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Investigation of Secondary School Students' Self-Efficacy for STEM Activities[1]

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Abstract

The STEM education approach aims to raise qualified individuals who can create global competitiveness. The high self-efficacy of the students in STEM disciplines will ensure that the goals are achieved smoothly. This research was aimed to develop a valid and reliable scale that can measure secondary school students' self-efficacy towards STEM activities. In addition, it was aimed to examine secondary school students' self-efficacy towards STEM activities in terms of different variables. The research, in which the survey design was used, was conducted with 786 (N1=445; N2=341) secondary school students. "STEM Activities Self-Efficacy Scale (STEM-ASES)" was developed, in which the $\chi 2$/df value and the model-structure fit perfectly and it fits well according to the CFI and TLI values with a reliability coefficient of (0.939). In addition, as a result of the research, it was stated that the secondary school students' STEM activities self-efficacy scores did not show a statistically significant difference according to the variables of gender, school type, class level and frequency of technological use. However, it was stated that the students' self-efficacy in STEM activities differed statistically according to their achievement scores.

INTRODUCTION

The 21st century emerges as the era in which the world rotates much faster in scientific and technological terms. In order for countries to have a say in the international arena, they need to keep pace with the new world order both individually and socially. At this point, qualified workforce in different fields has become more important for nations (Karakaya & Avgin, 2016; Bahçepınar, 2023). As a matter of fact, when the main aims of education are examined, it is seen that it is aimed to raise individuals who follow scientific and technological developments and to develop creative, questioning, critical thinking and communication skills of these individuals (Timur & Belek, 2020). Both these important shifts in the targets of the countries and the changes in the target behaviors expected from the individuals have caused radical changes in the education systems and in recent years, an understanding of education that combines different disciplines such as science, technology, engineering and art has begun to be accepted (Aşılıoğlu & Yaman, 2020). In accordance with these developments, it is seen that many countries have made improvements, updates and radical changes in their education systems and curricula (Savran Gencer et al., 2019). When we look at the education system from the perspective of Turkey, it is seen that there have been significant changes in recent years. Especially when the science course curriculum is examined, it is seen that new approaches were adopted, and different learning outcomes were targeted by making some updates in 2005, 2013 and 2017 (MoNE, 2018). Çakıcı (2013) emphasized that with the changes made in the education systems of the countries, they plan to train students as "science/nature" personalities with scientific thinking skills. One of the educational arrangements made in this context is the integration of science, technology, engineering and mathematics with an interdisciplinary approach (Aşılıoğlu & Yaman, 2020; Karakaya & Yılmaz, 2022). Many Asian and European Union countries, led by the United States of America, have started to implement STEM (Science-Technology-Engineering-Mathematics) education at different school levels in order to create a social structure that is suitable for current approaches (Karakaya, 2021; Yılmaz et al., 2017).

Literature review

STEM education approach and its importance

The 21st century can be defined as an era in which many innovations and developments are integrated into human life. In this century, the need for individuals who can think critically and innovatively, know how to use technology while accessing information, who have high self-efficacy, are productive, inquisitive and understand technology has increased (Uluyol & Eryılmaz, 2015). Countries have added different technological applications to their programs by making updates in their education programs over the years. In the 2023 vision document published by MoNE, it sees its main goal as educating individuals with the knowledge and skills that it foresees to be needed in today's conditions and in the future, called 21st century skills (MoNE, 2018). The emergence and development of the STEM education approach were influenced by combining different disciplines (Sungur Gül et al., 2022) and the need of countries for a qualified workforce (Tekerek & Karakaya, 2018).

It is known that the concept of STEM was first used in history in 2001 by Judith A. Ramaley, who was the director of the Education and Human Resources department of the American National Science Foundation (Koonce et al., 2011). The National Science Association first used the expression "SMET" as the abbreviation of the initials of science, technology, engineering and mathematics disciplines, but this expression was later converted to "STEM" (Sanders, 2009; Er & Acar, 2020). STEM is a teaching approach that removes the barriers between science, technology, engineering and mathematics and suggests that all fields should be considered together (Wang, 2012). There are different explanations in the literature regarding the definition of the STEM concept. For example, Bybee (2010) defined STEM as an approach to make connections between different disciplines. Sanders (2009), STEM education is the collocation of multiple disciplines. According to Gonzalez and Kuenzi (2012), STEM is an interdisciplinary approach that covers all teaching processes from pre-school to higher education. STEM is to find solutions to the situations encountered related to the engineering field by using knowledge in science and mathematics disciplines with the help of the technology field (Kennedy & Odell (2014). According to Yıldırım (2013), STEM is an approach that keeps individuals’ dynamic for the learning field, enables them to reach their goals and reflect the knowledge they have learned to life.

