Makalenin Geliş Tarihi: 08.04.2021
1. Hakem Rapor Tarihi: 30.04.2021
2. Hakem Rapor Tarihi: 22.06.2021
Kabul Tarihi: 27.08.2021

ADAPTATION OF TEACHING MATHEMATICS EFFICACY BELIEF INVENTORY (TMEBI) INTO TURKISH

(Araştırma Makalesi)

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Abstract

Self-efficacy in teaching mathematics can be explained as teachers' personal beliefs about their self-efficacy beliefs in teaching mathematics and personal perceptions of their self-ability to teach mathematics to others. Also, teachers' attitudes, believes, and behaviors have a significant effect on students' preparation and their academic success. So, it is important to examine teachers' efficacy beliefs towards teaching mathematics. Not more quantitative research was found on the evaluation tools for determining teaching mathematics efficiency belief of teachers in Turkey. The purpose of the current study is to adapt the Teaching Mathematics Efficacy Belief Inventory (TMEBI) to the Turkish language. The sample of the study consists of 426 prospective mathematics teachers (54.5% female and 45.5% male). The scale that was used in the study was developed by Enochs, Smith, and Huinker (2000) to determine teaching efficacy belief towards mathematics. Firstly, for linguistic equivalence study, the correlation coefficient was examined, and then validity and reliability analysis were conducted. Validity and reliability studies were applied to adapting the Turkish form. Findings showed the high-reliability coefficients of the scale were found (Cronbach's α (.91), McDonald's ω (.85), and Two-Half Test (r =.83)). Finally, it can be said that the MTEBI, which was adapted to the Turkish language is a valid and reliable measurement tool.

Keywords: *Teaching Mathematics, Teaching Efficacy, Belief, Validity, reliability.*

Matematik Öğretimi Yeterlik İnancı Envanteri (MÖYİE)'nin Türkçeye Uyarlama Çalışması

Öz

Matematik öğretiminde öz-yeterlik, öğretmenlerin matematik öğretiminde öz-yeterlik inançlarına ilişkin kişisel inançları ve başkalarına matematik öğretme öz yeterliklerine ilişkin kişisel algıları olarak açıklanabilir. Ayrıca, öğretmenlerin tutumları, inançları ve

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davranışları öğrencilerin hazırlanmaları ve akademik başarıları üzerinde önemli bir etkiye sahiptir. Bu nedenle, öğretmenin matematik öğretimine yönelik yeterlik inançlarını incelemek önemlidir ve Türkiye'de öğretmenlerin matematik öğretimi inançlarını belirlemeye yönelik değerlendirme araçlarına ilişkin nicel araştırmalara rastlanmamıştır. Bu çalışmanın amacı, Matematik Öğretimi Yeterlilik İnanç Envanteri'ni (MÖYİE) Türkçe diline uyarlamaktır. Araştırmanın örneklemini 426 matematik öğretmeni adayı (%54,5 kadın ve %45,5 erkek) oluşturmaktadır. Araştırmada kullanılan ölçek Enochs, Smith ve Huinker (2000) tarafından matematik öğretimi yeterlik inancını belirlemek için geliştirilmiştir. Dilsel eşdeğerlik çalışması için öncelikle korelasyon katsayısı incelenmiş, ardından geçerlilik ve güvenilirlik analizi yapılmıştır. Türkçe formun uyarlanmasında geçerlilik ve güvenilirlik çalışmaları yapılmıştır. Bulgular, ölçeğin yüksek güvenirlik katsayılarının bulunduğunu (Cronbach's α (.91), McDonald's ω (.85) ve İki Yarı Testi (r = .83) göstermiştir. Son olarak Türkçeye uyarlanan MÖYİE'nin geçerli ve güvenilir bir ölçme aracı olduğu söylenebilir.

Anahtar Kelimeler: *Matematik Öğretimi, Öğretim Yeterliği, İnanç, Geçerlilik, Güvenilirlik.*

1. Introduction

Imagining what is necessary to achieve goals personally or professionally is associated with feelings (positive or negative) on self-efficacy (Bandura, 1977; Hackett and Betz, 1989). Bandura's (1997) postulate on this topic is that behavior is related to the individual's belief in his/her self-efficacy rather than what he/she can manage. Belief in perceived efficacy can influence the individual in a positive and reinforcing way, but also in a negative and discouraging way (Pajares, 1996; Pajares, and Miller, 1994; Podell and Soodak, 1993). Teachers' belief in their self-efficacy allows for structuring of knowledge and understanding in terms of meeting students' learning needs and brings about better structuring and presentation of instruction that allows for student access to knowledge. In doing so, there is a strong relationship between teacher effectiveness and increased student achievement (Aerni, 2008; Keith and Cool, 1992; Zimmerman, 2000).

