (Aronin & Floyd, 2013; DeJarnette, 2012). It is promising to see that participants' scores on the overall scale (attitudes towards STEM) and the subscale of engineering-technology are close. However, the significant differences in these subscales were in favor of pre-service science teachers. Higher education in Turkey should consider the educational reforms that focus on integrating STEM education into teacher preparation programs.Gender did not lead to a significant difference in pre-service teachers' attitudes toward STEM. Huziak-Clark et al. (2015), Lin and Williams (2016), and Tekerek and Karakaya (2018) also concluded that gender did not lead to a significant difference in pre-service teachers' attitudes towards STEM. Another result reached within the scope of this research is the statistically significant difference in the engineering-technology subscale in favor of males and the 21st-century skills in favor of females. These results are consistent with the finding of Yenilmez and Balbağ (2016). Smith, Rayfield, and McKim (2015) reported that female teachers perceive technology as less essential than male teachers.

Margot and Kettler (2019) expressed that gender may have an impact on teachers' STEM perception. Lee et al. (2019) and Yıldız et al. (2019) found that male pre-service teachers have more positive attitudes than females. Female teachers have more negative perceptions about STEM than males (Park, Byun, Sim, Han, & Baek, 2016). Bong (1999) argued that women might underestimate their ability and efficacy because of the social norms that assert that men are more capable in those fields. Furthermore, the cultural norms that give women less time to manipulate, build, and observe STEM activities than males may lead to a low level of attitudes towards STEM in female pre-service teachers (Huziak-Clark et al., 2015). Within the context of the mentioned literature related to gender, it is possible to say that the female pre-service teachers may have underestimated their ability or confidence in engineering-technology or spent less time on engineering-technology than males. Female pre-service teachers need to be more engaged in STEM activities that also include engineering design using technology.

Pre-service teachers' attitudes towards STEM significantly differed based on class level. Especially, third and fourth-year students have a higher level of attitudes than others. This finding underpins Tekerek and Karakaya (2018). Senior pre-service teachers also have more positive attitudes towards science, mathematics, and engineering-technology than other pre-service teachers.

Most participants had no traineeship, such as a course related to STEM, and had no information about STEM. Our research findings showed that pre-service teachers who had a traineeship or information about STEM had more positive attitudes towards STEM than others who had not. STEM information that is gained through STEM courses or workshops may develop and improve their awareness. Teachers feel more comfortable to teach STEM subjects when they take more courses related to STEM (Margot & Kettler, 2019). Pre-service teachers with information about STEM had also a higher level of attitudes towards science and engineering-technology.

The description of participants' attitudes towards STEM may give an insight into the future of teachers' STEM implementations in Turkey. Science pre-service teachers had the most positive attitudes towards STEM. Besides, upper grades had more positive attitudes than lower grades. As pre-service teachers progress through teacher preparation programs, their knowledge and skills improve. We can say that improvement in knowledge, skills, and experiences may lead to an improvement in attitudes as it is also found that having information or traineeship about STEM led to significant differences in STEM attitudes. Thibaut and her colleagues (2018b) concluded that teachers' attitudes toward teaching integrated STEM are related to their participation in professional development, personal relevance of science, and social context. Similarly, professional development (having traineeship about STEM) is found to be related to pre-service teachers' attitudes towards STEM and STEM disciplines. Therefore, it is possible to say that providing scaffolding to both teachers and pre-service teachers would positively improve attitudes towards STEM and STEM teaching.

The Relationship between Pre-Service Teachers' Attitudes and GPA

Correlation analysis revealed no relationship between pre-service teachers' academic achievement from cognitive assessments based on outcome evaluation and STEM attitudes. This result shows that the academic success of PSTs during their undergraduate years does not lead to an improvement in STEM attitudes. It is difficult to say that successful pre-service teachers tend to teach STEM subjects when they become teachers. PSTs have improved their knowledge and skills related to their content area, but it may be implied that the increase in knowledge and skills could not improve STEM attitudes. Based on this result, it is possible to say that pre-service teachers' content areas are not related to STEM. This result points out the necessity of revising teacher education programs' content to focus on STEM education.

Contrary to this finding, pre-service science teachers who had higher academic achievement reported higher STEM education awareness (Tekerek & Karakaya, 2018). Furthermore, it is said that STEM education positively affects academic achievement (Herdem & Ünal, 2018). Lin and Williams (2016) asserted that knowledge-oriented examinations might hinder pre-service teachers from focusing on teaching interdisciplinary STEM. This assertation may be valid also for this study. The evaluations are mostly high-stakes tests to enter faculty and to be appointed as a teacher. Pre-service teachers may also focus on only their content areas to succeed in these tests, which may partially explain why there is no relationship between attitudes and academic achievement.

