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Adaptation of the Perceived Self Efficacy Toward STEM Knowledge Survey into Turkish

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Abstract

This study aimed to adapt the Perceived Self Efficacy toward STEM Knowledge Survey, developed by Lee, Hsu, and Chang (2019), into Turkish to measure teachers' self-efficacy perceptions regarding STEM education. For this purpose, validity and reliability analyzes of the survey were made. Participants were 204 in-service teachers who were working in different branches and from various cities in Turkey. A confirmatory factor analysis was performed to investigate whether the survey showed a similar structure with six factors and 30 items as the original version. The study findings showed that the adapted survey consisted of six factors, namely, scientific inquiry, technology use, engineering design, mathematical thinking, and synthesized knowledge of STEM and attitudes toward STEM education. Also, the t-test results of 30 items in the survey were found to be significant. The Cronbach's Alpha reliability coefficient was calculated as .972. The results demonstrated that the Turkish version of the Perceived Self Efficacy toward STEM Knowledge survey consisting of 6 factors and 30 items was a valid and reliable measurement tool.

Keywords: STEM, STEM Knowledge Survey, Teacher, Scale Adaptation, Self-Efficacy

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Introduction

The teaching methods adopted in the education system change as a parallel to changes in the world. Nowadays, one of the most accepted education approaches is STEM education. STEM is an educational approach in which science, technology, engineering, and mathematics courses are conducted in parallel with each other (Corlu, Capraro & Capraro, 2014), and students are taught with an interdisciplinary approach (Meng, Idris & Eu, 2014). STEM education enables students to perceive the world by presenting the disciplines that are not independent and separate from each other like intertwined in daily life (Dugger, 2010). Students work on their everyday life problems using knowledge and skills from multiple disciplines in this educational approach (Honey, Pearson & Schweingruber ,2014).

The Importance of STEM in Education System

Students acquire 21st century skills via STEM education. These skills are defined in the literature as creativity, innovation, critical thinking, problem-solving, communication and collaboration, information literacy, technology, and media literacy (Kennedy & Odell, 2014). Individuals who acquire these skills with STEM education are trained as STEM literate individuals. STEM literacy refers to "the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to innovate to solve them" (Balka, 2011, p. 7). Tang and Williams (2019) have expressed STEM literacy as the development of STEM-related knowledge and skills of every individual in the society and the ability of individuals to participate in social problems related to STEM, to generate ideas, and make choices about them. NRC (2012) highlighted STEM education's reasons as a need to increase STEM literacy and engage students to pursue careers in STEM fields.

The importance of STEM education for society emerges when the above definitions of STEM literacy are considered. Thomas and Watters (2015) pointed out the importance of STEM education for the community as a needed international approach that supports science and technology development to address and solve many global problems such as climate change, reduced energy, water resources, and overpopulation. In this context, STEM education can be seen as the unique educational approach to enhance students' thinking skills and knowledge for inquiry and investigation through using incorporating some or all of the four disciplines of science, technology, engineering, and mathematics (STEM) (Moore et al., 2014). STEM education establishes a relationship between real-world situations and academic content in science, technology, engineering, and mathematics and ensures the development of new economic, competitive conditions with STEM literacy (Tsupros, Kohler & Hallinen, 2009). Raising students with STEM education means exposing them to use these four disciplines holistically for being successful innovators of the 21st-century labor market. It is stated that STEM literacy is essential for scientific leadership and economic growth in many countries

(Lacey & Wright, 2009). Students are prepared for the 21st-century global economy with STEM education (Becker & Park, 2011).

The Teachers' Role in STEM Education

Teachers play a dynamic role to educate students for STEM (Honey, Pearson & Schweingruber, 2014;) and to do this they need some competencies that are defined as the professional knowledge, professional skills, and attitudes-values required for them to perform profession efficiently which are also essential for successful STEM education (Dailey, Bunn & Cotabish, 2015).