Teacher efficacy corresponds to the belief of having the efficacy to impact student success and learning in a way that includes all students with developmental deficits (Hoy, 2000; Pajares, 1996; Secada, 1992). Studies on teacher efficacy have been conducted extensively for the last fifty years and it has been stated that teacher effort, which is thought to have a positive effect on students' mathematics success and learning, is a degree of belief. Bandura (1977) defined teacher efficacy as teachers' belief to show low or high performance. The indicator of teacher effectiveness can be explained by teachers' preferred teaching methods and strategies for effective teaching (Gibson and Dembo, 1984; Guskey, 1988; Midgley, Feldlaufer, and Eccles, 1989; Ross, 1994). The teachers' level of efficacy states the amount of effort made, the length of time obstacles

is encountered, the degree of resilience in coping with failure, and the degree of stress or depression teachers experience when confronted with difficult situations (Allinder, 1994; Ashton and Webb, 1986; Bandura, 1977; Gibson and Dembo, 1984). Teachers who have a low sense of teaching efficacy or a low sense of personal teaching efficacy look for the reasons for their students' failure, low motivation, and attitude (Gibson and Dembo, 1984). Teachers with a high sense of teaching efficacy have a positive belief that they can take personal responsibility for student learning in order to reach students who have difficulty learning (Allinder, 1994; Ashton, Buhr and Crocker, 1984; Ashton and Webb, 1986; Bandura, 1997; Gibson and Dembo, 1984).

Teacher self-efficacy consists of personal teaching efficacy and teacher outcome efficacy (Allinder, 1995; Swars, 2005). Personal teaching efficacy is a teachers' belief in his or her abilities and skills to positively influence student achievement, while teacher outcome efficacy is a teachers' belief that the educational system can produce results for all students, regardless of external influences such as socioeconomic status, family life, motivation, or other personal circumstances that may have an impact (Swackhamer, Koellner, Basile, and Kimbrough, 2009; Swars, 2005).

Individuals' beliefs play an effective role in their cognitive, affective, motivational, and selection processes (Bandura, 1977; Guskey and Passaro, 1994). The concept of efficacy belief consists of two components: self-efficacy and outcome expectations. While self-efficacy pertains to one's beliefs in one's self capability, outcome expectations refer to perception of the possible consequences of one's actions (Maddux, Norton, and Stoltenber, 1986). It has been suggested that individuals with high self-efficacy perception make more efforts, are more persistent and patient to achieve their goals (Chester and Beaudin, 1996). Teachers' attitudes, believes, and behaviors have a significant effect on students' preparation and their academic success (Askar and Umay, 2001; Charalambous, Philippou, and Kyriades, 2008; Enochs, Smith and Huinker, 2000). The research literature indicates that there is a strong relationship between teachers' self-efficacy perceptions and their classroom practices. Furthermore, teachers with high self-efficacy demonstrate more willingness and excitement toward teaching (Hoy, 2000; Knapp, Copland and Talbert, 2003).

There are many studies on teacher' and prospective teachers' self-efficacy in Turkey (Aksu and Kul, 2019; Aydın and Çelik, 2016; Deniz and Koç, 2020; Esendemir, Çırak and Samancıoğlu, 2015; Koyuncu, Güzeller and Akyüz, 2017; Taşdemir, 2019). However, the results of many studies in the literature have shown that the self-efficacy beliefs of mathematics teachers and prospective teachers are not at the desired level. As a result, this problem experienced by teachers, one of the most important elements of the mathematics teaching process, affects the mathematics teaching process negatively (Bursal, 2010; Hacıömeroğlu and Şahin-Taşkın, 2013). In other words, the results of the research revealed that there is a positive relationship between self-efficacy belief and achievement variable (Yıldırım, 2011). A teacher whose pedagogical knowledge level is