Self-Efficacy for STEM Activities

Self-efficacy was first defined in the Social Cognitive Learning Theory put forward by Albert Bandura in 1977 (Bıkmaz, 2004; Ekici, 2009; Senemoğlu, 2007). Bandura (1986), defined self-efficacy as the thoughts belonging to the ability of the individual to make the necessary plans in order to achieve a situation and to put the necessary actions into practice in line with this plan. According to Senemoğlu (2007), self-efficacy is the individual's thoughts about himself in order to be successful in the face of possible difficulties that may arise in the future. In addition, self-efficacy can be defined as individuals' judgments about how successful they will be by managing their own performance (Holden & Rada, 2011). Considering the common points of these self-efficacy definitions, it can be concluded that self-efficacy is a person's belief in himself. As a matter of fact, even if individuals have sufficient knowledge and experience in a subject, if they have low self-efficacy beliefs that they will be successful, they are more likely to fail (Gawith, 1995). An individual's self-efficacy belief affects his perspective on work, the energy he will spend, his reaction according to whether the result is successful or unsuccessful, and what attitude they show in negative situations (Duman, 2017). Bandura (1977) stated that individuals with high self-efficacy behave differently and stated that the performance of the individual's behaviors can be predicted by looking at their self-efficacy status. The low self-efficacy of individuals causes them to be uneasy about the problems they encounter, to avoid dealing with them again when the desired result is not achieved, to experience insecurity, and to remain passive in their studies (Korkmaz, 2011).

In order to achieve the targeted gains in STEM activities, students' attitudes, awareness and self-efficacy towards STEM disciplines must be high. For STEM activities, self-efficacy perception is the belief that individuals have about the work plan of the activities they will do in STEM, the implementation of the application and whether the application can be evaluated or not (Karakaya & Yılmaz, 2022). If individuals want to acquire skills and competencies, self-efficacy should be supported (Akkoyunlu & Kurbanoğlu, 2003). Students' high self-efficacy in STEM may increase their interest in STEM subjects, may cause them to prefer STEM-related professions, and may also cause them to make academic choices about STEM (Sheu et al., 2010). Uğraş (2019) stated that the high self-efficacy and attitudes of students towards STEM fields also cause students' high interest in STEM professions. It is considered important that students have high self-efficacy in providing meaningful learning in STEM activities and in identifying and supplying the necessary materials (Hacıömeroğlu, 2020). STEM education is an approach that improves students' engineering skills and increases their academic success and interest in STEM professions (Katehi, Pearson, & Feder, 2009). From this perspective, it can be concluded that students' high STEM self-efficacy will increase their preference for professions in these fields. Achieving success in STEM depends on the high STEM self-efficacy of both teachers and students (Öztürk, 2019). Because individuals can use the knowledge of different disciplines together, create an exemplary model, and develop different models by blending their existing knowledge in engineering applications that they use while performing STEM activities with newly acquired knowledge (Yıldırım & Altun, 2015). While making these practices, individuals with high self-efficacy can reach their goals without giving up and relying on themselves.

The Purpose of Research

This research aimed to develop a measurement tool that can measure the self-efficacy of secondary school students towards STEM activities and to examine the students' self-efficacy in terms of different variables. This research focused on the variables of gender, school type, grade level, frequency of technology use and academic achievement score.

METHOD

Study Design

The scanning model was used in this research. According to Karasar (2006), the survey model is a system of surveys made on the population or a sample selected from the population in order to evaluate the population that contains many different variables in its structure. In addition, the survey model is research on a multi-component universe, the entire universe, or a sample taken from it in order to evaluate the universe as a whole.

