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Comparing the STEM Attitudes of Science and Classroom Pre-service Teachers Receiving STEM Education: An Effect Size-Based Study

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Abstract: The purpose of this study is to determine the attitudes of pre-service science and classroom teachers who have completed a STEM education course toward STEM education and to examine whether these attitudes differ by teaching specialisation. This study used a descriptive survey design, a type of quantitative research. The students participating in the study were science and pre-service classroom teachers who had taken a STEM education course. Data were collected using the STEM Education Attitude Scale, and the results were analysed using an independent samples *t*-test. The effect size (Cohen's d) calculation was applied to assess the significance of differences between groups. The findings revealed that both groups of pre-service teachers demonstrated high levels of positive attitudes toward STEM education. No statistically significant differences were found between pre-service science teachers and classroom teachers in overall STEM attitude scores or subscale scores. Moreover, the calculated effect sizes were

small, indicating that the differences by teaching specialisation were also limited in practical terms. This result may be attributed to the fact that all participants had previously completed a STEM education course. In general, it is necessary to increase the number of courses on STEM education in teacher training programs because it has been observed that STEM education promotes similar, positive attitudes among pre-service teachers from different disciplines.

Keywords: STEM education, pre-service teachers, STEM attitude, effect size.

Introduction

In the 21st century, rapid changes in science and technology, coupled with increased global competition, have further emphasised the importance of a highly qualified workforce. A qualified workforce requires individuals not only to be knowledgeable but also to possess fundamental 21st-century skills such as problem-solving, critical thinking, creativity, and interdisciplinary thinking. In this context, countries are shifting their education policies towards holistic and innovative approaches to cultivate individuals capable of creating products that solve real-world problems. One of the most important of these approaches is STEM education, which integrates the teaching of science, technology, engineering, and mathematics.

Türkiye began integrating STEM education into its education system in 2016 (MoNE, 2016), as many other countries have done. Since teachers play a critical role in the implementation of STEM education (Wang et al., 2011), Turkey has initiated in-service training programs to ensure they possess sufficient knowledge, skills, and competencies in STEM education, and has spearheaded teacher training in collaboration with universities. Teachers possessing these qualities can establish meaningful connections across disciplines in their relevant courses and prioritise enabling students to learn these areas in an integrated, holistic manner. The main goal of STEM education is to enable students to perceive information in an interconnected way rather than in fragmented pieces, and to support their holistic understanding of the world (Aydagül & Terzioğlu, 2014; Aydeniz & Bilican, 2018). As future teachers, pre-service teachers need to develop positive attitudes towards STEM education (Fulton et al., 2010). To reach this standard, universities need to integrate courses that explain this perspective into their programs (Rogers et al., 2015).

STEM education encompasses all grade levels from early childhood to higher education and can be implemented in both formal and informal learning settings. It offers students opportunities to develop 21st-century skills and higher-order thinking abilities (Gonzalez & Kuenzi, 2012; Meyrick, 2011). Other aims of STEM education include cultivating curious learners and effective decision-makers. All these skills, referred to as 21st-century competencies, can be achieved through STEM, an interdisciplinary educational approach (Yamak et al., 2014).

Teachers play a critical role in STEM education, directly influencing knowledge, skills, and attitudes toward STEM disciplines, the quality of classroom practices, and students' perceptions of these fields. Teachers with a positive attitude toward STEM and adequate pedagogical preparation are more likely to integrate interdisciplinary approaches effectively into their teaching practices. Consequently, pre-service teachers must develop positive attitudes toward STEM education during their preservice training.

Attitude can be defined as a summary evaluation of the object of thought (Aronson et al., 2012). Allport (1935) defines attitude as a state of mental and nervous readiness that is organised through experience and has a guiding, dynamic effect on the individual's responses to all objects and situations with which they are involved (as cited in Tavşancıl, 2014). Based on these definitions, attitudes are considered extremely important because they partially or completely shape individuals' behaviour. Teachers' attitudes toward STEM disciplines reveal their feelings, beliefs, and perceptions regarding STEM education.