Teachers' self-efficacy defined as someone's beliefs and perceptions about own capabilities (Bandura, 1997) is one of the most issue for the effectiveness of teachers' instructional style and behavior. Self-efficacy also refers to one's ability to task performance (Bandura & Locke, 2003). Teachers' self-efficacy affects their teaching practices. Thus, high self-efficacy leads teachers to show better teaching performance (Unruh, 2019). The Ministry of National Education also has emphasized the importance of making self-assessment of teachers in the general proficiency document of the teaching profession (MEB, 2017). In this context, it is important to understand how teachers perceive themselves in STEM education because teachers' self-efficacy towards STEM is a major effect on their teaching quality in STEM. It is asserted that persons who have high STEM self-efficacy perform better than the others who have low STEM self-efficacy (Rittmayer & Beier, 2009). Stohlmann, Moore and Roehrig (2012) emphasized the importance of quality STEM education for students' future success. Also, it is predicted that teachers' quality teaching in STEM education leads to reduced anxiety in students (Wong & Maat,2020).

Teachers are the key persons who bridge the gap between information and learning. Therefore, teachers should have knowledge and skills about STEM to train students about it. However, it is asserted that teachers have a poor understanding of what STEM is and how to teach it (Bartels & Rupe, 2019; Dare, Ring-Whalen & Roehrig, 2019). In this sense, it is vital to determine teachers' STEM self-efficacy about how to effectively integrate STEM into their classroom practices and create engaging students' STEM activities. However, determining teachers' self-efficacy perception knowledge positively impacts how to develop teacher training and teacher professional development (Lee & Tsai, 2010). Therefore, this study aims to adapt to the Perceived Self Efficacy toward STEM Knowledge survey developed by Lee, Hsu, and Chang (2019) into Turkish due to the absence of such a survey that can be used to measure teachers' perceived self-efficacy about STEM in Turkey.

Method

This study was carried out for scale adaptation. In this context, the Perceived Self Efficacy toward STEM Knowledge survey has been adapted to Turkish.

Participants

Participants of the study were 204 in-service secondary school teachers who teach at different branches in Turkey.

Table 1. Demographic Variables of Participants

Variables	N	%
Gender		
Male	78	38.2
Female	126	61.8
Age		
21-30	72	35.3
31-40	86	42.2
41-50	36	17.6
50+	10	4.9
Branch		
Science	123	60.3
Mathematics	19	9.3
English	21	10.3
Turkish	11	5.4
Music	4	2
Design and technology	9	4.4
Social studies	11	5.4
Religious culture and ethics	4	2
Physical education	2	1
Professional experience (year)		
1-5	57	27.9
6-10	48	23.5
11-15	44	21.6
16-20	25	12.3
21+	30	14.7
Participation in STEM training before		
Yes	57	27.9
No	147	72.1

Data Collection Tool

In this study, the Perceived Self Efficacy toward STEM Knowledge survey developed by Lee, Hsu, and Chang (2019) to assess teachers' perceived self-efficacy and attitudes towards STEM education was adapted into Turkish. The researchers developed the original survey in line with the suggestions of three experts in STEM education during the development process. The survey consists of 30 items and is rated on 5-point Likert scales from 1‘‘strongly disagree" to 5 "strongly agree.". It has six factors: scientific inquiry, technology use, engineering design, mathematical thinking, synthesized knowledge of STEM, and attitudes toward STEM education. The Cronbach's alpha for each factor is .92,.91,.92,.92,.91 and .89, respectively. The first factor (scientific inquiry) is about measuring teachers' confidence while conducting scientific research, the second factor (technology use) refers to teachers' confidence while solving problems through technology, the third factor (engineering design) assessing teachers' confidence in integrating engineering into science activities, the fourth factor (mathematical thinking) refers to teachers' confidence in mathematical thinking while solving science problems, the fifth factor (synthesized knowledge of STEM) relates to teachers' confidence in integrating disciplines (math, technology, engineering) as solving science problems, the sixth factor (Attitudes toward STEM Education) is related to measure teachers' attitudes toward STEM education.