Participants

In the 2022-2023 academic years, the research was carried out with the participation of students studying at different educational institutions. The institutions where the participants studied are located in a province in the Central Anatolia region of Turkey. The research, in which the appropriate sampling method was used, was carried out on a voluntary basis and taking into account the rule of "at least five times the number of items" (Tavşancıl, 2006) According to Büyüköztürk (2010, p.92), the convenient sampling method is; the preferred method because of its easy accessibility and applicability in cases where there are limitations in terms of time, financial opportunities and working conditions of the researcher. In this research, convenient sampling method was preferred in order to provide easy access to individuals. Descriptive statistics for the research groups are presented in Table 1.

Table 1. Descriptive information about the participants

		EFA group		CFA group	
Demographic Characteristic		N	%	N	%
Gender	Female	277	62.2	165	48.4
	Male	168	37.8	176	51.6
Type of school	State	303	68.1	233	68.3
	Private	142	31.9	108	31.7
Grade level	5	99	22.2	60	17.6
	6	110	24.7	57	16.7
	7	115	25.8	81	23.8
	8	121	27.2	143	41.9
Frequency of technology use	Sometimes	140	31.5	63	18.5
	Usually	230	51.7	202	59.2
	Very often	75	16.9	76	22.3
Achievement score	0-69	59	13.3	46	13.5
	70-84	155	34.8	97	28.4
	85-100	231	51.9	198	58.1
Total		445	100.0	341	100.0

As is seen in Table 1, 62.2% (N=277) of the students (N= 445) who participated in the exploratory factor analysis process of the research were female and 37.8% (N= 168) were male. A total of (N= 341) students, 48.4% (N=165) female and 51.6% (N= 176) male, participated in the confirmatory factor analysis process.

Data Collection

The development process of the scale is given in Figure 1. In the process of creating the item pool, the opinions of the teachers who actively applied STEM activities were taken. In addition, studies in the related literature (for example, Eroğlu & Bektaş, 2016; Evans, 2015; Hsu et al., 2011; Karakaya & Yılmaz, 2022) were analyzed. Afterward, a draft scale form consisting of 40 items was prepared that will enable to evaluate STEM activities from different perspectives. In order to create the form and ensure its validity some opinions were taken from experts working in different fields (2 academicians who are experts in the field of STEM, 1 Turkish expert to check their language skills and comprehension, and a teacher with a rich experience in actively doing STEM activities in this field). In accordance with the received opinions, six questions in the item pool were removed and a draft scale form consisting of 34 questions was created. In this research, a value of 0.32 was accepted as the lower limit of factor load in item selection with principal component analysis. Because 0.32 represents 10% of the variance explained by that item (Selçuk, 2019). It was decided when the items would be removed from the scale, based on the analysis results (item-total test correlation, exploratory factor analysis, Cronbach's α coefficient) and expert opinion. In co-items, the inclusion process of items with high correlation coefficients was followed. Items that did not meet the specified criteria were not included in the draft scale. After the items were removed, exploratory factor analysis was applied again to investigate the changes in the factor structure of the scale continuously.

1.	• Scanning the literature
2.	• Creation of the item pool
3.	• Ensuring content and face validity
4.	• Creation of the draft scale form
5.	• Making the first application
6.	• Making the item analysis
7.	• Ensuring construct validity
8	• Making the second application
9.	• Ensuring construct validity
10.	• Calculating credibility

Figure 1. Scale development steps

Data Anaylsis

The data obtained within the scope of the research were analyzed using a statistical package program. Skewness and kurtosis values were calculated for the assumption of normality of the data. According to the data obtained from the scale, the values of Skewness [-.527] and kurtosis [.155] were calculated. Tabachnick and Fidell (2013) emphasized that skewness and kurtosis values should be between ±1.5 in order to state that the data obtained in a study show normal distribution. Since the normality conditions were met, parametric tests were used in the data analysis of the research.

Ethics

Participants of this study were selected on a voluntary basis. In addition, they were informed both verbally and in written form that their data would only be used for scientific purposes. Anonymity was ensured by giving pseudonyms to the participants. In addition, the ethics committee approval was obtained before starting the study, and as a result of the audit, approval was obtained for the study with the report from Yozgat Bozok University Social and Human Sciences Ethics Committee' dated 19.10.2022 and numbered 37/26.

FINDINGS

In this section, the findings are presented respectively in accordance with the aims of the research. In the research, firstly, findings for developing a valid and reliable scale that can measure secondary school students' self-efficacy for STEM activities were given.

Development Findings of the Self-Efficacy Scale for STEM Activities

Item analysis and investigation of the factor structure of the scale

The item-total test correlations of 34 items in the draft scale form are given in Table 2.