There are numerous studies in the literature examining teachers' and pre-service teachers' attitudes toward STEM education. Many of these studies have reported generally positive attitudes toward STEM. However, studies comparing the STEM-related attitudes of pre-service teachers from different teaching specialisations remain limited. In particular, there are limited studies that directly compare the attitudes of pre-service science and classroom teachers who have taken STEM education courses. Existing studies make generalisations and recommendations based on statistical significance (p-values) without discussing practical significance, which limits the interpretation of group differences from an applied perspective. Therefore, including effect size (e.g., Cohen's d) alongside significance tests helps us make more comprehensive interpretations about whether observed differences are practically meaningful.

Science and classroom teaching, which play a critical role in implementing STEM applications at the primary education level, share a common foundation due to the interdisciplinary nature of STEM education, despite some differences in their curricula and pedagogical approaches. Therefore, comparing the attitudes of pre-service science and classroom teachers who have received STEM education provides valuable insights into the effectiveness of teacher education programs and contributes to efforts to improve these programs.

Much of the literature on STEM education consists of descriptive studies by various educational specialists on the use of STEM attitude scales with teachers or students. It has been noted that few studies examine the STEM attitudes of pre-service classroom teachers (Er & Acar Başeğmez, 2020). Direct comparisons between pre-service science and classroom teachers who have completed STEM education courses are rare. Furthermore, it is unclear whether a common STEM education course serves as an interdisciplinary “equalising” experience or whether it creates discipline-specific differences in attitudes. To address this gap, STEM courses are increasingly being incorporated into university education faculty teacher training programs. Evidence is needed on who benefits from the revised programs and to what extent they benefit.

Literature Review

Studies on the conceptual foundations of STEM and STEAM education constitute the most important research base. STEM education emerged as a strategic multidisciplinary educational approach to meet the demands of 21st-century societies (Bybee, 2013; Gonzalez & Kuenzi, 2012). Rather than addressing these disciplines in isolation, it encourages interdisciplinary problem solving, design-based learning, and real-world experiences (Honey et al., 2014; Wang et al., 2011). Engineering design is seen as an applied mechanism for reasoning and mathematical modelling that uses scientific knowledge in a technological context (Brophy et al., 2008). Research shows that students' academic achievement can be positively influenced when integrated STEM approaches are consistently applied (Becker & Park, 2011; Li et al., 2020). However, this success also underscores that it depends on teachers' teaching beliefs, contextual factors, and professional preparation as STEM practitioners (Margot & Kettler, 2019; Thibaut et al., 2018). In recent years, the integration of an artistic perspective into the STEM approach, transforming STEM into STEAM, has broadened the pedagogical discourse. STEAM frameworks emphasise creativity, collaboration, and innovation in addition to technical proficiency (Connor et al., 2015; Yakman & Lee, 2012). STEAM-based applications have shown that they require changes in teacher identity and instructional design and reinforce the importance of teacher attitudes and pedagogical flexibility (Quigley & Herro, 2016; Herro et al., 2017).

Teachers are recognised as central actors in STEM and STEAM applications (Wang et al., 2011; Song & Zhou, 2021). Research indicates that teachers' willingness to adopt interdisciplinary teaching practices is influenced by their beliefs, perceived competence, and attitudes (Lee et al., 2019; Thibaut et al., 2018). Professional learning communities play a key role in strengthening teachers' capacity in STEM teaching (Fulton et al., 2010; Rogers et al., 2015). At the same time, teachers' STEM attitudes influence their teaching intentions and their implementation of STEM in the classroom (Aronson et al., 2012). Although STEM attitudes cannot be directly observed, they are considered strong indicators of behavioural tendencies (Tavşancıkara, 2014). Therefore, examining pre-service teachers' attitudes toward STEM education is critical to understanding future classroom practices. Experimental studies in the literature frequently report positive attitudes toward STEM education (Al Salami et al., 2017; Eroğlu & Bektaş, 2016). On the other hand, the literature presents mixed findings regarding interdisciplinary differences. Most studies report that pre-service science teachers demonstrate greater self-confidence in STEM areas due to their familiarity with the subject discipline (Kızılay, 2016; Çınar et al., 2016), whereas others report that differences vary across fields (Demirtaş & Ekşioğlu, 2020; Er & Acar Başeğmez, 2020).

Methodological accuracy is essential in comparative STEM research. Statistical methods such as t-tests and effect size calculations are frequently used to compare groups (Akgül, 2005; Büyüköztürk, 2018; Tabachnick & Fidell, 2019). However, relying solely on statistical significance without incorporating effect sizes may limit the practical interpretation of findings. The educational research methodology literature emphasises the importance of reporting both statistical and practical significance when evaluating group differences (Büyüköztürk et al., 2020). In STEM education studies, clearer results are needed regarding whether the observed interdisciplinary differences meaningfully affect program design or remain insignificant in practice.

