Adaptation of the Teaching Engineering Self-Efficacy Scale to Turkish and Analysis of Science Teachers' Teaching Engineering Self-Efficacy Beliefs across Different Variables*

Derya ERDEMİR YILMAZ [1], Çiğdem ŞAHİN ÇAKIR [2]

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[1] deryaerdemir28@hotmail.com, orcıd.org/ 0000-0003-0994-6866, Ministry of National Education, Türkiye

[2] cigdem.sahin@giresun.edu.tr, orcid.org/ 0000-0001-7041-3773, Giresun University, Türkiye

ABSTRACT

The objective of this study was to adapt the Teaching Engineering Self-Efficacy Scale (TESS) to Turkish through comprehensive validity and reliability assessments and to analyze science teachers' (specializing in science, physics, chemistry, biology) Teaching Engineering Self-Efficacy (TES) beliefs concerning various variables. The study employed the TESS, originally developed by Yoon, Evans, and Strobel (2014), alongside a personal information form, and followed a descriptive survey model as its research methodology. The adapted TESS's validity and reliability were evaluated using data from 476 science teachers in schools under the Ministry of National Education (MoNE) in X province, and the main study involved 221 science teachers from Y province. The assessment of teachers' TES beliefs in relation to different factors was executed using independent samples t-tests, One-Way ANOVA, and the Scheffe test. It revealed that science teachers' TES beliefs significantly varied based on factors such as their involvement in providing engineering education, the integration of engineering education into their teaching, and their specific teaching subjects, but not gender. The study contributes a valid and reliable scale to the academic literature.

Keywords: *STEM education, teaching engineering self-efficacy scale, teaching engineering self-efficacy, science teachers, scale adaptation.*

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INTRODUCTION

In our era, the need for qualified individuals and quality education is paramount to address global issues (Anagün & Atalay, 2017; Ministry of National Education [MoNE], 2016). Traditional teaching methods are often insufficient for cultivating competent individuals, highlighting the importance of modern educational approaches (Bybee, 2013). Among these, the Science, Technology, Engineering, and Mathematics (STEM) education approach stands out. Countries are increasingly incorporating the STEM education approach into their educational policies, recognizing it as essential for achieving developmental goals. Teachers are pivotal in the effective implementation of the STEM education approach (Nguyen & Redding, 2018; Tunc & Bagceci, 2021; Wang, 2013). However, expertise solely in science and mathematics is inadequate for preparing a workforce that aligns with the demands of the current era (Çorlu, Capraro & Capraro, 2014). As a result, science teachers are expected to enhance their knowledge and skills across STEM disciplines—science, technology, engineering, and mathematics—to effectively impart these subjects (Lantz, 2009). A significant challenge is that K-12 teachers often lack a sufficient background in teaching engineering, as engineering education is not typically included in their training at universities (Rogers & Portsmore, 2004; Sun & Strobel, 2013). Research indicates that science teachers face numerous challenges when implementing the STEM (Science, Technology, Engineering, Mathematics) approach (Diana, 2021; Tunc & Bagceci, 2021). A significant difficulty lies in integrating engineering, a core STEM component, into their lessons (Yoon, Diefes-Dux & Strobel, 2013). Often, these teachers, not being specialists in all STEM fields, show reluctance in adopting STEM-based teaching methods (Diana, 2021). This hesitancy leads them to revert to more traditional pedagogical strategies (Rogers & Portsmore, 2004; Sun & Strobel, 2013; Tunc & Bagceci, 2021). Therefore, it is deemed essential for teachers to receive specialized training in STEM areas, such as engineering, to effectively impart these subjects (Gormaz-Lobos, Galarce-Miranda & Kersten, 2021). Additionally, fostering a belief among teachers in the appropriateness of integrated STEM for science education is crucial (Diana, 2021). The self-efficacy beliefs of teachers in implementing STEM are influential in their ability to conduct classes effectively using this approach. Teachers with high self-efficacy are more likely to embrace modern teaching methods and dedicate more time to instruction (Czerniak & Lumpe, 1996; Guskey, 1988; Stein & Wang, 1988). For example, Perera et al. (2022) identified a direct positive correlation between teachers' self-efficacy beliefs in science teaching and their engagement in inquiry-based science teaching practices.

This study recognizes the importance of investigating teachers' Teaching Engineering Self-Efficacy (TES) to facilitate their effective integration of engineering into lessons within the contemporary STEM framework. Assessing teachers' TES prior to their training in engineering education is crucial for tailoring the educational process. Therefore, tools for measuring TES are essential. Yoon, Evans, and Strobel (2014) developed the Teaching Engineering Self-Efficacy Scale (TESS) for this purpose. However, the TESS is not currently available in Turkish, creating a gap in the literature and necessitating studies to either develop or adapt the TESS to Turkish. Thus, the primary goal of this study is to adapt the TESS, as developed by Yoon et al. (2014), to Turkish and to evaluate its validity and reliability. This adaptation is expected to address the lack of a Turkish version of the TESS and to stimulate further research in this area. A review of existing literature reveals a dearth of studies focusing on teachers' engineering teaching self-efficacy beliefs (Christian, 2021; Hammack & Ivey, 2017; Lakin et al., 2019; Perkins-Coppola, 2019). Furthermore, a literature analysis specifically on TES indicates a significant shortfall in research in this domain (Haines, 2023; Menon, 2023; Wieselmann, 2023). While there are a few international studies on the subject, research in Turkey has not extensively explored this area. In Turkey, focus has primarily been on understanding science teachers' perceptions of STEM education (Deligöz & Han-Tosunoğlu, 2023) and investigating their views on STEM activities (Tosmur-Bayazıt et al., 2018). Effective teaching of engineering concepts within STEM education is essential. The self-efficacy of teachers in this realm plays a significant role in influencing students’ grasp and development of engineering skills. It is crucial for teachers to competently apply their engineering knowledge in the educational curriculum. Assessing teachers’ self-efficacy in teaching engineering can contribute to the enhancement of educational programs and teacher training, helping to identify and address gaps in teachers' skills. Therefore, measuring teachers’ Teaching Engineering Self-Efficacy (TES) is a critical step towards improving the quality of education and student outcomes. Measurement tools are necessary for this assessment, and it is important to have tools that are culturally and linguistically appropriate. Currently, there is no Turkish version of the Teaching Engineering Self-Efficacy Scale (TESS) mentioned in the literature. This gap underscores the need for the development or adaptation of the TESS into Turkish. Consequently, this study aims to adapt the TESS, originally developed by Yoon et al. (2014), into Turkish. It is anticipated that this adaptation will fill the existing void in Turkish literature concerning the TESS and stimulate further research in this area.