Table 2. Item-total score correlation values of the draft scale

Item	Correlation Coefficients	Item	Correlation Coefficients	Item	Correlation Coefficients
I1	0.695**	I13	0.680**	I25	0.667**
I2	0.661**	I14	0.656**	I26	0.666**
I3	0.655**	I15	0.444**	I27	0.650**
I4	0.637**	I16	0.629**	I28	0.687**
I5	0.678**	I17	0.685**	I29	0.648**
I6	0.649**	I18	0.584**	I30	0.677**
I7	0.662**	I19	0.644**	I31	0.584**
I8	0.562**	I20	0.674**	I32	0.723**
I9	0.703**	I21	0.673**	I33	0.667**
I10	0.656**	I22	0.635**	I34	0.713**
I11	0.701**	I23	0.714**		
I12	0.656**	I24	0.543**		

*p<.05 **p<.01; I: Item

When the table was examined, it was seen that all items were within acceptable values. In this context, items with high correlation coefficients were determined from the equivalent items in the scale (1-9, 2-25, 3-29, 4-16, 7-19, 11-23, 14-27, 20-34, 22-30) and it was decided that they should be in the form of a scale. Within this framework, the draft scale form consisting of 34 items was reduced to 25 items. Before starting the analysis of the data in the scale, Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity test results were evaluated to see if the data structure was suitable for factorization.

Table 3. Results of KMO and Bartlett Sphericity Test

KMO		.963
Bartlett Sphericity	Chi square test	5080.967
	Degree of freedom	300
	Significance level	.000*

*p<.01

When the table is examined, the KMO coefficient was calculated as (.963) and the Bartlett test was calculated as [$\chi2$=5080.967; p<.01)]. In the literature, for the KMO value, 0.60 (desired) was determined as the lower limit (Tabachnick & Fidell, 2013). Leech et al. (2005) defined the KMO value as "more than 0.80 is good, and higher than 0.90 is excellent for factor analysis". In the light of the results of the Bartlett sphericity test, it is possible to comment on the significant factorization of the data from the multivariate normal distribution and correlation matrix (Yurttaş Kumlu et al., 2017). It can be stated that the obtained data set is suitable for factor analysis.

EFA Results

The results obtained from the exploratory factor analysis (EFA) performed on the draft scale form (25 items) are given in Table 4.

Table 4. Factor analysis of the draft scale form and reliability results

	Factor Loads (EFA 1)			Factor Loads (EFA 2)		
Items	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
I6	.646			.637		
I7	.661			.654		
I8	.579			.591		
I9	.711			.715		
I10	.657			.655		
I12	.673			.677		
I13	.682			.685		
I14	.657			.651		
I16	.637			.642		
I17	.695			.708		
I18	.585			.594		
I21	.686			.688		
I23	.718			.724		
I25	.664			.659		
I26	.679			.680		
I28	.693			.699		
I30	.690			.696		
I31	.586			.587		
I32	.735			.740		
I33	.671			.678		
I34	.713			.726		
I3	.651		.383	-		
I5	.679		.323	-		
I15	.431	.717		-		
I24	.530	.444		-		
Eigenvalue (Total)	10.745	1.111	1.020	9.486	-	-
Explained Variance	42.981	4.445	4.078	45.170	-	-
Reliability (Cronbach Alfa)	0.944			0.939	-	-

When the table is examined, it has been determined that the draft scale form has a three-factor structure with an eigenvalue above 1.00. It was calculated that three factors with an eigenvalue greater than 1.00 explained 51,574% of the total variance. However, it was determined that some items gave load values to different factors (I3, I5, I15 and I24). For this reason, the relevant items were removed and EFA was performed again. When the literature is examined, if the variance explained by the first factor is 30% or more; it can be said that a scale has a one-dimensional structure (Büyüköztürk, 2010). The EFA results obtained within the scope of the research, the total variance explained by the first factor were calculated as 42.981%. It can be interpreted that the scale has a one-dimensional structure. In addition, the fact that the eigenvalue of the first factor is higher than the other factors also supports this interpretation. For this reason, I3, I5, I15 and I24 items were removed from the draft scale form and exploratory factor analysis was performed again. As a result, it was determined that the draft scale form had a single factor structure with an eigenvalue above 1.00. In addition, it was calculated that a single factor with an eigenvalue greater than 1.00 explained 45.170% of the total variance. The scree plot of the final form of the scale is given in Figure 2.