STEM education has been the most popular educational approach in Turkey in recent years (Akgündüz & Ertepınar, 2015; Aydeniz & Bilican, 2018). National studies show parallels with international studies and emphasise the need to train teachers with interdisciplinary teaching skills (Aydagül & Terzioğlu, 2014; Çorlu et al., 2014). Studies in Turkey have shown that STEM-based activities can positively influence both skills and attitudes (Yamak et al., 2014; Yıldırım & Selvi, 2016). Meta-synthesis studies also highlight the methodological variability and the need for comparative designs of different teacher education programs (Herdem & Ünal, 2018). While there are many studies on pre-service teachers' STEM awareness and self-efficacy (Karakaya & Yılmaz, 2018; Özçakır-Sümen & Çalışıcı, 2016), there are fewer studies that directly compare pre-service science and classroom teachers who have completed equivalent STEM courses. Even in these comparative studies, the findings are contradictory. For example, while some studies point to discipline-based differences (Çınar et al., 2016; Kızılay, 2016), others report minimal differences (Demirtaş & Ekşioğlu, 2020).

In general, integrated STEM and STEAM education initiatives positively influence STEM attitudes and teaching readiness. However, inconsistencies persist regarding whether disciplinary background significantly affects pre-service teachers' attitudes after completing structured STEM courses. Moreover, many comparative studies do not sufficiently interpret the practical magnitude of differences through effect size analysis. Thus, examining STEM attitudes within teacher specialisation areas, including the interpretation of statistical significance and effect sizes, contributes to a more nuanced understanding of whether STEM courses function as discipline-specific experiences or as equalising, interdisciplinary interventions in teacher education programs.

Research Problem

Although STEM education is inherently interdisciplinary, not all teachers have the same academic background, disciplinary knowledge, pedagogical background or professional expectations. This has led to different effects across teaching specialities during the integration of STEM education into teacher training programs, and these have been identified as problems.

However, there is very little research on whether taking a STEM education course leads to discipline-based differences in teachers' or pre-service teachers' attitudes, or whether it serves as a common pedagogical experience that standardises attitudes across fields. Comparative studies directly examining pre-service science teachers and classroom teachers under similar teaching conditions remain scarce.

Many studies have focused solely on statistical significance, thereby limiting the interpretation of their findings for educational practice. Therefore, the main problem of this study is to determine whether there are significant differences in the attitudes toward STEM education among pre-service science and classroom teachers who have taken a STEM education course and to reveal whether the observed differences are practically meaningful.

Research Aim

This study aims to examine attitudes toward STEM education among pre-service science and classroom teachers who have completed a STEM education course and to compare these attitudes by teaching specialisation.

The scientific focus of the study is to investigate whether STEM education courses contribute to the formation of discipline-specific attitudes or promote a common interdisciplinary pedagogical perspective among pre-service teachers. In addition to statistical comparisons, this study emphasises interpreting effect sizes to assess the practical significance of group differences.

Research Questions

In line with this purpose, the study seeks to answer the following research questions:

1. What is the level of attitudes toward STEM education among pre-service science teachers who have completed a STEM education course?
2. What is the level of attitudes toward STEM education among pre-service classroom teachers who have completed a STEM education course?
3. Do the attitudes toward STEM education of pre-service science and classroom teachers who have completed a STEM education course differ significantly according to teaching specialisation?
4. What is the practical magnitude (effect size) of any observed differences between the two groups?

In addition, the study interprets the magnitude of any observed differences using effect size indices to clarify the practical implications of the findings.

Methods

Research Design

This study adopted a quantitative research approach using a comparative survey design. Comparative survey designs aim to identify and explain differences between groups on specific variables by defining the current conditions (Büyüköztürk et al., 2020). This study aims to identify pre-service teachers' attitudes toward STEM education and to examine the extent to which these attitudes differ by science and classroom teaching.

Participants

The study involved pre-service science and classroom teaching students at a state university located in a major city in Türkiye. The participants were selected using criterion sampling, a purposeful sampling method. In this study, criterion sampling was used. This sampling technique involves including all individuals who meet a predetermined criterion (Yıldırım & Şimşek, 2018). The primary criterion for participants was that they had taken and successfully passed a STEM education course or an equivalent course as part of their undergraduate teacher education program, either as a required or elective course. At this point, 37 pre-service classroom teachers and 37 pre-service science teachers were included in the study group, reaching a total of 74 participants.