The Adaptation Process of the Survey

To adapt the survey into Turkish, we first contacted Lee, Hsu, and Chang (2019), who were developer the original survey via e-mail, and asked for permission to use the survey. The survey was then translated from English to Turkish by four experts, two of whom were in English Language Teaching department and the other two were in Science Education. After the survey was translated into Turkish, it was examined by two professors in the field of Turkish Language and Literature, checked by grammatical structure and Turkish grammar, and then necessary corrections were made. Later, the survey was re-checked by seven graduate students in terms of understandability and readability of the items in the survey. After the final version of the survey, a pilot study was conducted with 62 in-service science teachers to see how the survey works.

The Cronbach Alpha internal consistency coefficient was calculated for the reliability of the survey's factors and the whole. LISREL and SPSS package programs were used to analyze the collected data. Confirmatory factor analysis (CFA) was conducted to validate the survey's factor structure.

Results

Reliability Analysis

Table 2. Reliability Analysis of Survey

Factors	Total Item	Cronbach Alfa
Factor 1: Scientific Inquiry	5	.931
Factor 2: Technology Use	5	.942
Factor 3: Engineering Design	5	.912
Factor 4: Mathematical Thinking	5	.950
Factor 5: Synthesized Knowledge of STEM	5	.947
Factor 6: Attitudes toward STEM Education	5	.872
Total	30	.972

Table 2 provides Cronbach Alpha values of survey's factors that ranged between 0.872 and 0.950. The Cronbach Alpha coefficient for total survey was found .972. Both the reliability coefficients of the factors and the full survey's reliability coefficient indicate that the survey is highly reliable, fulfilling the acceptable reliability criteria (Nunnally, 1978).

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was used to determine the construct validity of factors in the adapted survey through the LISREL package program. The CFA was performed with first 6 factors and 30 items in the original survey. The results are presented in Figure 1.