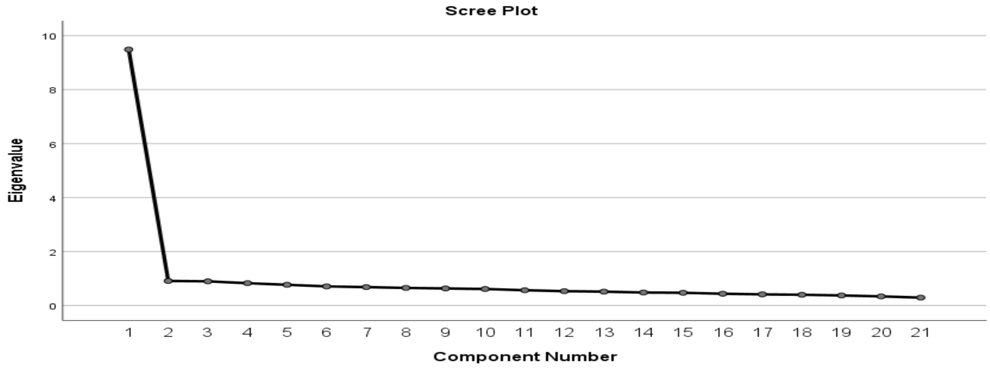

Figure 2. Eigenvalues of the components of the scale (scree plot)

CFA Results

Confirmatory factor analysis (CFA) was performed to verify the factor structure of the form obtained from EFA analysis. It was made using the lavaan (Rosseel, 2012) package over the R program. In addition, the semPlot (Epskamp, 2015) package was run for the image of the model. The R codes used in the analysis are given in Figure 3 and the standardized estimations of the model and variables (observed-implicit) established for the structure of the scale are given in Figure 4.

```
library(lavaan)
library(semPlot)

model <-"f1 =~ M1+M2+M3+M4+M5+M6+M7+M8+M9+M10+
          M11+M12+M13+M14+M15+M16+M17+M18+M19+M20+M21
          M10 ~~ M18
          M1  ~~ M6"

fit <- cfa(model, data = STEM)

summary(fit, standardized=TRUE,  ci=TRUE, fit.measures=TRUE)

modindices(fit, minimum.value = 10, sort = TRUE)

semPaths(fit, what = "paths", whatLabels = "par", layout = "tree",
      color = list(lat = rgb(245, 253, 118, maxColorValue = 255),
              man = rgb(155, 253, 175, maxColorValue = 255)),
              mar = c(10, 5, 10, 5))
```

Figure 3. R codes for Analysis (M: Item)

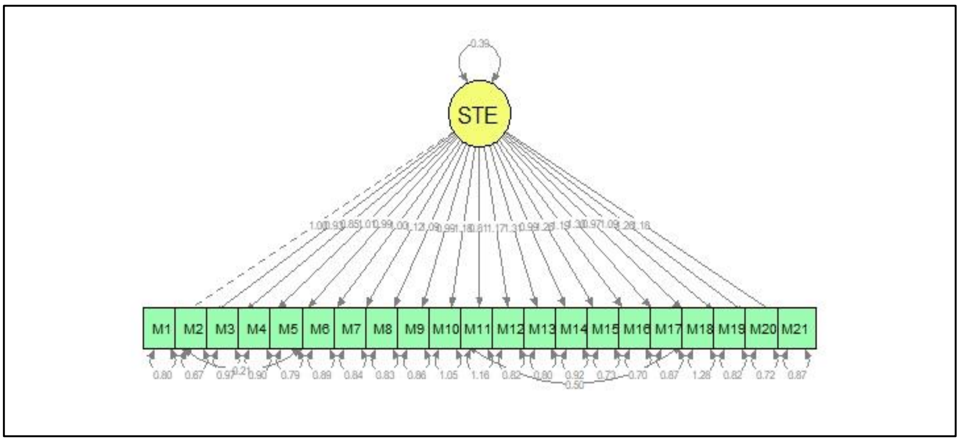

Figure 4. Structural equation modeling of the scale (M: Item)

When Figure 4 is examined, the structural equation modeling regarding the one-dimensional structure of the STEM Activities Self-Efficacy scale is seen. Error covariances were modified between the 1st and 6th items and the 10th and 18th items of the scale. In this way, new covariances were created for those with high covariance among the residual values of the items that reduced the fit of the model. The fit indices related to the results of the confirmatory factor analysis conducted within the scope of the research are given in Figure 5.