Data Collection Instrument

The STEM Education Attitude Scale developed by Koçakülah, Abacı, and Koçakülah (2021) was used as a data collection tool. Initially, 44 attitude statements related to STEM education were generated. For content validity and clarity, expert reviews were obtained from an academic specialising in Turkish language education and an academic in educational sciences. After the scale was reviewed and pilot studies were conducted, the final version of the scale consisted of 36 items grouped into four factors: (a) positive attitudes toward STEM education (20 items), (b) negative attitudes toward STEM education (7 items), (c) the importance of STEM education (4 items), and (d) concerns about STEM education (5 items). Answers were recorded on a 5-point Likert scale. The scale's overall internal consistency coefficient is 0.96, indicating high reliability, while Cronbach's alpha reliability coefficients for the subscales range from 0.71 to 0.96 (Büyüköztürk, 2018).

Data Collection Procedure

Participants completed the STEM Education Attitude Scale either in person or online. Informed consent was obtained from all participants before completing the scale. The process of answering the questions took an average of 20 minutes.

Data Analysis

Data was analysed using SPSS statistical software. Descriptive statistics, including frequencies, means (M), and standard deviations (SD), were calculated to determine the general attitude levels of pre-service science and classroom teachers toward STEM education. To examine whether the data met the assumptions of normality, skewness and kurtosis values were evaluated. The values obtained were within the skewness and kurtosis limits of ±1.5, which are considered normal according to Tabachnick and Fidell (2019). In addition, the Kolmogorov-Smirnov test was performed to assess the normality of the data (Akgül, 2005). The results indicated that the normality assumption was satisfied for both pre-service science teachers (p = .125) and pre-service classroom teachers (p = .141).

Following confirmation of the normality assumption, an independent samples ***t***-test was used to compare STEM attitude scores between the two groups. The assumption of homogeneity of variances was tested using Levene's test, which indicated that the variances were homogeneous (p > .05). In addition to statistical significance testing, effect size (Cohen's *d*) was calculated to assess the practical significance of the observed differences. According to Cohen's criteria, *d* values below 0.20 indicate a small effect, values between 0.20 and 0.60 indicate a medium effect, and values above 0.60 indicate a large effect.

Results

This section presents the findings obtained from the analysis of pre-service teachers' attitudes toward STEM education. The results are organised in accordance with the research questions and supported by descriptive statistics, normality analyses, effect size calculations, and results from independent samples *t*-tests.

Normality of the Data

Descriptive statistics, skewness and kurtosis values, and Kolmogorov-Smirnov test results indicated that STEM attitude scores did NOT follow a normal distribution. For both pre-service science and pre-service classroom teachers, skewness and kurtosis values fall within the acceptable range of -1.5 to +1.5 (Table 1). Additionally, Kolmogorov–Smirnov test results indicated that the data did not significantly deviate from normality for pre-service science teachers (p = .125) or pre-service classroom teachers (p = .141). Therefore, parametric statistical analyses were deemed appropriate.

Table 1

Descriptive Statistics and Normality Indicators of STEM Attitude Scores

Group	M	SD	Median	Skewness	Kurtosis
pre-service science teachers	141.00	15.88	141.00	-0.238	0.970
pre-service classroom teachers	144.11	16.88	142.00	0.398	-0.070

Note. The skewness and kurtosis values fall within the acceptable range (-1.5 to +1.5), indicating a normal distribution.

STEM Attitudes Of Pre-Service Science Teachers

The first research question examined the level of STEM attitudes among pre-service science and classroom teachers who had received STEM education. The average STEM attitude score of pre-service science teachers is 141.00, with a standard deviation of 0.97 (Table 2). According to the predefined score intervals (133–180), this mean score corresponds to a high level of attitude toward STEM education. These findings indicate that pre-service science teachers who received STEM education generally held positive attitudes toward STEM.

Table 2

Descriptive Statistics of pre-service science teachers' Total STEM Attitude Scores

Group	n	Min.	Max.	M	SD
pre-service science teachers	37	97.00	174.00	141.00	0.970

Note. Mean scores between 133 and 180 indicate a high level of attitude toward STEM education.