not sufficient cannot be expected to give confidence to his students and to establish an authority based on respect. Therefore, the most important feature expected from primary school and mathematics teachers is to have high self-efficacy beliefs about mathematics (Dede, 2008; Doruk and Kaplan, 2012). Peker (2009) stated that having low mathematics teaching anxiety in teachers may also help reduce the mathematics anxiety levels of their students. Başpınar and Peker (2015) found a negative, moderate and significant relationship between prospective elementary teachers' anxiety about teaching mathematics and their beliefs about teaching and learning mathematics. A mathematics teacher with low self-efficacy may also lower the self-efficacy belief of his student, who sees himself as a model, towards learning the lesson (Graham, Harris, Fink, and MacArthur, 2001; Wertheim and Leyser, 2002).

In light of the above discussion, it is suggested that determining the level of prospective teachers' self-efficacy beliefs about mathematics may have a contribution to understand how prospective teachers are benefited from teacher training programs. It may also be important to determine the effectiveness level of teacher training programs on pre-service teachers' so that steps can be taken to improve the programs. Not more quantitative research was found on the evaluation tools for determining teaching mathematics efficiency belief of teachers in Turkey. Moreover, this scale was previously adapted by Çakıroğlu (2000) to be applied to pre-service mathematics teachers. However, the same scale was adapted back to Turkish by Hacıömeroğlu, Şahin-Taşkın (2010) and it was aimed to determine the efficacy beliefs of prospective primary school teachers in teaching mathematics. It is seen that the adapted version of the scale consists of 17 items and the distribution of the factors that make up the scale is different from the original version. When the literature is examined, the fact that no Turkish version of the scale has been found for the sample of prospective mathematics teachers or mathematics teachers increases the importance of our study. In addition, considering today's changing conditions (teaching methods, technology, etc.) and the Turkish adaptation of the scale on different samples, the necessity of this study has gained importance. So, the aim of this research which intends to respond to the related need is to determine the psychometric properties of the Turkish form of Teaching Mathematics Efficiency Belief Inventory (TMEBI) developed by Enochs, Smith, and Huinker (2000).

2. Method

2.1. Research Design

Survey design, which is one of the designs of quantitative research method, was used in the study. Survey design is carried out within the scope of large samples compared to other designs and is a design in which qualities such as interest, skill, opinion, and attitude of the participants about a subject or event are revealed (Fraenkel and Wallen, 2006). In this context, as it was aimed to adapt a scale to Turkish in the current study, the survey design was used.

2.2. Participants

In scale adaptation or development studies, the sample size should be decided after the selection of the appropriate sample (Erkuş, 2012; Koyuncu, and Kılıç, 2019). For the sample size, it is stated that the number of items should be at least 5 times (Bryman and Cramer, 2001), 10 times (Nunnally, 1978), and Gorusch (1983) stated that a number of items should be at least 15 times (Ergene, 2020; Koyuncu, and Kılıç, 2019). In addition, Comrey and Lee (1992) express the sample size depending on the number of people to whom the scale was applied, for example, 100 people poor, 200 people moderate, 300 good, 500 very good, 1000 excellent (Ergene, 2020). In our adaptation study, the sample consists of 426 prospective mathematics teachers (54.5% female and 45.5% male) from Sakarya University, Marmara University, and Boğaziçi University. It is thought that this sample size is sufficient (for 21 items) for the scale adaptation study.

2.3. Data Collection Tools

Teaching Mathematics Efficacy Belief Instrument (TMEBI): The scale that was used in the study was developed by Enochs, Smith, and Huinker (2000) to determine teaching efficacy belief towards mathematics. The scale was designed in a 5-point Likert type. The scale consisted of 21 items and two factors; first factor is called Personal Mathematics Teaching Efficacy (PMTE) consisting of 13 items and second factor is called Mathematics Teaching Outcome Expectancy (MTOE) consisting 8 items. The highest score that can be obtained from this scale is 105, and the lowest score is 21. High scores indicate high efficacy belief in teaching mathematics.

2.4. Data Analysis

Missing data is a potential source of bias in statistical estimations, as a problem that is addressed first and foremost. A second problem is that missing data leads to a lack of information and, consequently, to a decrease in the power of statistical analysis. The most common solution used for missing data is to exclude missing data for any variable from the analysis (Demir and Parlak, 2012). Thus, a complete data set without missing data is obtained and any of the familiar statistical analyzes (listwise deletion-LD, casewise deletion-CD, complete case analysis-CCA) can be easily applied. Before the analysis of our study, complete data was obtained by arranging the lost data with the “casewise deletion-CD” method (Little and Rubin, 1987; Allison, 2002).