This research makes a significant contribution to the literature by analyzing science teachers' TES beliefs in relation to various factors, such as gender, their experience in receiving engineering education, and their practice of delivering engineering education in their classes. Assessing the current state of TES beliefs among science teachers using the adapted the TESS can provide valuable insights. Understanding science teachers' TES is key to effectively incorporating engineering concepts from the STEM framework into educational practices. Furthermore, this understanding can inform the development of content for in-service teacher training programs. Consequently, this study not only aims to adapt the TESS into Turkish and evaluate its validity and reliability but also seeks to investigate the TES beliefs of science teachers across different specializations (biology, chemistry, and physics) within the realm of science education.

Teaching Engineering Self-Efficacy Beliefs

According to Bandura (1995), self-efficacy is a powerful motivator that drives individuals to initiate tasks. Individuals with high self-efficacy persevere through challenges and remain committed to completing their tasks (Pajares, 1996). In this regard, it is critical for teachers to have high self-efficacy to overcome challenges encountered in the teaching process. Teacher efficacy varies depending on the subject matter and learning environment (Bandura, 1997) and significantly influences the learning approaches, teaching materials, methods, and techniques that teachers use in designing their instructional settings (Hammack & Ivey, 2017; Yaşar, Baker, Kurpius-Robinson, Krause, & Roberts, 2006). Indeed, teachers often prefer pedagogical strategies they believe in and are comfortable with, especially in mathematics and science education (Rogers & Portsmore, 2004; Sun & Strobel, 2013). Therefore, it is essential for them to have confidence in their ability to implement the STEM education approach in their classrooms. Science teachers face challenges in integrating engineering and technology while providing mathematics and science education within the STEM framework (Sujarwanto & Ibrahim, 2019). Although elementary school teachers may not always possess strong self-efficacy to support students' learning in engineering and STEM fields (Hammack & Ivey, 2017; Perkins Coppola, 2019; Yaşar et al., 2006), they are nonetheless expected to effectively integrate engineering concepts into their lessons (Yesilyurt, Deniz, & Kaya, 2021). Consequently, the importance of teachers' self-efficacy in teaching engineering becomes clear. Yoon et al. (2014) defined teaching engineering efficacy as 'the personal belief of a teacher in their ability to positively influence students' learning in engineering.

The integration of engineering concepts into science education has become increasingly important due to the rising demand for interdisciplinary approaches in addressing complex real-world problems. Understanding science teachers' self-efficacy in teaching engineering concepts is crucial, as it directly influences their ability to effectively incorporate engineering practices into their classrooms. This study aims to adapt the Teaching Engineering Self-Efficacy Scale (TESS) into Turkish to provide a validated tool for assessing Turkish science teachers' beliefs in this area. The findings will offer insights into how teachers specializing in science, physics, chemistry, and biology perceive their capabilities, which can inform targeted professional development and curriculum enhancement. Given the importance of equipping students with the necessary skills for future STEM careers, this research holds significance in both educational and scientific contexts.

The sub-problems of the research are expressed below:

- Are the results obtained from the Turkish adaptation of the TESS valid and reliable?
- Do science teachers' (specializing in science, physics, chemistry, and biology) Teaching Engineering Self-Efficacy beliefs significantly differ based on variables such as gender, experience in engineering education, incorporation of engineering education in their teaching, and branch?

RESEARCH METHOD

Research Model

The research was carried out in two phases. During the first phase, the TESS was adapted into Turkish, and the validity and reliability of this Turkish version were established. The second phase involved examining the TES beliefs of science teachers with respect to various variables. The study employed a descriptive survey model which is a method wherein participant perspectives or characteristics, such as interest, skill, ability, and attitude related to the topic or event under investigation, are identified through a larger sample (Büyüköztürk et al., 2017).

Participants

The study's sample was selected using purposive sampling, a method commonly preferred in research aimed at exploring and explaining phenomena, natural and societal events, and their interrelationships based on specific criteria (Büyüköztürk et al., 2017). For this study, the data collection instruments were purposefully distributed to science teachers. The sample comprised teachers who voluntarily participated in the research. These science teachers included elementary science teachers, as well as biology, physics, and chemistry teachers. In Turkey, elementary science teachers are responsible for teaching science classes in primary schools, whereas biology, physics, and chemistry teachers instruct their respective subjects at the high school level.

The research was executed in two distinct phases: adaptation and application of the TESS. During the adaptation phase, the TESS was administered to a total of 476 science teachers, encompassing elementary science teachers, and high school physics, chemistry, and biology teachers, all working in schools under the MoNE in X province. In the subsequent implementation phase, following the adaptation process, the TESS was administered to 221 science teachers, including elementary science, physics, chemistry, and biology teachers in schools affiliated with the MoNE in Ordu province. The demographic characteristics of the participating teachers are detailed in Tables 1 and 2.

Table 1. *Demographic Characteristics of Teachers in the TESS Adaptation Stage Sample*

		Frequency (f)	Percentage (%)
Branch	Elementary science teacher	237	49.8
	Physic teacher	68	14.3
	Chemistry teacher	81	17
	Biology teacher	90	18.9
Gender	Female	288	60.5
	Male	188	39.5
Participation in teaching engineering	Yes	31	6.5
	No	445	93.5
Status of providing teaching engineering in course	Yes	37	7.8
	No	439	92.2

The demographic characteristics of the teachers participating in the adaptation stage of the TESS are presented in Table 1. The distribution of teachers by their field shows that 49.8% (n=237) are science teachers, 14.3% (n=68) are physics teachers, 17% (n=81) are chemistry teachers, and 18.9% (n=90) are biology teachers. In terms of gender distribution, 60.5% (n=288) are female, while 39.5% (n=188) are male. Of these science teachers, 6.5% (n=31) have experience in teaching engineering, while the remaining 93.5% (n=445) do not. When asked about the integration of engineering teaching into their classes, 7.8% (n=37) responded affirmatively, whereas 93.5% (n=439) answered negatively.

Following the successful adaptation of the TESS to Turkish, the second phase of the study focused on examining the TES of science teachers based on various variables. Efforts were made to reach out to science teachers working in schools under the MoNE. The demographic characteristics of these teachers are detailed in Table 2.

Table 2 presents the demographic details of the sample group to which the adapted TESS was applied. Of the participating teachers, 34.7% (n=77) were science teachers, 20.7% (n=46) were physics teachers, 21.2% (n=47) were chemistry teachers, and 23.4% (n=52) were biology teachers. In terms of gender, 61.7% (n=137) were female and 38.3% (n=85) were male. Approximately 6.8% of the teachers had received training in teaching engineering, while 93.2% had not. A breakdown by subject area revealed that of the 76 science teachers, only 9 (11.7%) had attended such training; among the 46 physics teachers, 3 (6.5%) had participated; none of the 47 chemistry teachers had attended; and 2 (3.85%) of the 52 biology teachers had undergone training in teaching engineering. Concerning the integration of engineering teaching into their classes, 13.1% (n=29) affirmed doing so, while 86.9% (n=193) indicated they did not.