STEM Attitudes Of Pre-Service Classroom Teachers

The second research question determines the level of attitude toward STEM among pre-service classroom teachers who have received STEM education. The average STEM attitude score of pre-service classroom teachers was 144.11, with a standard deviation of 16.88. This value indicates that pre-service classroom teachers, like pre-service science teachers, exhibit a positive attitude toward STEM education.

Table 3

Descriptive Statistics of CPre-Service Classroom Teachers' Total STEM Attitude Scores

Group	n	Min.	Max.	M	SD
pre-service classroom teachers	37	109.00	180.00	141.11	16.88

Note. Mean scores between 133 and 180 indicate a high level of attitude toward STEM education.

Comparison of STEM Attitudes by Teaching Specialisation

The third research question examined whether STEM attitudes differed significantly between pre-service science and classroom teachers. Independent-samples *t*-tests were conducted to compare total attitude scores and subdimension scores across teaching specialisations. As shown in Table 4, no statistically significant differences were found between pre-service science and classroom teachers in terms of positive attitude, negative attitude, importance of STEM, concerns, or total STEM attitude scores ($p > .05$).

Although pre-service classroom teachers demonstrated slightly higher mean scores on total STEM attitudes (M = 144.10) than pre-service science teachers (M = 141.00), this difference was not statistically significant, $t(72) = -0.82$, $p > 0.05$.

Table 4

Independent Samples t-Test Results by Teaching Specialisation

Sub-dimension	Group	N	M	SD	t	p
Positive Attitude	Science	37	80.27	9.22	-0.190	0.85
	Classroom	37	80.72	11.48		
Negative Attitude	Science	37	27.40	5.61	-1.265	0.21
	Classroom	37	28.97	5.01		
Importance of STEM	Science	37	18.21	1.88	0.596	0.553
	Classroom	37	17.94	2.01		
Concerns	Science	37	15.10	3.55	-1.514	0.134
	Classroom	37	16.45	4.10		
Total Attitude	Science	37	141.00	15.57	-0.823	0.413
	Classroom	37	141.00	16.87		

Note. $p > .05$ for all comparisons.

Effect Size Analysis

In addition, the effect sizes were calculated using Cohen's *d* to assess the practical significance of differences between groups. As shown in Table 5, the effect size for total STEM attitude scores was small (Cohen's $d = 0.19$), indicating that the difference between pre-service science and classroom teachers was limited in practical terms. Effect sizes for the sub-dimensions ranged from very small to small, with the largest effect observed in the "Concerns" sub-dimension.

Table 5

Effect Size (Cohen's d) Values by STEM Attitude Sub-dimensions

Sub-dimension	**Cohen's *d***	**Effect Size Interpretation**
Positive Attitude	0.04	Very small
Negative Attitude	0.30	Small
Importance of STEM	−0.14	Very small
Concerns	0.35	Small

Note. Cohen's d value is below 0.20: very small effect; 0.20 - 0.60: small effect; and above 0.60: a large effect.

Although no significant differences were found at the scale or subscale level, item-level analyses showed statistically significant differences between pre-service science and classroom teachers on various individual items ($p < .05$). In particular, significant differences were identified in the items related to taking additional STEM courses, the desire to obtain advanced STEM education, interest in following STEM-related topics in the media, hesitation towards STEM-related topics, and excitement about designing STEM projects.

Although there were differences at the item level, these did not translate into significant differences in overall STEM attitude scores. Therefore, these findings should be interpreted with caution and considered exploratory, especially given the multiple comparisons.

In summary, the results demonstrated that both pre-service science and classroom teachers who had completed a STEM education course exhibited high levels of positive attitudes toward STEM education. No statistically significant differences were found between the groups in terms of overall STEM attitudes or subscale scores. Moreover, the small effect sizes indicated that teaching specialisation had a limited influence on pre-service teachers' attitudes toward STEM education.