SPSS 25.0 and LISREL 8.7 programs were used for the validity and reliability analyzes required during the development of the scale. Firstly, for linguistic equivalence study, the correlation coefficient was examined, then validity and reliability analysis were conducted. The skewness and kurtosis coefficients were examined to determine whether the items considered to be included in the scale were normally distributed. Kaiser Meyer Olkin (KMO) and Bartlett tests were analyzed to examine the construct validity. Factor separations of the scale were tested by Exploratory factor analysis and Confirmatory factor analysis.

When the reliability determination methods were examined, it was seen that the methods based on a single application were preferred. It is thought that the use of reliability estimation methods based on more than one application is less preferred because it imposes an extra burden on researchers in terms of both cost and time (Delice and Ergene, 2015; Ergene, 2020; Şahin and Boztunç Öztürk, 2018). When the national literature is examined; during the scale development process, it is seen that the Cronbach α coefficient and Spearman Brown Two-Half Test reliability were reported in most or all the studies (Acar Güvendir and Özer Özkan, 2015; Gül and Sözbilir, 2015). It is thought that the reason why these two methods are preferred more is the use of ready-made programs in their calculations. In our study, Cronbach's α, McDonald's **ω** (omega) and Two-Half Test (r) reliability coefficients were calculated in determining the internal consistency level. In addition, it is stated that the omega coefficient gives more reliable results than the Cronbach's alpha coefficient (Peters, 2014).

2.5. Ethics of Research

Necessary permissions for conducting the study were obtained from Sakarya University Ethics Committee with the ethics committee document dated 13.01.2021 and numbered E-61923333-050.99-3539. The participants of the research took part in the research on a voluntary basis. All information obtained in the study has been kept confidential for the security of students' personal information.

3. Findings

3.1. Linguistic Equivalence

Firstly, the original form (the form in English) and the Turkish form of MTEBI have applied to 64 English teachers one week apart. For linguistic equivalence, the correlation analysis was applied between the scores obtained from these two forms. As the result of the correlation analysis, the linguistic equivalence coefficients were found between .61 and .87, as shown in Table 1.

Table 1. Findings of Linguistic Equivalence Coefficients

Item Number	r	Item Number	r	Item Number	r
1	.82*	**8**	.63*	**15**	.64*
2	.79*	**9**	.74**	**16**	.62*
3	.65**	**10**	.68**	**17**	.77**
4	.75*	**11**	.82**	**18**	.87*
5	.78*	**12**	.83*	**19**	.81*
6	.61*	**13**	.62**	**20**	.74**
7	.63*	**14**	.65*	**21**	.75**

*p< .05; **p< .01

3.2. Validity Studies

Before the validity and reliability studies for adaptation process, the skewness and kurtosis coefficients of the scores obtained from the scale were examined and it was found that these values were distributed between -1 and +1 (Tabachnick and Fidell, 2013). According to these results, it was seen that the data obtained from the scale showed a normal distribution. In addition, the fact that the p-value calculated because of the Kolmogorov-Smirnov test is higher than $\alpha = .05$ is considered as proof that the scale scores come from the normal distribution (Mertler and Vannatta, 2005). In the adaptation process of the scale, descriptive analysis, exploratory and confirmatory factor analysis, item analysis, reliability analysis of factors, and determination of factor relationships were carried out. In these stages, the findings obtained regarding the reliability and validity studies of the scale were presented and interpreted in the form of tables.