Table 2. *Demographic Characteristics of Teachers Participating in the Application Stage of the TESS*

		Frequency (f)	Percentage (%)
Branch	Elementary Science teacher	77	34.7
	Physic teacher	46	20.7
	Chemistry teacher	47	21.2
	Biology teacher	52	23.4
Gender	Female	137	61.7
	Male	85	38.3
Participation in teaching engineering	Yes	15	6.8
	No	207	93.2
Status of providing teaching engineering in course according to branch			
Elementary Science teacher	Yes	9	11.7
	No	67	88.3
Physic teacher	Yes	3	6.5
	No	43	93.5
Chemistry teacher	Yes	0	0
	No	47	100
Biology teacher	Yes	2	3.85
	No	50	96.15
Status of providing teaching engineering in course	Yes	29	13.1
	No	193	86.9

Data Collection Tool

In this research, 'the Teaching Engineering Self-efficacy Scale (TESS)' was used as the data collection tool.In the initial phase of this research, we established contact with Dr. So Yoon YOON via email to request permission for adapting the TESS into Turkish. After receiving authorization to use the scale, we obtained research permission from both the Giresun Provincial Directorate of National Education and the Ordu Provincial Directorate of National Education. This was accompanied by ethical approval to administer the scale to science teachers (specializing in science, physics, chemistry, biology) working in middle and high schools in the X and Y provinces. With all necessary permissions in place, we began the linguistic translation process.

A translation team was formed, comprising three foreign language experts who independently translated the scale into Turkish. The researchers then compared these translations to determine the expressions most closely aligned with the original version. After this initial translation, the Turkish version of the scale was reviewed for clarity and cultural appropriateness by four domain experts, specializing in science education, Turkish language grammar, measurement and evaluation, and foreign languages.

Subsequently, the Turkish version was back-translated into English by two different foreign language experts to ensure fidelity to the source language. This back-translated version was then compared with the original scale, with minor adjustments made to ensure no alteration of the original meaning. The scale was also reviewed by a specialist in Turkish language education to check grammar and comprehensibility. For conceptual validity, the scale was presented to two experts in science education with a focus on STEM studies. After completing all evaluations, the final version of the scale was established.

The adapted Turkish version of TESS comprises four sub-dimensions: engineering pedagogical content knowledge self-efficacy (KS), engineering disciplinary self-efficacy (DS), engineering engagement self-efficacy (ES), and engineering outcome expectancy (OE). These four constructs, as measured by the respective subscales, contribute to a single overall construct, TES, similar to the original version. The scale employs a 6-point Likert-type format, ranging from 1 (Strongly Disagree) to 6 (Strongly Agree). While the original version contained 23 items, the Turkish adaptation includes a total of 20 items.

To establish the construct validity and factor structure of the Turkish version, Exploratory Factor Analysis (EFA) was conducted using SPSS 22.0 software. Confirmatory Factor Analysis (CFA) was then performed with AMOS 24.0 software to verify the compatibility of the scale's factor structure, as identified through EFA, with the data. The Cronbach's alpha internal consistency coefficient was also calculated using

SPSS 22.0 to assess the reliability of the TESS and its sub-factors.

The TESS, having been confirmed to possess appropriate psychometric properties, was subsequently used to examine the Teaching Engineering Self-Efficacy beliefs of science teachers (specializing in physics, chemistry, biology, and general science) in relation to various variables. This aspect of the study is detailed in the following sections.

The Second Phase of the Study: Examination of Science Teachers' Teaching Engineering Self-Efficacy Beliefs in Terms of Different Variables

In the second phase of the study, the TESS was used to assess the self-efficacy of science teachers working in schools affiliated with the MoNE in the Ordu province, focusing on specific identified variables. For this purpose, the TESS, which had been adapted for the Turkish context, served as the primary measurement tool.

Collection of Data

Throughout the adaptation process of the TESS, validity and reliability assessments were conducted using data collected from its online form (Google Forms) with 476 participants. Participation in the study was voluntary, and a disclaimer assuring that the data would be exclusively used for research purposes was included in the form. Similarly, during the implementation phase, data from 221 participants were collected using the Google Forms interface. To ensure genuine responses to the TESS on Google Forms, the primary researcher personally contacted each teacher by phone. This contact involved providing details about the research and emphasizing the importance of honest responses to the TESS items for the integrity of the study. The contact information for the teachers was sourced from the Provincial Directorate of the MoNE.

Data Analysis

For the linguistic equivalence of the scale, quantitative measurements employing the test-retest technique were used. Spearman correlation analysis was performed using the SPSS 22.0 statistics package for each item and sub-dimension scores, based on data from 25 science teachers. Exploratory Factor Analysis (EFA) was conducted via SPSS 22.0 to examine the construct validity and factor structure of the TESS. Confirmatory Factor Analysis (CFA) using AMOS 24.0 was then utilized to determine if the factor structure established by EFA aligned with the data. The data's suitability for factor analysis was initially assessed using the Kaiser-Meyer-Olkin (KMO) and Bartlett's test. The KMO value for the 23 items was .875, and Bartlett's test yielded significant results ($\chi 2 = 1878.802$, df=231, $p < .001$). For factor analysis suitability, a KMO value above .60 and a significant Bartlett's test (Büyüköztürk, 2012; Pallant, 2016) are required, both of which were met in this study, indicating the data's appropriateness for factor analysis. Additionally, the Cronbach's alpha coefficient was calculated in SPSS 22.0 to determine the reliability of the adapted TESS, further establishing its validity and reliability.

When a study involves more than one dependent variable, Multivariate Analysis of Variance (MANOVA) is the preferred method (Tabachnik & Fidell, 2013). In this study, as the TESS comprises four sub-factors, MANOVA analysis was employed to compare the TES beliefs of science teachers across variables such as gender, receipt of engineering education, their involvement in teaching engineering in their courses, and subject specializations. One reason for choosing MANOVA is its capacity to uncover differences that individual ANOVA tests for each dependent variable might not reveal (Tabachnik & Fidell, 2013). Another reason is MANOVA's effectiveness in controlling the risk of Type 1 error. As Pallant (2016) notes, the probability of finding significant results increases with the number of analyses conducted, even when no actual significant difference exists between groups. Hence, MANOVA was selected to analyze the data in this study, minimizing the risk of Type 1 error. Subsequent Analysis of Variance (ANOVA) tests were conducted to identify which sub-factors of the TESS showed significant differences. Considering the four sub-factors of the TESS, Bonferroni corrections were applied to these ANOVA tests, setting the alpha level at 0.008 (Cevahir, 2020).

FINDINGS

In this section, the study presents findings related to the adaptation of the TESS to Turkish. These findings cover the linguistic equivalence, validity, and reliability of the scale, in that order. Following this, the results from the practical application of the adapted TESS are presented, marking the second phase of the research.

Findings Regarding the Linguistic Equivalence of the TESS

The linguistic equivalence between the Turkish and original versions of the TESS was assessed both qualitatively and quantitatively. For the qualitative aspect, two language education experts were consulted individually. The Turkish version of the TESS was translated back into English by these experts, and the two English translations were compared to create a unified version. This back-translation was then compared with the original TESS. No significant differences were observed, affirming the equivalence of the scales. The experts suggested no major modifications to the TESS, so no changes were made to the items.