Fit Indexes	Perfect Fit Criterion	Acceptable Compliance Criteria	Calculated Values	Result
X^2/sd	0 – 3	3 – 5	1.817	Perfect fit
RMSEA	.00 ≤ RMSEA ≤ .05	.05 < RMSEA ≤ .10	0.049	Perfect fit
SRMR	.00 ≤ SRMR ≤ .05	.05 < SRMR ≤ .10	0.043	Perfect fit
CFI	.95 ≤ CFI ≤ 1.00	.90 ≤ CFI < .95	0.94	Good fit
TLI	.95 ≤ CFI ≤ 1.00	.90 ≤ CFI < .95	0.93	Good fit

Figure 5. Fit Indices for structural equation modeling of the scale

Since the RMSEA and SRMR values are between the desired values, the model-structure fit is perfect, It was determined that it showed good agreement according to CFI and TLI values.

Findings Obtained in the Analysis of Secondary School Students' Self-Efficacy on STEM Activities According to Different Variables

This research focused on the question *"Do the secondary school students' self-efficacy for STEM activities differ significantly according to demographic variables?"* In this context, the findings obtained from the sub-problems are given in order. In the research, the question to the "Do the secondary school students' self-efficacy towards STEM activities differ significantly by gender?" has been sought. The results of the one-way independent t-test analysis are given in Table 5.

Table 5. Results of one-way independent t-test analysis according to gender

Scale	Gender	N	$\bar{x}$	df	t	p
STEM-ASES	Female	165	76.20	339	1.085	.279
	Male	176	74.46			

*p<.05

When the table is examined, it was determined that the scores of secondary school students from the STEM activities self-efficacy scale ($t_{(339)}$=1.085; p>.05) did not differ significantly according to the gender variable.

In the research, the question to the *"Do the secondary school students' self-efficacy towards STEM activities differ significantly according to the type of school?"* has been sought as well. The results of the one-way independent t-test analysis are given in Table 6.

Table 6. One-way independent t-test analysis results according to school type

Scale	Type of school	N	$\bar{x}$	df	t	p
STEM-ASES	State	233	74.83	339	-.854	.394
	Private	108	76.31			

*p<.05

When the table was examined, it was determined that the scores of secondary school students from the STEM activities self-efficacy scale ($t_{(339)}$=-.854; p>.05) did not differ significantly according to the school type variable.

In the research, the answer to the question *"Do the self-efficacy of secondary school students towards STEM activities differ significantly according to grade level?"* has been sought. One-way analysis of variance (ANOVA) results are given in Table 7.

Table 7. ANOVA results for grade level

Factors		Sum of squares	df	Mean of squares	F	p
STEM-ASES	Between groups	818.409	3	272.803	1.239	.296
	In-group	74221.872	337	220.243		
	Total	75040.282	340			

*p<.05

When the table is examined, it is seen that the scores of secondary school students from the STEM activities self-efficacy scale [$F_{(3,337)}$= 1.239; p>.05] did not differ significantly according to the grade level variable.

In the research, the answer to the question *"Do the secondary school students' self-efficacy for STEM activities differ significantly according to the frequency of technology use?"* has been sought. One-way analysis of variance (ANOVA) results are given in Table 8.

Table 8. ANOVA results on the frequency of technology use

Factors		Sum of squares	df	Mean of squares	F	p
STEM-ASES	Between groups	214.378	2	107.189	.484	.617
	In-group	74825.904	338	221.378		
	Total	75040.282	340			

*p<.05

When the table is examined, it is seen that the scores of secondary school students from the STEM activities self-efficacy scale [$F_{(2,338)}$= .484; p>.05], it was determined that there was no significant difference according to the technology usage frequency variable.

In the research, the answer to the question *"Do the self-efficacy of secondary school students towards STEM activities differ significantly according to their achievement score?"* has been sought. One-way analysis of variance (ANOVA) results are given in Table 9.