3.2.1. Exploratory Factor Analysis (EFA)

In the EFA made to examine the factorial decomposition of the scale, firstly, the correlation matrix between all items was examined and whether there were significant correlations, and it was seen that there were significant relationships suitable for factor analysis. Then, sampling adequacy and Barlett Sphericity Tests were performed. Kaiser-Meyer-Olkin (KMO) is an index that compares the size of the observed correlation coefficients with the size of the partial correlation coefficients. The KMO ratio being greater than .60 indicates the suitability of the data set for Principal Component Analysis (Büyüköztürk, 2017; Erkuş, 2012). EFA was carried out with data collected from 426 prospective mathematics teachers. There are various statistical methods for determining the number of factors. One of them is the eigenvalue method proposed by Kaiser-Meyer-Olkin (KMO). Accordingly, it should be continued with factors with eigenvalues greater than 1 (Field, 2009; Hair, Black, Babin, Anderson, and Tatham, 2006; Kaiser, 1960). The scale showed a 2-factor structure according to the Kaiser criterion. Considering the theoretical basis, it was continued with a 2-factor structure. In addition, the KMO value was calculated as .756 because of the test. In addition, there is a high correlation between variables because the p value is less than .01 according to the Bartlett Test ($\chi^2 = 2608.145$; $df = 221$; $p = .00$). Accordingly, the high value of KMO (.756) and the significant Barlett Test ($p < .01$) showed that the data were suitable for EFA.

Factor loadings show the correlation between the item and the structure to be measured. In the study, for an item to be shown in a factor, it was sought that it should have a factor load of at least .30 and that the difference between the load values in the factors in which the items were found and the load values in other factors should be .10 and above (Büyüköztürk, 2017). Accordingly, the factor loads obtained because of Principal Components Analysis and related factors were examined, and factor loads of items were between .49 and .76.

The results of the Principal Components Analysis made as a result of the application performed with the data collected from the study group are shown in Table 2. According to the Principal Component Analysis results, the scale consists of two sub-factors. There are 13 items about the "*Personal Mathematics Teaching Efficacy*" factor of the scale and the factor load values of the items vary between .49 and .76, and also explain 28.15% of the total variance. The second factor is "Mathematics Teaching Outcome Expectancy", and there are four items related to this factor and the factor load values of the items vary between .49 and .73, and it also explains 23.45% of the total variance. Accordingly, the variance amount explained by the two factors is 51.60%.

Table 2. Results of Principal Components Analysis

	ITEMS	PMTE	MTOE
2	Matematik öğretimi için daima daha iyi yollar bulurum.	.74	
3*	Çok fazla denesem bile, birçok dersi öğretebildiğim gibi matematiği öğretemeyeceğim.	.72	
5	Matematik kavramlarını etkili bir şekilde nasıl öğreteceğimi biliyorum.	.64	
6*	Matematik aktivitelerini yönetirken çok etkili olamıyorum.	.61	
8*	Genelde, matematiği etkisiz bir şekilde öğretiyorum.	.55	
11	Temel matematiğin öğretiminde etkili olmak için matematik kavramlarını gerektiği kadar anlıyorum.	.49	
15*	Matematiğin ne için kullanıldığını öğrencilere açıklamak için örnekleri kullanmayı zor buluyorum.	.65	
16	Öğrencilerin sorularına belli cevaplar verebilirim.	.49	
17*	Matematik öğretimi için gerekli becerilere sahip olabileceğimi merak ediyorum.	.76	
18*	Bir tercih hakkı verilirse, okul müdürünü/müfettişi matematik öğretimimi değerlendirmesi için davet etmem.	.53	
19*	Bir öğrenci, bir matematik kavramını anlarken zorluk yaşıyorsa, onun daha iyi anlamasına nasıl yardımcı olacağımı genellikle bilemem.	.62	
20	Matematik öğretirken, öğrenci sorularıyla genellikle karşılaşıyorum.	.66	
21*	Öğrencileri matematiğe yöneltmek için ne yapmam gerektiğini bilmiyorum.	.54	
1	Bir öğrenci her zamankinden daha iyi matematiği yapıyorsa, bunun nedeni genellikle öğretmenin fazladan az bir çaba sarf etmesidir.		.68

4	Öğrencilerin matematik düzeyleri geliştiğinde, bu durum genelde öğretmenlerinin daha etkili bir öğretim yaklaşımı bulmasından dolayıdır.		.71
7	Eğer öğrenciler matematikte başarısızsalar, bu da büyük olasılıkla etkisiz matematik öğretiminden dolayıdır.		.65
9	Bir öğrencinin matematik temelindeki yetersizliği, iyi bir öğretimle giderilebilir.		.49
10	Düşük başarılı bir öğrenci, matematikte gelişim gösterdiğinde, bu durum genellikle öğretmenin fazla ilgisinden dolayıdır.		.53
12	Genelde, öğrencilerin matematikteki başarılarında öğretmenler sorumludur.		.62
13	Öğrencilerin matematikteki başarıları, öğretmenlerinin matematik öğretimindeki etkililiği ile doğrudan ilişkilidir.		.69
14	Eğer aileler çocuklarının matematikle okulda daha çok ilgilendiklerini belirtiyorlarsa, muhtemelen bu durum, çocuğun öğretmeninin performansına bağlıdır.		.73
	Explained variance (%)	**28.15**	**23.45**