Discussion

This study determined that pre-service science and classroom teachers who took the STEM education course had high attitudes toward STEM education, and that there was no significant difference by subject variable. This result requires pedagogical interpretation. The absence of significant differences between disciplines suggests that STEM education serves as a common professional socialisation experience, reducing the gap in attitude development. The literature suggests that STEM education will enable individuals to develop positive attitudes towards S-T-E-M and present opportunities to relate the information given to everyday life. In this light, it can be suggested that the course content and interdisciplinary structure may have created a shared learning experience that minimised pre-existing differences between pre-service science teachers and classroom teachers. Rather than reinforcing discipline-specific identities, the course may have encouraged a holistic perspective toward STEM education. This is consistent with studies showing that pre-service teachers will contribute to STEM education in many ways (Al Salami et al., 2017; Çınar, Pırasa & Sadoğlu, 2016; Eroğlu & Bektaş, 2016; Kızılay, 2016; Lee et al., 2019; Song & Zhou, 2021; Wang, 2011; Yıldırım & Selvi, 2016). The findings obtained in this study also support this. Many studies show that pre-service teachers' attitudes towards STEM are generally positive, supporting this finding (Herdem & Ünal, 2018; Özçakır-Sümen & Çalışıcı, 2016). However, this study makes these findings more meaningful by also conducting an effect size analysis. Although there was no statistically significant difference, the calculated Cohen's d values also indicated that the practical magnitude of the difference between the groups was small. This suggests that the similarity between the groups was not solely due to sample size or statistical power but rather reflected a truly limited disciplinary effect. Meyrick (2011) states that providing STEM education at all levels will give learners opportunities to develop cooperative learning, critical thinking, interpersonal communication skills (called 21st-century skills), and engineering skills. Demirtaş and Ekşioğlu (2020) conducted a study with pre-service teachers in the departments of Science, Mathematics, and Classroom Teaching and found that attitudes did not differ by subject area. The consistency between these findings and the current results strengthens the interpretation that STEM education can serve as a balancing pedagogical framework in the training of pre-service teachers.

Contrary to these findings, Wang et al. (2011) reported that, in a study with teachers from different disciplines, their attitudes toward STEM varied by teaching discipline. These conflicting results in the literature can be attributed to the interpretation that participants took STEM education courses at different levels. In the present study, all participants had completed a STEM education course, which may have reduced potential disciplinary disparities. The interdisciplinary nature of STEM education is frequently emphasised in the literature as positively influencing pre-service teachers' perceptions of STEM fields and increasing their professional motivation (Brophy et al., 2008; Wang et al., 2011).

The absence of a significant difference across subject areas is consistent with similar studies in the literature. Studies comparing the attitudes of pre-service science and classroom teachers toward STEM education have reported that subject area does not significantly affect attitudes (Demirtaş & Ekşioğlu, 2020; Er & Acar Başeğmez, 2020). These results indicate that pre-service teachers achieve common gains in the STEM education process and that subject-based differences are limited. The small effect sizes calculated in this study (Cohen's d) are consistent with similar findings reported in the literature. From a practical perspective, small effect sizes suggest that teaching specialisation plays a limited role in shaping attitudes toward STEM when a structured, common educational experience is provided. This has important implications for teacher education programs, as it indicates that well-designed STEM courses can promote shared professional attitudes across different disciplines.

In previous studies, when no statistically significant differences were found, it was stated that these differences were low in practical terms and that STEM education played an equalising role in pre-service teachers' attitudes (Yıldırım, 2016; Wang et al., 2011). In this context, it can be said that the STEM education course standardises pre-service teachers' attitudes toward STEM to some extent. However, studies in the literature also reveal that pre-service teachers' or teachers' attitudes toward STEM education differ by field of study. Some studies have indicated that pre-service teachers studying in fields with a focus on science and mathematics have higher attitudes toward STEM (Kızılay, 2016; Wang et al., 2011). However, these studies highlight that these differences are closely related to pre-service teachers' STEM education, practical experiences, and program content. The fact that all participants in this study had taken a STEM education course can be considered an important factor in explaining the lack of significant differences between disciplines. In item-based analyses, the finding of significant differences in some attitude statements by the subject variable is consistent with findings from some studies in the literature. Previous studies have also reported that pre-service teachers may exhibit subject-based differences in certain statements of interest, desire, and motivation regarding STEM education (Çınar, Pırasa & Sadoğlu, 2016; Yamak, Bulut & Dündar, 2014). However, these differences are not reflected in overall attitudes and are more closely related to individual experiences and professional expectations. In this study, it is also observed that differences that emerge at the item level do not lead to significant divergence in the overall M attitude scores.