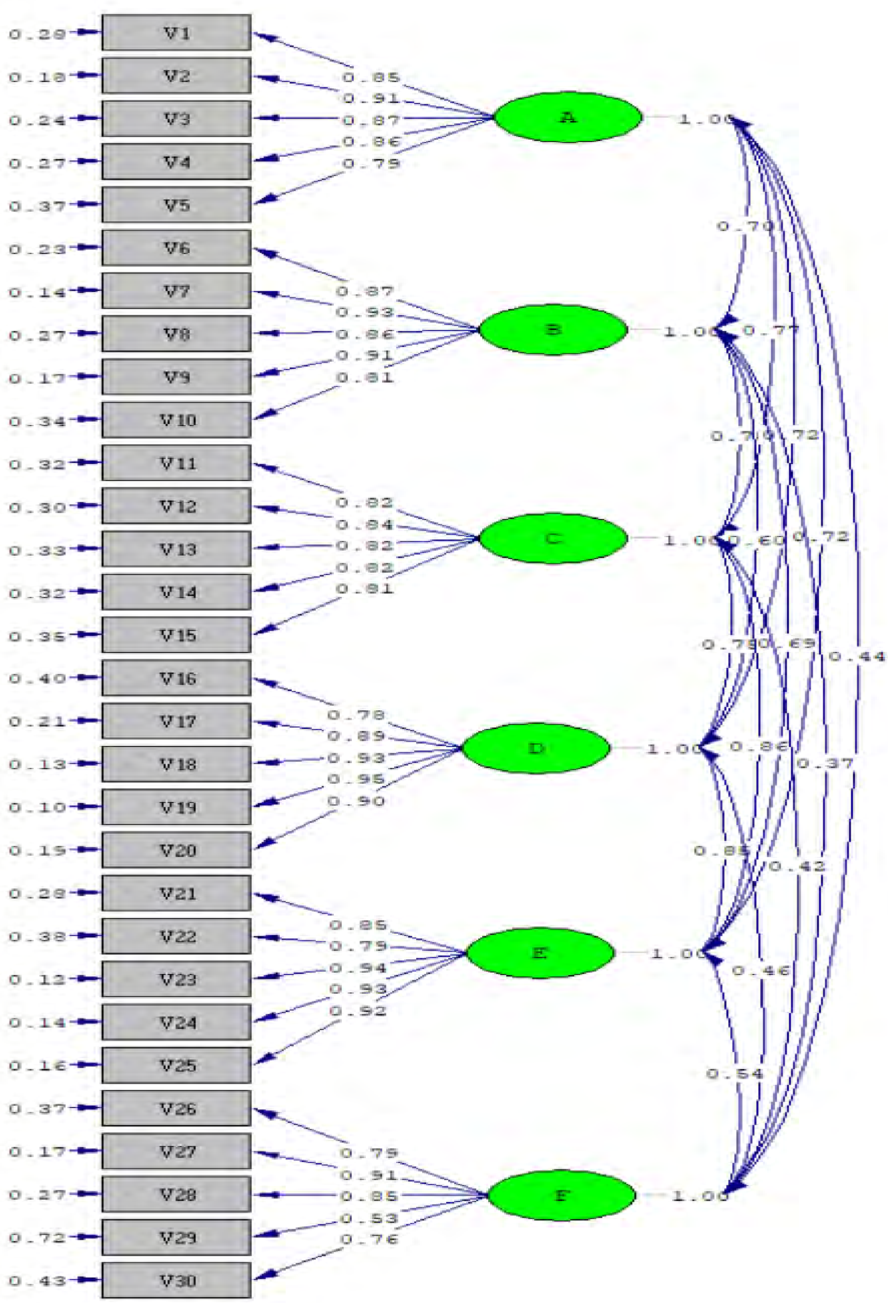

Figure 1. Standardized CFA for the Survey

As seen in the Figure 1, the values calculated for the model fit of the CFA result were found as $\chi2$ / df = 2.8, NNFI = .89, RMSEA = .094. When these values are examined, it is seen that the survey has a proper model-data fit. Also, the DFA and t values of the survey items were examined, and the results are given in Table 3.

Table 3. t Values of the Items in the Survey

Item No	t Value	Item No	t Value	Item No	t Value
1	8.49	12	8.43	23	7.32
2	7.21	13	8.63	24	7.76
3	8.12	14	8.61	25	8.08
4	8.36	15	8.78	26	8.49
5	9.03	16	9.53	27	5.59
6	8.43	17	8.67	28	7.49
7	6.92	18	7.53	29	9.73
8	8.71	19	6.71	30	8.83
9	7.60	20	8.51		
10	9.12	21	9.14		
11	8.59	22	9.49		

Table 3 provides that the t values of the items in the survey vary between 5.59 and 9.73. This finding points out that t-values are significant that means it is not necessary to remove items from the survey (Byrne, 2010).

Table 4 demonstrates that the Pearson correlation coefficient analysis that presents the relationship between the survey factors with each other and the total score.

Table 4. The Pearson Correlation Coefficient Analysis

Factors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Total Score
Factor 1	1	.695**	.720**	.706**	.693**	.489**	.846**
Factor 2		1	.737**	.613**	.690**	.413**	.815**
Factor 3			1	.741**	.810**	.488**	.890**
Factor 4				1	.836**	.522**	.882**
Factor 5					1	.593**	.921**
Factor 6						1	.694**
Total Score							1

** p<.01

The findings in Table 4 indicate that there is a significant and positive intercorrelations between the overall and factor's scores (p <.01).

To determine the items' discrimination values in the survey, item-total score correlations were calculated for each item. Then, for each item in the survey, 27% of upper and subgroup comparison was made, and the difference between item scores between groups was determined by t-test. Findings regarding the analyzes are presented in Table 5.