* These items are coded in reverse, **PMTE:** Personal Mathematics Teaching Efficacy, **MTOE:** Mathematics Teaching Outcome Expectancy

3.2.2. Confirmatory Factor Analysis (CFA)

CFA is the second step used to check the functioning and consistency of the structure defined in EFA (Büyüköztürk, 2017; Can, 2013; Harrington, 2009; Tabachnick and Fidell, 2013). The findings obtained as a result of analyzing the established model with CFA are given below.

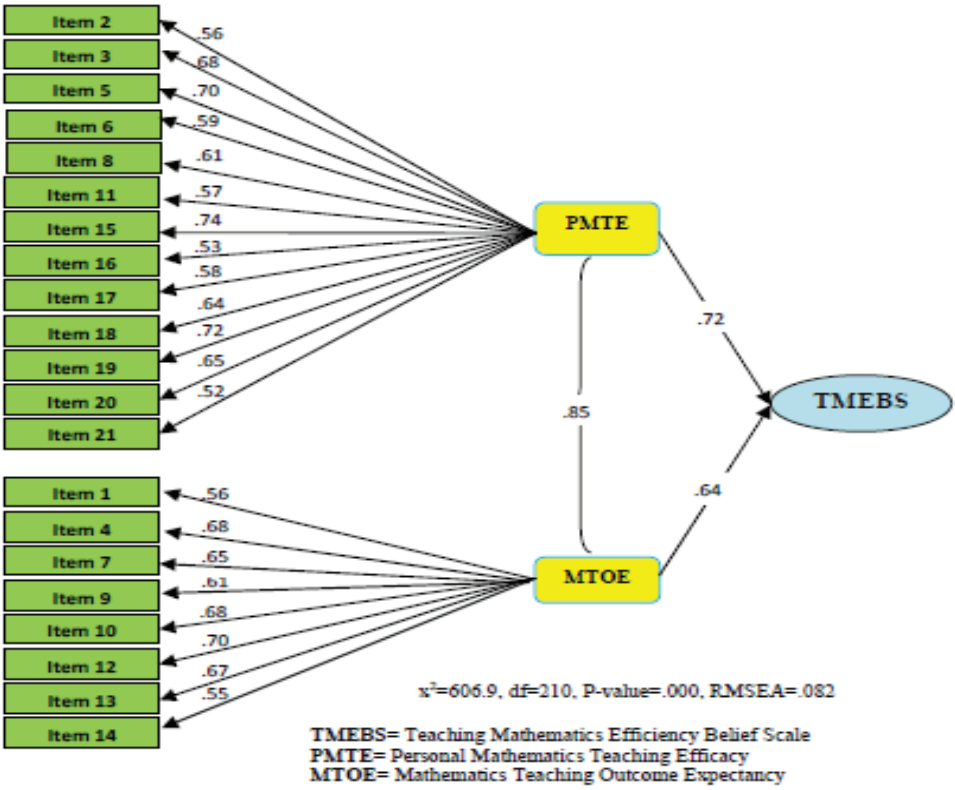

Figure 1. Path Diagram

If the calculated $\chi 2$ / df ratio is less than 3, GFI and AGFI values higher than .90 indicate model data fit (Jöreskog and Sörbom, 1993). High values were obtained according to the model fit indexes based on the correlations of 30 items with three different sub-factors. Each of the factor loads showing the item-factor correlation was found to be statistically significant ($p < .05$). The fit statistics calculated in this analysis are RMSEA = .082, IFI = .93, GFI = .91, RFI = .92, CFI = .92, NFI = .94, $\chi 2$ / df = 2.89; AGFI = .91 was calculated. The statistical testing of the item-factor correlations obtained according to these results was carried out.

3.3. Structure Validity (Convergent and Divergent Validity)

Convergent validity states that the expressions related to the variables are related to each other and the factor they formed. Fornell and Larcker (1981) proposed techniques based on the Average Variance Extracted (AVE) value obtained from each factor for convergent validity as a method of examining the construct validity. Accordingly, he

stated that AVE value should be greater than .50 for convergence validity. The AVE values are shown in Table 3.