For the quantitative analysis of linguistic equivalence, 25 bilingual science teachers voluntarily participated in the study. They were administered both the Turkish and original versions of the TESS, with a one-week interval between them. Participants were also asked about the time taken to complete the scale, clarity of the items, appropriateness of the rating scale, and any difficulties encountered in marking the ratings. The findings indicated that the items were understandable, completion time ranged from 5 to 15 minutes, the rating scale was generally appropriate, and participants did not face significant difficulties.

To confirm the quantitative linguistic equivalence of the TESS, Spearman correlation analysis was conducted on each item and sub-dimension score using SPSS 22.0. This analysis was based on the responses collected. Table 3 displays the Spearman rank difference correlation coefficients calculated for item scores and sub-dimension scores of the different language forms, ensuring the linguistic equivalence of the scale.

Table 3. *Correlations between Scores Obtained from Turkish and English Forms*

	Factor 1 The KS			Factor 2 The DS			Factor 3 The ES			Factor 4 The OE	
Item	r	p	Item	r	p	Item	r	p	Item	r	p
m1	.53	.007	m14	.88	.000	m10	.57	.003	m19	.62	.001
m2	.51	.010	m15	.74	.000	m11	.65	,000	m20	.75	.000
m3	.54	.005	m16	.70	.000	m12	.76	,000	m21	.87	.000
m4	.71	.000	m17	.87	.000	m13	.77	,000	m22	.64	.001
m5	.56	.004	m18	.78	.000				m23	.53	.006
m6	.43	.030									
m7	.81	.000									
m8	.68	.000									
m9	.81	.000									
Total	.77	.000	Total	.86	.000	Total	1.000	.000	Total	1.000	.000

In Table 3, the Spearman correlation coefficients for each item of the TESS are presented, ranging from .43 to .88. Additionally, the correlation coefficients for the total scores of the sub-dimensions are detailed as follows: .77 for the KS, .86 for the DS, 1.000 for the ES, and 1.000 for the OE.

Findings on the Structural Validity of the Scale (EFA and CFA Analysis)

The data's appropriateness for EFA was verified using the KMO test (with a value of .920, exceeding the .60 threshold) and Bartlett's test ($\chi2$ = 4163.17, df=253, $p < .001$). Principal component analysis with varimax rotation was conducted on the 23 items of the TESS to determine which items to retain. The analysis led to the removal of the 9th item, which showed factor loadings across two factors with a difference of less than .10, necessitating a repeat of the factor analysis (Büyüköztürk, 2012). As a result, the factors were composed of 8 items (m1, m2, m3, m4, m5, m6, m7, m8), 5 items (m14, m15, m16, m17, m18), 4 items (m10, m11, m12, m13), and 5 items (m19, m20, m21, m22, m23). The subsequent KMO value (.925 > .60) and

Bartlett's test ($\chi2$ = 3860.26, df=231, p < .001), as shown in Table 4, indicated the necessity of conducting EFA again.

Table 4. *The Results of KMO and Bartlett's Analysis*

KMO Analysis		.93
Barlett Test results	$\sim x^2$	3860.26
	df	231
	P	.000

The Turkish version of the TESS, following the analyses conducted, retains a four-factor structure analogous to the original scale. The percentages of variance explained by this four-factor model are as follows: 20.24% for the first factor, 18.61% for the second, 15.89% for the third, and 14.78% for the fourth, culminating in a total variance of 69.51%. Eigenvalues greater than 1 were utilized for factor determination, as suggested by Büyüköztürk (2012). The eigenvalues for the first, second, third, and fourth factors were calculated to be 9.55, 2.60, 1.88, and 1.28, respectively, as depicted in Figure 1.

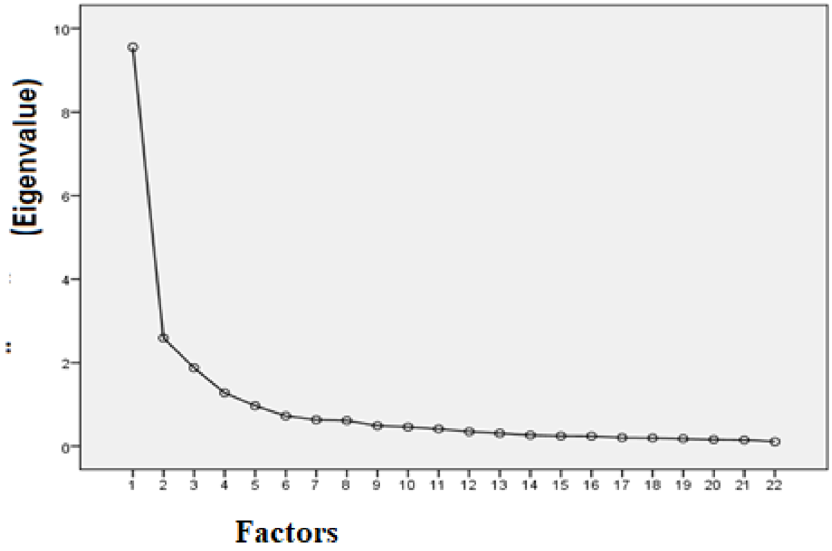

Figure 1. *Eigenvalue-Factor (Scree Plot) Diagram of the TESS*

Table 5 displays the Exploratory Factor Analysis (EFA) results for the Turkish version of the TESS. This version also maintains a four-factor structure. The factor loadings for the items in the first factor range from .37 to .81, in the second factor from .58 to .88, in the third factor from .72 to .77, and in the fourth factor from .63 to .83.

Table 5. *EFA Results for the Turkish Version of the TESS*

Item	Factor 1	Factor 2	Factor 3	Factor 4
m4	.81			
m6	.79			
m5	.77			
m3	.74			
m7	.69			
m2	.67			
m8	.64			
m1	.37			
m16		.88		
m17		.88		
m15		.85		
m14		.83		
m18		.58		
m12			.77	

m10	.75	
m11	.75	
m13	.72	
m20		.83
m19		.80
m21		.73
m22		.71
m23		.63

Findings from the CFA Analysis of the Scale

The CFA was performed on the TESS to identify which items appropriately fit their respective factors. The initial analysis showed normal fit indices (χ^2/df= 2.974, RMSEA= .09, RMR= .066, GFI= .805, AGFI= .757, CFI= .865, NFI= .811), but the standardized regression weights for the first two items (m1= .328 and m2= .402) were below the acceptable threshold of .50. As a result, these items were removed, and the CFA was conducted again. This led to the exclusion of m1 and m2 from the TESS, reducing the scale to 20 items. The subsequent CFA included the Chi-Square Goodness test (χ2), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), Normed Fit Index (NFI), Root Mean Square Residuals (RMR), and Root Mean Square Error of Approximation (RMSEA) index. The CFA results presented in Table 6 indicate the fit indices, with the Chi-Square value being χ^2 = 537.377, df=164, p = .000.