Table 5. Values Related to Item Analysis of the Survey

Factors	Item No	Item-Total Score Correlation	t value (Bottom 27%, Top 27%)
Scientific Inquiry	1	.710	9.383*
	2	.786	12.719*
	3	.736	11.226*
	4	.741	11.086*
	5	.771	12.980*
Technology Use	6	.691	10.491*
	7	.741	12.482*
	8	.765	11.858*
	9	.733	11.919*
	10	.742	11.907*
Engineering Design	11	.766	12.370*
	12	.753	12.208*
	13	.776	12.820*
	14	.764	13.115*
	15	.771	13.195*
Mathematical Thinking	16	.796	11.232*
	17	.767	11.485*
	18	.882	13.201*
	19	.881	13.722*
	20	.836	14.863*
Synthesized Knowledge of STEM	21	.828	15.519*
	22	.777	14.807*
	23	.866	17.030*
	24	.856	16.687*
	25	.853	15.334*
Attitudes toward STEM Education	26	.642	8.862*
	27	.557	7.245*
	28	.471	6.048*
	29	.596	9.369*
	30	.543	6.775*

Table 5 demonstrates that the item-total score correlations of the items in the survey vary between .471 and .882. This finding indicates that the item-total score correlations of the items are positive and at acceptable values. It is because of the item-total item correlation having a value of .30, or higher indicates that the items are discriminatory and are items to measure the same behavior (Büyüköztürk, 2014). The t value of the difference between the item average scores of the lower 27% and upper 27% groups was calculated for each item in survey. Table 5 represents that the lower-upper group t value for each item is significant (*p <.05). The Turkish version of the survey is presented in Appendix 1.

Discussion, Conclusion and Recommendations

Today, when traditional teaching methods are insufficient for effective and meaningful learning, new teaching approaches are emerging. For teachers to apply these new teaching approaches, their competencies and attitudes towards these methods should be positive. The education approach that can keep up with the recently developing and changing world standards has been accepted as STEM education. Previous research highlights the positive correlation between teachers' self-efficacy in STEM knowledge and their STEM teaching. (Nadelson,2013).

It was hypothesized in this study that adaptation of "the Perceived Self Efficacy toward STEM Knowledge survey" into Turkish will contribute to the literature in measuring teachers' self-efficacy perceptions and attitudes towards STEM education in Turkey. In the study of adapting the survey to Turkish, the survey's construct validity and reliability were calculated. Then, Confirmatory Factor Analysis (CFA) was performed through structural equation modeling. CFA results of the survey, whose original form consisted of 6 factors, also stated that the fit indices of the survey showed acceptable fit, and the Turkish form of the survey consisted of 6 factors and 30 items. In summary, it was concluded that the survey, which was adapted to Turkish, is valid and reliable so that researchers can use it.

The high level of teachers' self-efficacy towards STEM knowledge is a factor that directly affects their performance in STEM education. A teacher's high STEM self-efficacy means that that teacher can apply STEM effectively in his/her lessons. Thus, it is thought that the scale adapted into Turkish will contribute to the determination of the level of STEM self-efficacy of teachers and to make more efficient studies on STEM education in line with studies' results.

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Appendix 1

STEM BİLGİSİ ÖZYETERLİK ALGISI ÖLÇEĞİ

Bilimsel Araştırma

1) Bilimsel sorgulamanın nasıl yürütüldüğünü bilirim.

2) Bilimsel sorgulama etkinliklerinin nasıl tasarlandığını bilirim.

3) Bilimsel sorgulama etkinliklerinin derste nasıl yürütüldüğünü bilirim.

4) Bilimsel sorgulama hakkında yeterli bilgiye sahibim.

5) Öğrencilere bilimsel sorgulama yoluyla sorunları/problemleri çözmeleri için nasıl rehberlik edileceğini bilirim.