Table 9. ANOVA results for achievement score

Factors		Sum of squares	df	Mean of squares	F	p	Tukey
STEM-ASES	Between groups	7005.022	2	3502.511	17.401	.000*	1<2 1<3
	In-group	68035.259	338	201.288			
	Total	75040.282	340				

*p<.05

When the table is examined, it is seen that the scores of secondary school students from the STEM activities self-efficacy scale [$F_{(2,338)}$= 17.401; p<.05] differed significantly according to the success score variable. According to the results of the Tukey test, it was determined that there was a significant difference in the scores of the students whose achievement level was between (70-84) and (85-100) in the self-efficacy scale for STEM activities compared to the students who were in the range of (0-69).

CONCLUSION, DISCUSSION AND SUGGESTIONS

In this research, it was aimed to develop a measurement tool that can measure the self-efficacy of secondary school students towards STEM activities and to examine the students' self-efficacy in terms of different variables. As a result, the "STEM Activities Self-Efficacy Scale (STEM-ASES)" consisting of 21 items that can measure self-efficacy for STEM activities has been developed. The scale items were scored as "5 = strongly agree", "4 = agree", "3 = undecided", "2 = disagree" and "1 = strongly disagree". The draft scale form (34 items) prepared during the scale development process was created with the participation of 445 secondary school students. The draft scale form, in which the item-total score correlation values were calculated, was obtained by taking the opinions of the experts and a structure consisting of 25 items. EFA was conducted by considering 25 items. As a result of EFA, 4 items that loaded different factors were removed from the draft scale form and the scale form (21 items) turned into a single-factor structure. Cronbach Alpha of the scale form in this structure was calculated as 0.939. In addition, it was determined that it explained 45.170% of the total variance. The scale form for CFA was applied to 341 secondary school students who did not participate in the first study. As a result, the scale provided a high degree in terms of both fit indices and model-structure fit. The reliability coefficient of the final scale was calculated as 0.916. It can be claimed that the developed scale can be used to determine the STEM activities self-efficacy of secondary school students. When the literature on the subject is examined, it is seen that Özdemir et al. (2018) developed a one-dimensional scale that can be used to determine teachers' self-efficacy for STEM applications. Additionally, Karakaya and Yılmaz (2022) stated that the scale they developed has a one-dimensional structure.

In the research, secondary school students' self-efficacy for STEM activities was examined in terms of gender variable. As a result of the research, it was determined that the gender variable did not make a statistically significant difference in the self-efficacy scores of secondary school students for STEM activities. According to these results, it can be said that the gender variable is not a factor affecting secondary school students' self-efficacy for STEM activities. Indeed, Brown et al. (2016) concluded that there was no significant difference according to gender in the study they conducted with secondary school students on STEM self-efficacy. Dadacan (2021) found in her study that there was no significant difference between pre-service teachers' self-efficacy regarding STEM teaching and their gender. Çevik et al. (2017) found that there was no significant difference between secondary school teachers' STEM awareness and gender. Aydin et al. (2017) stated in their study that there was no significant difference between students' attitudes towards STEM fields and their self-efficacy. In addition, in many studies on STEM, it is stated in the literature that the gender variable does not make a significant difference (Aşılıoğlu & Yaman, 2020; Özdemir & Cappellaro, 2020; Luo et al. 2021).

In the research, secondary school students' self-efficacy for STEM activities was examined in terms of school type variables. As a result of the research, it was determined that the school type variable did not make a statistically significant difference in the secondary school students' self-efficacy scores for STEM activities. According to these results, it can be said that the school type variable is not a factor affecting secondary school students' self-efficacy towards STEM activities. Ozyurt et al. (2018) in their studies investigating the attitudes of primary school students towards STEM, found that students' attitudes towards STEM differ in favor of students who go to private schools. However, in his study with middle school students, Bulut (2020) concluded that the STEM attitudes of the students did not differ according to the type of school. Aydin et al. (2017) compared the attitudes of public and private school students towards STEM in their study with secondary school students. As a result of the research, they determined that there was no significant difference between the attitudes of students attending public and private schools towards STEM. Karakaya et al. (2018) stated in their study with science teachers that there is no significant relationship between the type of school they work in and their awareness of the STEM education approach. Similarly, Şahin (2019) mentioned in her study that the professional competencies of teachers regarding the STEM education approach do not change according to the type of school they work in.