Table 6. *Fit Indices Values for the Turkish Version of the TESS in CFA*

Fit indices	Calculated Fit Index	Fit Indices in the Literature	References
χ^2/df	3.28	Acceptable Fit (χ2/sd ≤5)	Anderson & Gerbing, (1984)
RMSEA	.098	Perfect Fit (RMSEA≤0.06, 0.08, 0.10)	Hu & Bentler, (1999); Kline, (2013)
RMR	.063	Perfect Fit (0.05≤RMR ≤0.08, 0.10)	Hu & Bentler, (1999)
GFI	.85	Good Fit (GFI≥0.85)	Weizmann-Henelius et al., (2010)
AGFI	.80	Good Fit (AGFI≥0.80)	Weizmann-Henelius et al., (2010)
CFI	.90	Good Fit (CFI≥0.90)	Weizmann-Henelius et al., (2010)
NFI	.83	Acceptable Fit (NFI≥0.80)	Hooper et al., (2008)

Analyzing the goodness-of-fit indices in Table 6 for the CFA of the TESS, the CMIN/DF (χ^2/df) value is observed to be greater than 1 and below the recommended upper limit of 5, indicating an acceptable fit (χ^2/df = 3.28). The Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), and Normed Fit Index (NFI) are all close to the suggested ideal value of 1. Additionally, the Root Mean Square Error of Approximation (RMSEA) value is near .10. The CFA results are also statistically significant ($p < .001$). Table 7 presents the outcomes of the standardized factor loadings for the TESS items derived from the CFA.

Table 7. *Results Obtained from the Standardized Factor Loadings of the TESS Items in the CFA*

Factor 1		Factor 2		Factor 3		Factor 4	
The KS		The DS		The ES		The OE	
Item	Load value	Item	Load value	Item	Load value	Item	Load value
m3	.65	m18	.68	m10	.79	m23	.69
m4	.68	m17	.87	m11	.82	m22	.61
m5	.75	m16	.85	m12	.80	m21	.85
m6	.79	m15	.83	m13	.79	m20	.74
m7	.79	m14	.83			m19	.65
m8	.78						

Reviewing Table 7 reveals that the standardized factor loadings for the items in the TESS's factors vary from .61 to .87. Figure 2 displays a screen capture of the TESS as visualized in the CFA.

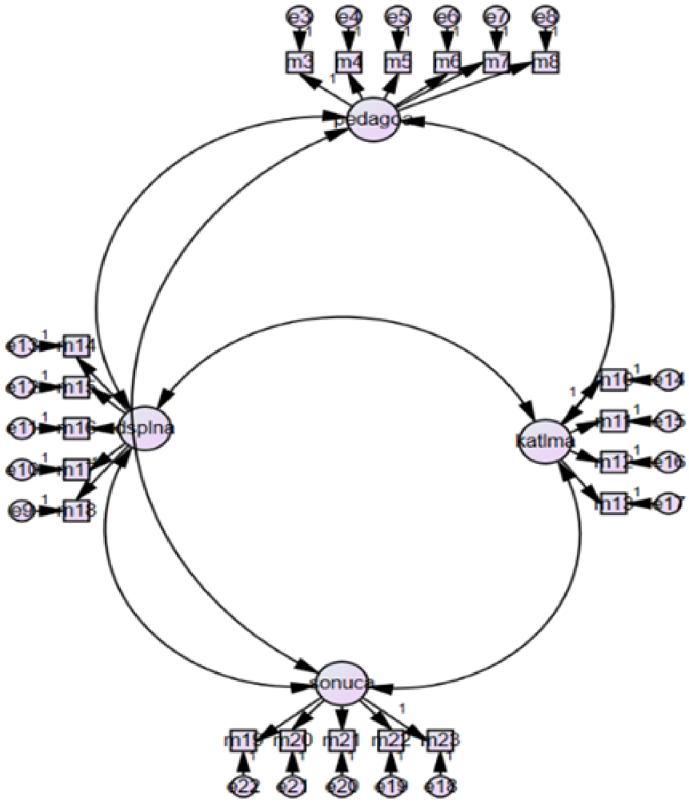

Figure 2. *Screen Capture of the TESS in CFA*

Reliability Analysis Results of the TESS

Table 8 shows the reliability coefficients for the factors of the TESS, which range from .84 to .92. It is noted that the removal of items within the scale's factors does not significantly impact the reliability of these factors, thereby affirming the reliability of the items within each factor of the TESS.

Table 8. *Cronbach's Alpha Reliability Coefficients (α) of Factors When Items within the Scale Factors were Deleted*

Factor 1 α= .90		Factor 2 α= .92		Factor 3 α= .91		Factor 4 α= .84	
The KS		The DS		The ES		The OE	
Item	Item deleted α	Item	Item deleted α	Item	Item deleted α	Item	Item deleted α
m3	.89	m14	.89	m10	.89	m19	.80
m4	.88	m15	.90	m11	.87	m20	.79
m5	.89	m16	.89	m12	.87	m21	.79
m6	.88	m17	.89	m13	.88	m22	.83
m7	.88	m18	.93			m23	.83
m8	.89						

Table 9. *Cronbach's Alpha Reliability Coefficients of the Turkish Version of the TESS*

Item	Item deleted α	Item	Item deleted α	Item	Item deleted α	Item	Item deleted α
m3	.92	m10	.92	m16	.92	m22	.93
m4	.92	m11	.92	m17	.92	m23	.92
m5	.92	m12	.92	m18	.92		
m6	.92	m13	.92	m19	.93		
m7	.92	m14	.92	m20	.92		
m8	.92	m15	.92	m21	.92		

Table 9 shows that the overall reliability coefficient for the adapted Turkish version of the TESS is .93.

The results from the EFA and CFA, as detailed in Table 9, indicate that all 20 remaining items should be retained in the TESS, despite the removal of 3 items. Some items of the adapted Turkish final version of TESS were presented in Appendix 1.

Teaching Engineering Self-Efficacy Beliefs of Science Teachers by Gender

Table 10. *Descriptive Statistical Findings Regarding Science Teachers' TES Beliefs based on Gender*

Dependent Variable	Gender	Mean	Std. Deviation	N
The TES	Female	88,62	12,85	136
	Male	87,38	13,32	85
	Total	88,14	13,02	221
The KS	Female	23,25	5,91	136
	Male	23,16	5,52	85
	Total	23,22	5,75	221
The DS	Female	24,19	3,74	136
	Male	24,18	3,85	85
	Total	24,19	3,77	221
The ES	Female	19,03	2,79	136
	Male	18,58	3,56	85
	Total	18,86	3,11	221
The OE	Female	22,15	4,16	136
	Male	21,46	4,32	85
	Total	21,88	4,22	221

Table 10 provides a comparison of the average scores obtained by male and female science teachers on the TESS and its subscales. It is evident from the table that the average scores of male and female science teachers are closely aligned.