Teknoloji Kullanımı

6) Bir bilimsel etkinliğin problemlerini çözmek için teknolojiyi kullanabilirim.

7) Bilimsel sorgulama etkinliklerini yürütebilmek için teknolojiyi kullanabilirim.

8) Bir bilimsel etkinliğin problemlerini çözmek için teknolojiyle ilgili bilgilere nasıl ulaşıldığını bilirim.

9) Bilimsel sorgulama yürütürken karşılaştığım problemleri çözmek için teknolojiyi kullanabilirim.

10) Bilimsel etkinliklerin içeriğini teknolojik kaynaklarla nasıl bütünleştireceğimi bilirim.

Mühendislik Tasarımı

11) Bilimle ilgili etkinlikler için teknoloji hakkında yöntemsel bilgiyi bilirim.

12) Bilimsel konularla ilgili teknolojinin nasıl tasarlandığını ve üretildiğini bilirim.

13) Bilimle ilgili problemleri çözmek için uygun materyallerin ve araçların etkili bir şekilde nasıl kullanılacağını bilirim.

14) Mühendislik tasarım döngüsünü kullanarak bilimsel sorgulama etkinliklerini planlamayı bilirim.

15) Mühendislik tasarımını bilimsel etkinliklerle bütünleştirebilirim.

Matematiksel Düşünme

16) Bilimsel etkinliklerdeki gözlemsel verilerin nicel veri biçiminde nasıl tanımlandığını bilirim.

17) Bilimsel etkinliklerdeki verileri matematiksel istatistiklerle analiz edebilirim.

18) Bilimsel sorgulamayı yürütürken matematiksel düşüncenin nasıl kullanıldığını bilirim.

19) Bilimsel sorgulama etkinliklerinde yer alan matematiksel düşünce kavramlarını bilirim.

20) Bilimsel problemleri çözmek için matematiksel bilgileri sistematik olarak uygulayabilirim.

Sentezlenmiş STEM Bilgisi

21) Bilimsel etkinliklerde çeşitli problemlerin çözümünde matematiksel düşünceyi, tasarım yapmayı ve teknoloji desteğini kullanabilirim.

22) Bilimsel etkinliklerde belirli bir model tasarlamak için internette nasıl arama yapılacağını, basit materyallerin nasıl kullanılacağını ve uygun yapının nasıl hesaplanacağını (maksimum uzunluk, ideal genişlik vb.) bilirim.

23) Bilimsel problemleri çözmek için teknolojiyi, mühendislik tasarımını ve matematiksel düşünceyi aynı anda nasıl kullanacağımı bilirim.

24) Tek bir bilimsel problemin çözümünde teknoloji, mühendislik ve matematiği bütünleştiren çeşitli yolları kullanabilirim.

25) Bilimsel sorgulama etkinliklerinde uygun mekanik yapıları tasarlarken bilimsel bilgi ve matematiksel düşünceyi kullanabilirim.

STEM Eğitimine Yönelik Tutumlar

26) Sınıfta fen öğretimine matematiksel düşünce, teknoloji kullanımı ve mühendislik tasarımını bütünleştirmeye istekliyim.

27) Matematiksel düşünce, teknoloji kullanımı ve mühendislik tasarımı fen öğretimi ile bütünleştirildiğinde öğrenciler daha iyi öğrenir.

28) Öğrencilerin gelişimi için matematiksel düşünce, teknoloji okuryazarlığı ve mühendislik tasarımını fen öğretimi ile bütünleştirmek çok önemlidir.

29) Sınıfımda STEM eğitimi kullandığım için mutluyum.

30) Bilimsel sorgulamada teknoloji okuryazarlığı, mühendislik tasarımı ve matematiksel düşünce öğretim ile bütünleştirilerek öğrencilerin gerçek yaşam problemlerini çözmelerine yardımcı olunabilir.