Additionally, the relationship between subscales and the overall scale was investigated. It was found that there were strong positive relationships between subscales and the overall scale, similarly to other researchers (Lee et al., 2019; Yıldız et al., 2019). Chia and Maat (2018) found high levels of attitudes towards STEM, which are also found to be positively correlated to the attitudes towards science, engineering-technology, and mathematics, respectively. They reported that teachers were aware of the relatedness and connectedness of STEM subjects. The strongest relationship occurred between the overall scale and the engineering-technology subscale in this study; attitudes towards engineering-technology explain 53,9% of the variance in STEM attitudes. We can say that attitudes towards engineering-technology play an essential role in predicting pre-service teachers' attitudes towards STEM. However, engineering-design skills are mentioned in only the science curriculum. Considering the educational system in Turkey, it is possible to say that technology and engineering are not be understood adequately (Acar et al., 2018). Therefore, teachers' endeavors to integrate engineering and technology through scientific and mathematical thinking get essential.

Recommendations

Based on the results of this study, we can make some implications and suggestions. It is worth considering that the departments in which participants of this study enroll have an essential role in strengthening the STEM pipeline. The recommendations are given in three main categories; the need to integrate STEM integration into teacher education, strategies to develop positive attitudes towards STEM, and supporting female pre-service teachers.

The need to Integrate STEM into Teacher Education

The results show that the academic achievement in undergraduate education is not related to STEM attitudes, pre-service teachers have positive attitudes toward their disciplines, and science teachers have the most positive attitudes towards STEM. Some studies found that the increase in mathematics attitude and achievement is lower than in science (Acar et al., 2018; Tseng et al., 2013). This may be because learners should not recognize the links between mathematics and other STEM subjects. Therefore, teacher education programs need to integrate interdisciplinary approaches into all departments and give courses including science, technology, engineering, and mathematics, and focus on helping pre-service teachers realize the connectedness of STEM subjects. Besides, based on the research findings, it is seen that having a traineeship about STEM or having STEM knowledge significantly differed pre-service teachers’ STEM attitudes. This result highlights the importance of providing STEM knowledge for pre-service teachers. It may be efficient to provide STEM knowledge through teacher preparation programs.

Professional Development

It is needed extended and continuous programs to improve attitudes towards STEM (Aldahmash et al., 2019). The most mentioned strategies to build STEM confidence include collaboration and real-life experiences. Small groups may be efficient to give pre-service teachers more opportunities for one-on-one attention from their peers and faculty (Huziak-Clark et al., 2015). Pre-service teachers should be assigned to schools that provide sufficient opportunities for guide and collaboration. Assignments should help pre-service teachers become aware of their attitudes toward STEM teaching and challenge them to change these attitudes (Thibaut et al., 2018).

Pre-service teachers should be allowed to increase their ability to effectively integrate STEM content into teaching (Margott & Kettler, 2019). This might be possible by helping pre-service teachers to teach STEM subjects as one cohesive unit. The integrative approach would lead to positive changes in teachers' classroom practices and students' learning outcomes (Breiner et al., 2012, p. 5). The other approach for improvements in especially attitudes towards engineering is project-based learning (Tseng et al., 2013). Teacher preparation programs should employ strategies that encourage pre-service teachers to teach interdisciplinary subjects using teaching methods such as project-based learning.

Scaffolding for Female Pre-Service Teachers

Female pre-service teachers need more support to develop positive attitudes towards engineering-technology. Results revealed that attitudes towards engineering-technology explain more than half of the variance in the attitudes towards STEM. Female pre-service teachers may need professional support, especially in designing activities related to engineering. Expected-value theory asserts that individuals perform an activity if they believe in the activity's usefulness or their ability for the required activity (Feather, 1982). Within this context, female pre-service teachers should engage in activities that make them perceive STEM education's usefulness in their teaching. Besides, they may be given the opportunities to see that they can teach STEM subjects. Furthermore, professional development programs that aim to foster female pre-service teachers' attitudes, confidence, and skills may be arranged. Female pre-service teachers should be given the opportunity to work with female cooperating teachers who effectively implement STEM education.

One of the limitations of this study is that pre-service teachers from only one teacher preparation program participated. The teacher preparation program in which this study was conducted does not follow a policy that focuses on STEM education in all departments. Some universities have STEM centers in Turkey. Although the sample size is enough to make the analysis in this study, further research may be performed in the universities with STEM centers. Additionally, this study used a self-reported measure to identify pre-service teachers' attitudes towards STEM and STEM disciplines. Self-reported measures are not enough to comprehend attitudes. It is required in-depth interviews, observations, and artifacts to understand the nature of the attitudes.

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