Table 11. *MANOVA Results Obtained from Comparing Science Teachers' TES Beliefs based on Gender*[a]

Dependent Variable	Within-subject effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared η^2
The TES	Gender	Wilk's lambda	,983	,922[a]	4,000	216,000	,452	,017

a. Exact statistic

Table 11 shows the MANOVA results, indicating no significant difference in the mean scores of science teachers on the TESS sub-dimensions based on gender [$\Lambda = 0.983$; $F(4, 216) = 0.922$; $p > 0.05$, partial eta squared (η^2) = 0.017]. The η^2 value suggests that only 1.7% of the variance in science teachers' TESS scores is attributable to gender. According to Cohen's guidelines (1988), with eta squared values of 0.01 being considered small, 0.06 as medium, and 0.14 as large (Cohen, 1992), the effect size for gender on the TESS scores falls into the category of a weak effect. The MANOVA results do not show statistically significant differences in the TESS scores of science teachers based on gender.

Teaching Engineering Self-Efficacy Beliefs of Science Teachers Based on Their Status of Receiving Engineering Education

Table 12. *Descriptive Statistical Findings Regarding Science Teachers' TES Beliefs Based on Their Status of Receiving Engineering Education*

Dependent Variable	Receiving Engineering Education	Mean	Std. Deviation	N
The TES	Yes	97,07	11,73	14
	No	87,54	12,90	207
	Total	88,14	13,02	221
The KS	Yes	28,00	4,19	14
	No	22,89	5,70	207
	Total	23,22	5,75	221
The DS	Yes	24,64	3,97	14
	No	24,15	3,77	207
	Total	24,19	3,77	221
The ES	Yes	20,64	2,41	14

	No	18,73	3,12	207
	Total	18,86	3,11	221
	The TES	The TES	The TES	The TES
The OE	No	21,75	4,18	207
	Total	21,88	4,22	221

Analysis of Table 12 reveals that science teachers who have received engineering education tend to have higher average scores on the TESS and its sub-factors, compared to those who have not received engineering education. For example, the average TESS scores of science teachers with an engineering background *(M* = 97.07) are notably higher than those of their counterparts without an engineering education (*M* = 87.54).

Table 13. *MANOVA Results Obtained from Comparing Science Teachers' TES Beliefs Based on Their Status of Receiving Engineering Education [a]*

Variable	Within-subject effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared η^2
The TES	Receiving engineering education	Wilk's lambda	.946	3.091[a]	4.000	216.000	.017	.054

a. Exact statistic

Upon analyzing Table 13, the MANOVA results reveal a significant difference in the mean scores of science teachers on the sub-dimensions of the TESS based on their engineering education status [$\Lambda = 0.946$; F (4, 216) = 3.091; $p < 0.05$, partial eta squared (η^2) = 0.054]. The partial η^2 value suggests that 5.4% of the variability in TESS scores among science teachers is attributable to whether or not they received engineering education. According to Cohen's categorization (1988), this effect size falls into the weak effect category, with 0.01 indicating a small effect, around 0.06 a medium effect, and values around 0.14 interpreted as large effects (Cohen, 1992). The significant differences found in the MANOVA led to subsequent Analysis of Variance (ANOVA) tests to determine in which sub-dimensions of the TESS these differences occur. The ANOVA was adjusted using Bonferroni corrections, and with the TESS consisting of four sub-factors, the alpha level was set at 0.008 (Cevahir, 2020). Table 14 presents the ANOVA results for each sub-dimension of the TESS.

Table 14. *ANOVA Results Obtained for the Sub-Factors of the TESS Based on Science Teachers' Engineering Education Status*

Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared η^2
The TES	1192.245	1	1192.245	7.235	.008*	.032
The KS	341.913	1	341.913	10.802	.001*	.047
The DS	3.126	1	3.126	.219	.640	.001
The ES	47.766	1	47.766	5.030	.026	.022
The OE	54.149	1	54.149	3.062	.082	.014

* Significant difference

Table 14 reveals that a significant difference was found only in the KS sub-factor of the TESS, favoring science teachers who have received engineering education ($F(1, 219) = 10.802$; $p < 0.008$; partial eta squared (η^2) = 0.047). For the DS ($F(1, 219) = 0.219$; $p > 0.008$; $\eta^2 = 0.001$), ES ($F(1, 219) = 5.030$; $p > 0.008$; $\eta^2 = 0.022$), and OE ($F(1, 219) = 3.062$; $p > 0.008$; $\eta^2 = 0.014$) sub-factors of the TESS, no significant differences were found. The partial η^2 value for the KS sub-factor indicates that 4.7% of the variability in the TESS KS sub-factor scores of science teachers is attributable to the variable of receiving engineering education.

Science Teachers' Teaching Engineering Self-Efficacy Beliefs Based on the Provision of Engineering Education in Their Classes

Table 15. *Descriptive Statistical Findings Regarding Science Teachers' TES Beliefs Based On Their Status Of The Provision Of Engineering Education In Their Classes*

Dependent Variable	Provision of Engineering Education in Their Classes	Mean	Std. Deviation	N
The TES	Yes	98,76	10,35	29
	No	86,65	12,58	191
	Total	88,25	12,95	220
The KS	Yes	27,62	4,00	29
	No	22,60	5,67	191
	Total	23,26	5,73	220
The DS	Yes	25,76	3,40	29
	No	23,96	3,78	191
	Total	24,20	3,78	220
The ES	Yes	19,97	3,27	29
	No	18,72	3,04	191
	Total	18,88	3,09	220
The OE	Yes	25,41	3,53	29
	No	21,38	4,06	191
	Total	21,91	4,22	220

Upon reviewing Table 15, it is evident that science teachers who incorporate engineering education into their classes have higher average scores on the TESS and all its sub-factors compared to those who do not. For example, the average score of science teachers who include engineering education in their classes (M = 98.76) was significantly higher than that of teachers who do not (M = 86.65).

Table 16. *MANOVA Results Obtained from Comparing Science Teachers' TES Beliefs Based on the Provision of Engineering Education in Their Classes*[a]

Variable	Within-subject effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared η^2
The TES	Provision of engineering education in their classes	Wilk's lambda	.867	8.256[a]	4.000	215.000	.000	.133

a. Exact statistic

Analysis of Table 16 reveals that the MANOVA results show a significant difference in the mean scores of science teachers on the sub-dimensions of the TESS based on whether they provide engineering education in their classes [Λ= 0.867; F (4, 215) = 8.256; p < 0.05, partial eta squared (η^2) = 0.133]. The partial η^2 value suggests that 13.3% of the variance in science teachers' TESS scores is attributable to the inclusion of engineering education in their classes. Based on Cohen's categorization (1988), this effect size falls into the medium category, with eta squared values of 0.01 considered small, around 0.06 as medium, and values near 0.14 as large effects (Cohen, 1992). Given these significant MANOVA findings, subsequent Analysis of Variance (ANOVA) tests were performed to identify in which sub-dimensions of the TESS these differences occur. These ANOVA tests were adjusted using Bonferroni corrections, setting the alpha level at 0.008 due to the TESS consisting of four sub-factors (Cevahir, 2020). The ANOVA results for each sub-dimension of the TESS are detailed in Table 17.