In the research, secondary school students' self-efficacy for STEM activities was examined in terms of grade level variables. As a result of the research, it was determined that the grade level variable did not make a statistically significant difference in the self-efficacy scores of secondary school students for STEM activities. According to these results, it can be said that the grade level variable is not a factor affecting secondary school students' self-efficacy for STEM activities. Gök (2022), in his study with secondary school students, found that students' attitudes towards STEM did not change according to grade level. In their study with BİLSEM students, who go to secondary school, Bircan and Köksal (2020) concluded that grade level does not statistically affect attitudes towards STEM disciplines. Balçın, Çavuş, and Topaloğlu (2018) stated in their study with secondary school students that there was no significant difference between students' grade levels and their attitudes towards STEM. However, unlike the research result, Unfried et al. (2014) found in their study with secondary and high school students that as the grade level increased, students' attitudes toward STEM increased positively.

In the research, secondary school students' self-efficacy for STEM activities was examined in terms of technology use frequency variable. As a result of the research, it was determined that the technology use frequency variable did not make a statistically significant difference in the secondary school students' self-efficacy scores for STEM activities. According to these results, it can be said that the variable of frequency of technology use is not a factor that affects secondary school students' self-efficacy towards STEM activities. As a matter of fact, Tekerek and Karakaya (2018) determined that there was no significant difference between pre-service science teachers' STEM awareness and the frequency of technology use. Demirtas and Eksioglu (2020) examined the relationship between pre-service teachers' STEM awareness and the level of information and communication technologies use. As a result of the research, they determined that there is a positive, significant but weak relationship between pre-service teachers' STEM awareness and their use of information and communication technologies.

In the research, secondary school students' self-efficacy for STEM activities was examined in terms of achievement score variable. As a result of the research, it was determined that the success score variable made a statistically significant difference in the self-efficacy scores of secondary school students for STEM activities. It was determined that the students in the range of achievement (0-69) had lower self-efficacy towards STEM activities than the students in the range of (70-84) and (85-100). According to these results, it can be said that the level of achievement is a factor that affects secondary school students' self-efficacy towards STEM activities. Bulut (2020) determined that the STEM attitudes of the students who have a success average between 70-84 and 85-100 differ significantly compared to the students with a success average of 1-50. In addition, in the study, it was determined that the STEM attitudes of the students with a success average of 70-84 and 85-100 differed significantly compared to students with a success average of 51-69. In her study, Dadacan (2021) concluded that there was no significant difference between pre-service teachers' self-efficacy regarding STEM teaching and their academic achievements.

Suggestions

As a result, it is important to carry out practice-oriented activities to improve secondary school students' self-efficacy for STEM activities. Examining the variables affecting students' self-efficacy in detail with their reasons is considered significant for the future of the practices.

Declaration

This research was produced from the master thesis completed by the first author under the supervision of the second author, which was completed in May 2023 at Yozgat Bozok University. Additionally, this study was presented as an oral presentation at the 14th Congress on New Trends in International Education.

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Annex-1 STEM Self-Efficacy Scale (Final Scale Form)

İtem Number	STEM Activities Self-Efficacy Scale (STEM-ASES)
1	I can create questions to evaluate the produced model.
2	I can identify problems in STEM activities.
3	I can use technological tools in STEM activities.
4	I can test whether the model I produced works.
5	I can develop projects using STEM activities.
6	I can evaluate the produced model in terms of usefulness
7	I can decide on the tools and equipment I will use in STEM activities.
8	I can develop multiple solution suggestions in STEM activities.
9	I can prepare a sample design for the solution of the problem in STEM activities.
10	I can do group work in STEM activities.
11	I can calculate costs in STEM activities.
12	I can tell you the shortcomings of the produced model.
13	I can list needs in STEM activities.
14	I can decide on the best solution in STEM activities.
15	I can use STEM activities in my projects.
16	I can check whether the model produced is fit for purpose.
17	I can explain the features of the developed product.
18	I can decide my model with my friends.
19	I can evaluate the produced model in terms of providing a solution to the problem.
20	I can evaluate the produced model in terms of efficiency.
21	I can fix the deficiencies in my model.

[1] This study was produced from the master thesis completed by the first author under the supervision of the second author, which was completed in May 2023 at Yozgat Bozok Universite. Additionally, this study was presented as an oral presentation at the 14th International Congress on New Trends in Education.