Nevertheless, comparisons of item-level differences should be made and interpreted with caution due to the increased risk of Type I error. Furthermore, the absence of a significant difference at the total scale level suggests that these variations may reflect specific areas of interest or motivational differences among pre-service teachers rather than structural attitude differences. Overall, the findings of this study support the literature indicating that pre-service teachers who have received STEM education hold high attitudes toward STEM education, and that the subject variable has a limited effect on these attitudes. Small effect sizes indicate that STEM education is effective in developing a common pedagogical understanding among pre-service teachers. These results are important because they indicate that STEM education courses in teacher training programs can yield similar gains for pre-service teachers across different disciplines.

In the present research, data from pre-service teachers in classrooms were collected face-to-face using printed scales. In contrast, data from science pre-service teachers were collected online via Google Forms. Although both groups used the same measurement tool, differences in how STEM was applied may have affected responses. Research in survey methodology suggests that online data collection environments may reduce social desirability bias by increasing perceived anonymity. In contrast, face-to-face administration may increase response conformity due to contextual or environmental influences.

In contrast, online environments may also lead to variations in attention span, response speed, and levels of environmental distraction. Thus, even if no significant group differences were observed, the possibility that the data collection method may have influenced subtle response patterns should be considered when interpreting the results. Another important dimension concerns the relationship between STEM education and educational technology. STEM education, by its nature, often incorporates technological tools, simulation software, digital collaboration platforms, and engineering design technologies.

Pre-service teachers in both groups may have developed high STEM attitudes because they were able to take technology-supported courses and had technology literacy. As the number of technology-supported teaching environments in teacher education programs increases, it will support interdisciplinary thinking and collaborative problem solving, which are fundamental elements of STEM education. It should also be clearly emphasised that this study did not directly measure technology integration proficiency or digital pedagogical readiness. Therefore, the relationship between STEM attitudes and educational technology proficiency remains an important direction for future research.

The findings of this study have several important implications for teacher education programs. First, the lack of statistically significant differences in attitudes between pre-service science and classroom teachers suggests that STEM education courses can provide comparable interdisciplinary benefits. Consequently, a common interdisciplinary STEM course could be included in teacher training programs. Second, small effect sizes indicate that attitudinal differences among pre-service teachers from different disciplines may decrease when taking a STEM course. Third, teacher training programs should not limit STEM education to theoretical content; rather, incorporating application-based learning opportunities, such as project-based modules, collaborative design tasks, and technology-supported simulations, can further strengthen the transfer of existing positive attitudes into classroom practices and behaviours. Furthermore, given the increasing integration of digital tools in education, STEM courses should intentionally incorporate e-learning components, digital design platforms, and collaborative technologies. Aligning STEM courses with educational technology competencies can enhance pre-service teachers' readiness to implement interdisciplinary education in digitally enriched classrooms.

Conclusions

The research findings showed that both groups of pre-service teachers had high attitudes toward STEM education. However, no statistically significant differences were found between the total STEM attitude scores and the subscale scores of pre-service science and classroom teachers. The findings of this study suggest that participation in a structured STEM education course may contribute to the development of consistent, positive attitudes across different teaching specialisations.

In addition, no significant differences were found in comparisons based on the subject variable; when the calculated effect sizes (Cohen's d) were examined, the differences were also quite limited in practical terms. The inclusıon of effect size analysis strengthens the interpretation of these results by demonstrating that a limited practical difference between groups accompanies the lack of statistical significance. The small effect size for total STEM attitude ($d = 0.19$) indicates that the difference between the two groups is low not only statistically but also in practical terms. Similarly, the effect sizes for the sub-dimensions, ranging from very small to small ($d = 0.04–0.35$), reveal that the branch difference does not have a decisive effect on pre-service teachers' STEM attitudes. This suggests that teaching specialisation alone may not be a determining factor in shaping preservice teachers' attitudes toward STEM when they are exposed to a common educational experience.

One possible reason for this situation is that all pre-service teachers included in the study had taken a STEM education or an equivalent course. Therefore, the STEM education course may have served as a shared professional development context that reduced potential disciplinary differences and supported a more unified perspective on STEM education. The STEM education course appears to have equalised the knowledge and awareness levels of pre-service teachers across disciplines to some extent. Indeed, the interdisciplinary nature of STEM education contributes to pre-service teachers developing a holistic perspective rather than one specific to their own discipline. In this context, it can be considered an expected result that both groups have similar and high levels of attitude towards STEM education.