Table 17. *ANOVA Results Obtained for The Sub-Factors of the TESS Based on Science Teachers' Provision of Engineering Education in Their Classes*

Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared η^2
The TES	3691,938	1	3691,938	24,352	,000*	,100
The KS	635,446	1	635,446	21,140	,000*	,088
The DS	81,620	1	81,620	5,847	,016	,026
The ES	39,229	1	39,229	4,164	,042	,019
The OE	410,289	1	410,289	25,688	,000*	,105

* significant difference

Analysis of Table 17 indicates that significant differences were found only in the KS (F(1, 218) = 21.140; p

< 0.008; partial eta squared (η^2) = 0.088) and OE (F(1, 218) = 25.688; p < 0.008; η^2 = 0.105) sub-factors of the TESS, favoring science teachers who incorporate engineering education in their classes. No significant differences were observed in the DS (F(1, 218) = 5.847; p > 0.008; η^2 = 0.026) and ES (F(1, 218) = 4.164; p > 0.008; η^2 = 0.019) sub-factors. The partial η^2 value for the KS sub-factor suggests that 8.8% of the variability in the KS scores of the TESS for science teachers is attributable to the variable of providing engineering education in their classes.

Engineering Teaching Self-Efficacy Beliefs of Science Teachers Based on Subject Specialization Variable

Table 18. *Descriptive Statistical Findings Regarding Science Teachers' TES Beliefs based on Branch Variable*

Dependent Variable	Branch	Mean	Std. Deviation	N
The TES	Biology	84,27	13,72	52
	Elementary Science	91,30	11,75	76
	Physic	88,72	13,23	46
	Chemistry	86,74	13,03	47
	Total	88,14	13,02	221
The KS	Biology	21,85	6,07	52
	Elementary Science	24,87	5,45	76
	Physic	23,35	5,31	46
	Chemistry	21,94	5,74	47
	Total	23,22	5,75	221
The DS	Biology	23,02	4,05	52
	Elementary Science	25,15	3,32	76
	Physic	24,11	3,67	46
	Chemistry	24,00	3,96	47
	Total	24,19	3,77	221
The ES	Biology	17,96	3,30	52
	Elementary Science	19,45	2,82	76
	Physic	18,87	2,94	46
	Chemistry	18,87	3,37	47
	Total	18,86	3,11	221
The OE	Biology	21,44	4,25	52
	Elementary Science	21,84	4,28	76
	Physic	22,39	4,60	46
	Chemistry	21,94	3,78	47
	Total	21,88	4,22	221

Analysis of Table 18 reveals that the average scores for both the TESS and all its sub-factors are higher for elementary science teachers compared to biology, physics, and chemistry teachers. For instance, the mean score of elementary science teachers (*M* = 98.76) exceeded the average TESS scores of biology (*M* = 84.27), physics (*M* = 88.72), and chemistry teachers (*M* = 86.74). Table 18 also shows a comparison of the total average scores of teachers' TES beliefs and the average scores in the TESS's KS, DS, ES, and OE sub-factors across different specializations. It was observed that elementary science teachers had the highest average scores, while biology teachers had the lowest. Furthermore, the average score of physics teachers was above the overall average, while the average score for chemistry teachers fell below the overall average.

Table 19. *MANOVA Results Obtained From Comparing Science Teachers' TES Beliefs based on Their Branches[a]*

Variable	Within-subject effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared η^2
The TES	Branch	Wilk's lambda	.882	2.300	12.000	566.5	.,007*	.041

a. Exact statistic

Upon reviewing Table 19, the MANOVA results show a significant difference in the mean scores of science teachers on the sub-dimensions of the TESS based on their specializations [Λ= 0.882; F (12, 566.5) = 2.300; p < 0.05, partial eta squared (η^2) = 0.041]. This partial η^2 value indicates that 4.1% of the variance in TESS scores among science teachers can be attributed to their branches. Based on Cohen's classification (1988), this effect size is categorized as medium, with eta squared values of 0.01 considered small, around

0.06 as medium, and values near 0.14 as large effects (Cohen, 1992). Given these significant MANOVA findings, subsequent ANOVA tests were performed to identify which sub-dimensions of the TESS these differences occur in. These ANOVA tests were adjusted using Bonferroni corrections, setting the alpha level at 0.008 due to the TESS consisting of four sub-factors (Cevahir, 2020). Table 20 presents the ANOVA results for each sub-dimension of the TESS.

Table 20. *ANOVA Results Obtained for the Sub-Factors of the TESS based on Science Teachers' Branches*

Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared η^2
The TES	1646.119	3	548.706	3.341	.020	.044
The KS	382.878	3	127.626	4.019	.008*	.053
The DS	142.548	3	47.516	3.452	.017	.046
The ES	68.203	3	22.734	2.396	.069	.032
The OE	22,244	3	7.415	.412	.744	.006

* significant difference

Analysis of Table 20 indicates that a significant difference was found only in the KS sub-factor of the TESS ($F(3, 217) = 127.626$; $p < 0.008$; partial eta squared (η^2) = 0.053), favoring the group of elementary science teachers.

DISCUSSION AND CONCLUSION

The adaptation of the TESS into Turkish was achieved through expert feedback and correlation analyses to ensure linguistic equivalence. The experts' endorsements of the scale's final version for research use, along with high correlation coefficients obtained by applying the TESS items in both languages, established significant relationships and confirmed the TESS's linguistic equivalence. Similar approaches have been utilized in scale adaptation studies as seen in the literature (Aksoy, Akbaş & Seferoğlu, 2018; Deryakulu & Büyüköztürk, 2002). The psychometric properties observed in the Turkish adaptation of the TESS indicate its suitability for research in Turkey. The EFA and CFA results affirm the structural validity of the TESS. The high Cronbach's alpha reliability coefficient for the adapted Turkish version (α= .926) signifies that the scale is highly reliable. Therefore, it is concluded that the Turkish-adapted TESS is a valid and reliable instrument.

The findings from the TESS in this study reveal no significant difference in the TES of science teachers in relation to their gender. This suggests that gender does not influence teaching engineering self-efficacy. While this absence of gender impact on TES can be seen positively, it might also be attributed to both male and female teachers having limited experience in engineering education. Hammack and Ivey (2017) noted that male K-5 teachers in elementary education exhibited higher TES than their female counterparts, possibly due to gender roles and family expectations, reflecting teachers' limited experiences in engineering. The lack of differences in TES between male and female teachers is viewed positively, indicating that female teachers believe in their ability to teach engineering as effectively as male teachers. The presence of female teachers adept at meeting 21st-century educational demands is encouraging for the future. There is a prevalent stereotype of engineering as a male-dominated field (Knight & Cunningham, 2004), which also influences children's perceptions. For example, Öztürk-İrtem and Hastürk (2021) found that middle school students typically depicted engineers as male. Similarly, Gülhan and Şahin (2018) observed that middle school students view engineering as a male profession, and this perception of female engineers decreases as students advance in grades. Nacaroğlu and Arslan (2020) also found that gifted students predominantly perceive engineering as a male-dominated profession. Altering traditional views of engineering in society requires educational interventions (Ergün & Kıyıcı, 2019). In this context, the absence of gender differences in TES among teachers responsible for delivering this education is a positive sign.

In this study, it was found that the TES beliefs of teachers who have received engineering-related education were higher compared to those without such education. Self-efficacy beliefs of individuals can be influenced by educational experiences. The TES beliefs of teachers and teacher candidates can be positively affected through in-service or pre-service engineering education. For example, Yoon et al. (2013) discovered that a professional development program enhanced class teachers' understanding of the Engineering Design Process, with participants expressing satisfaction with the program. Lakin et al. (2019) noted significant improvements in the TES of teachers who underwent engineering-related training. Guzey et al. (2014) showed that most class teachers in professional development programs were capable of effectively integrating and proficiently implementing engineering lessons. Therefore, it is concluded that engineering education has a positive impact on teachers' TES beliefs.

Teachers who provide engineering education exhibit higher TES beliefs compared to those who do not. This indicates that the experience of implementing engineering education in the classroom contributes to elevated TES beliefs. According to Bandura (1997), the most influential source on self-efficacy is successful or positive experiences. This research also found that teachers actively implementing engineering education in their classes possess higher self-efficacy beliefs. Therefore, it is inferred that teachers' experiences significantly impact their self-efficacy beliefs and their ability to perform related actions.

In this study, a comparison of TES beliefs among teachers from different fields revealed that elementary science teachers possess higher TES beliefs. This higher level of TES beliefs among science teachers might be due to their increased exposure to engineering education, as shown in Table 2. Teachers with engineering education background are more effective in integrating engineering disciplines into their classes, which positively impacts their TES beliefs (Guzey et al., 2014; Lakin et al., 2019; Perkins-Coppola, 2019). In the sub-factors of the Teaching Engineering Self-Efficacy Scale (TESS), it was observed that the mean scores of science and biology teachers favor science teachers, but only in the KS factor. No significant differences based on the fields were found in the DS, ES, and OE sub-factors of the TESS. The higher scores of elementary science teachers in the KS sub-factor could be attributed to engineering education being included in the science curriculum in Turkey (MoNE, 2018a), whereas direct engineering education is absent in the physics, chemistry, and biology curricula (MoNE, 2018b; 2018c; 2018d). The absence of differences in the ES and OE sub-factors among science teachers might be due to their limited experience in implementing engineering education in their classes. Although there is no separate engineering education course in middle schools, the opportunity for such education was integrated into the science curriculum in Turkey in 2018 (MoNE, 2018a). Hammack and Ivey (2017) observed that classroom teachers participating in in-service training displayed low OE but high KS, ES, and DS beliefs. Their study also suggested that deficiencies in classroom management skills and teaching strategies could be addressed. Perkins-Coppola (2019) found that elementary teacher candidates involved in engineering education exhibited significant increases in KS, ES, and DS, but not in OE. During this training, candidates experienced being a student in a sample lesson, prepared an engineering lesson plan, and taught an engineering lesson, albeit only once. For improvements in OE, additional mastery experiences are required (Perkins-Coppola, 2019). Therefore, it is considered essential for teachers to engage in engineering education in their classes to enhance their TES beliefs across all aspects.

Suggestions

- In this research, TESS can be employed in various studies to assess the current state of teachers' TES beliefs and to evaluate the influence of engineering education on these beliefs. This study explored the TES beliefs of teachers in elementary science, physics, chemistry, and biology. Future research could extend to examining the TES beliefs of teachers in other disciplines such as social sciences, mathematics, arts, and those integrating STEM fields.

- The research utilized quantitative methods to gather data. Future studies could incorporate qualitative methods to complement the quantitative findings, providing a more comprehensive understanding of TES beliefs by integrating in-depth qualitative insights with quantitative data.
- Service training programs focused on engineering education could be developed for teachers across various disciplines, and the effect of these programs on teachers' TES beliefs could be investigated. Additionally, research could explore the TES beliefs of teacher candidates.
- Pre-service training programs designed to strengthen the TES beliefs of teacher candidates could be initiated. Organizing engineering-oriented practical activities and projects is recommended to bolster teachers' self-efficacy beliefs in engineering education.

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Appendix 1. Some Items of the Adapted Turkish Final Version of TESS

Açıklama: Bu ölçek, öğretmenlerin mühendislik öğretimine ilişkin öz yeterlik ifadelerini içermektedir. Ölçekte mühendislik öğretimi öz yeterliği; öğretmenlerin mühendislik öğretimine ilişkin inançlarının öğrencilerin mühendislik öğrenmelerini olumlu yönde etkilemesi olarak tanımlanmıştır. Lütfen aşağıdaki ifadeleri okuyarak ne düzeyde katılıp katılmadığınızı yanda bulunan harfleri işaretleyerek belirtiniz. [Directions: This survey contains statements about teachers' teaching engineering self-efficacy. Here, teaching engineering self-efficacy is defined as teachers' personal belief in their teaching engineering ability to positively affect student learning of engineering. Please indicate the degree to which you agree or disagree with each statement below by marking on the appropriate letters to the right of each statement.]	KK=Kesinlikle katılmıyorum (SD = Strongly Disagree) PK= Pek Katılmıyorum (MD = Moderately Disagree) NN= Ne katılıyorum ne katılmıyorum (D = Disagree slightly more than agree) AK=Az katılıyorum (A = Agree slightly more than disagree) OK =Orta düzeyde katılıyorum (MA = Moderately agree) KA=Kesinlikle Katılıyorum (SA = Strongly agree)
1.Mühendisliğin günlük hayatımla nasıl ilişkili olduğunu tartışabilirim. (I can discuss how engineering is connected to my daily life.)	KK PK NNNAAKOOK KKA
2.Tüm konu alanlarındaki mühendislik kavramlarını ayırt edip anlayabilirim. (I can recognize and appreciate the engineering concepts in all subject areas.)	KK PK NN AAKOOK KKA
3.Sınıfıma mühendislik dersleri planlamak için gerekli zamanı ayırabilirim. (I can spend the time necessary to plan engineering lessons for my class.)	KK PK NNNAAKOOK KKA
4. Mühendislik etkinliklerini sınıfımda etkili bir biçimde kullanabilirim. (I can employ engineering activities in my classroom effectively.)	KK PK NNNAAKOOK KKA
5.Öğrencilerim için mühendislik hakkında yararlı sorular hazırlayabilirim. (I can craft good questions about engineering for my students.)	KK PK NNNAAKOOK KKA