Some studies in the literature indicate that pre-service teachers' attitudes towards STEM education do not differ by field. The findings of this study are consistent with previous studies conducted with science and classroom pre-service teachers, which reported no significant differences according to the field variable. In contrast, some studies have indicated that the subject variable affects STEM attitudes. Possible reasons for these differences may stem from variables such as variations in the content of the STEM education courses they take, program content and duration of implementation, and characteristics of the sample.

When the scale was analysed item by item, although statistically significant differences were found in some attitude statements depending on the branch variable, these differences did not reflect the general attitude level, indicating that STEM attitude tendencies remain similar across disciplines. This situation indicates that responses to specific statements may be influenced by prospective teachers' individual interests and experiences. These findings suggest that an interdisciplinary pedagogical orientation and shared professional values should be promoted in educational programs, and that the continuous integration and strengthening of STEM education should be recommended in teacher training programs. Furthermore, these findings should be considered exploratory.

In conclusion, the present study contributes to the growing body of literature on STEM education by demonstrating that STEM education courses play a significant role in fostering positive, comparable attitudes among pre-service teachers from different teaching specialisations. These findings support the continued expansion and strengthening of STEM education within teacher education programs to promote interdisciplinary teaching competencies and 21st-century skills. The structured STEM courses within teacher education programs may function as equalising pedagogical experiences across disciplines. When pre-service teachers are exposed to interdisciplinary problem-solving frameworks and integrated instructional approaches, disciplinary background appears to play a less decisive role in shaping attitudinal outcomes.

Limitations

A limitation of this study is that the sample is restricted to pre-service teachers from a single state university, limiting the generalizability of the findings. Another limitation is that the use of a self-report attitude scale may be subject to response bias, including social desirability effects. Finally, the use of both face-to-face interviews and online applications as data collection methods may have influenced response patterns across groups, even if the same tool was used. Furthermore, the study focused solely on attitude and did not measure related concepts such as self-efficacy, technological pedagogical competence, or intentions to apply in the classroom. Finally, although effect sizes were calculated, the relatively small sample size may limit statistical power and the precision of effect size estimates.

Suggestions for Future Research

Based on the findings of this study, several recommendations are proposed regarding teacher education programs, instructional practice, and educational policy in order to strengthen the role of STEM education in preservice teacher training.

- The high and comparable levels of positive attitudes toward STEM education among pre-service science and classroom teachers indicate that STEM education courses offered in teacher education programs provide shared and inclusive learning outcomes. In this regard, it is recommended that STEM education courses be structured not only as elective courses but, where feasible, as compulsory components of teacher education curricula. Moreover, these courses should not be limited to theoretical content; instead, they should be supported by practice-based and interdisciplinary activities that enable pre-service teachers to translate their positive attitudes toward STEM education into classroom practice.

- It is recommended that teacher education programs place greater emphasis on practical experiences that support pre-service teachers' skills in STEM-based lesson planning, activity design, and project development. Integrating STEM-oriented practices into teaching practicum and school experience courses may enhance pre-service teachers' self-confidence and increase their likelihood of implementing STEM practices in their future classrooms.

- The findings of this study demonstrate that STEM education is not an approach limited to science-focused disciplines but can foster similar attitudes among prospective teachers from diverse teaching specialities. From this perspective, it is recommended that the Ministry of National Education and other education policymakers promote STEM education within a broad framework rather than a discipline-specific one.

- STEM education is often implemented as a pedagogical innovation without being explicitly linked to broader educational technology strategies. To address this gap, STEM education courses in teacher training programs should be systematically aligned with national educational technology policies and digital competency frameworks.

- Integrating STEM instruction with digital teaching standards can strengthen coherence between interdisciplinary pedagogy and educational technology policy goals.

- Future research should examine how educational technology policies influence the implementation of STEM education in teacher preparation programs. By establishing stronger connections between STEM education and educational technology policy, teacher education programs can contribute not only to interdisciplinary competence but also to broader national goals related to digital transformation, innovation capacity, and sustainable educational development.

- Future research could benefit from examining pre-service teachers' attitudes toward STEM education in conjunction with other variables, such as self-efficacy beliefs, teaching competencies, and tendencies in classroom practice. Furthermore, qualitative or mixed-methods studies, conducted with larger and more diverse sample groups, would increase the generalizability of the findings.

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Conflict of Interest

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