Table 3. AVE Results Regarding the Structures of the Scale

Sub-Factors	AVE
PMTE	.62
MTOE	.64

Divergent validity, on the other hand, is that the statements regarding the variables should be less related to the factors other than the factor they belong to than the factor they belong to. Divergent validity is evaluated by comparing the square root of the mean explained variance (AVE) of a structure with the correlation coefficient of that structure with other structures. Fornell and Larcker (1981) stated that AVE values larger than shared variance (square of the correlation between structures) estimates support divergent validity. That is, the fact that the square roots of the AVE values are higher than the correlation coefficients between the sub-factors is evidence of the discriminant validity. Correlations and AVE square root values of each structure are shown in Table 4.

Table 4. Correlation Coefficients Between Sub-Factors and Square Roots of AVE Values

Sub-Dimensions	(1)	(2)
PMTE (1)	**.787***	
MTOE (2)	.674**	**.800****

* The diagonal elements of the matrix are the square roots of the AVE values.

As can be seen in Table 4, the diagonal elements of the matrix corresponding to the square roots of the AVE values are larger than the non-diagonal elements of the matrix. When Table 4 is examined, it is seen that the correlation value between the factors is .674 and has a significant at the .01 level. These findings show that the compatibility and relationship between the factors of the scale is high.

3.4. Reliability Studies

3.4.1. Item-Total Correlations

Item Total Correlations explain the relationship between test item scores and the total score of the test. If the Item Total Correlation is positive and high means that the items illustrate similar behaviors and high internal consistency (Büyüköztürk, 2017).

Since the corrected item-total correlations of the scale in our study were between .412 and .679, it can be said that all items were sufficient to distinguish the feature to be measured. This finding is also an indication that the internal consistency was provided. It was observed that the t-test values for the unrelated samples calculated for the item scores of the 27% lower and upper groups determined according to the total scores were ranked between 4.801 and 12.734 (Table 5). This shows that the scale has distinctive feature.

Table 5. Corrected Item-Total Correlations of the Scale and t Values Regarding 27% Subverted Group Difference

Items	Item-Total Correlation	t (up%27-down%27)	Items	Item-Total Correlation	t (up%27-down%27)
1	.486	8.120**	**11**	.612	4.731**
2	.412	6.452**	**12**	.478	10.552**
3	.654	8.727**	**13**	.510	6.818**
4	.473	5.530**	**14**	.459	7.371**
5	.536	9.926**	**15**	.523	5.223**
6	.583	12.734**	**16**	.649	5.623**
7	.442	10.480**	**17**	.618	11.115**
8	.576	8.176**	**18**	.612	12.722**
9	.467	7.524**	**19**	.679	10.887**
10	.452	10.834**	**20**	.506	4.801**
			21	.624	6.152**

* * p< .01

3.4.2. Cronbach α and McDonald's ω Reliability Coefficient, Two-Half Test Correlation

To examine the reliability of the scale, Cronbach's α and McDonald's ω (omega) reliability coefficients were examined, and a reliability study was conducted using two half-test methods for stability. Calculated values are given in Table 6.

Table 6. Reliability Coefficient Values of the Scale

Sub-Dimensions	Cronbach's α	McDonald's ω	Two-Half Test (r)
PMTE	.86	.80	.86
MTOE	.84	.83	.85
Total	.91	.85	.83

These results are proof that the scale has construct validity. Internal consistency coefficients made within the scope of reliability studies showed that the scale can be used reliably.

4. CONCLUSIONS

Special attention needs to be paid to the education of future teachers and to the development of their competencies as 21st century skills for teaching mathematics. 21st century skills such as critical thinking and problem solving are part of mathematical competencies and are increasingly important. It is not enough to prepare future mathematics teachers related to subject didactics, pedagogy, and content; they must also get new beliefs in these subjects (Borko and Putnam, 1996). The beliefs of teaching mathematics affect the quality of teaching and teaching methods in the classroom (Maasepp and Bobis, 2014; Takunyaci and Takunyaci, 2014). For this reason, it will be important to develop or adapt a scale into Turkish for future studies to have a valid and reliable scale that determines the beliefs of mathematics teachers and prospective teachers about teaching mathematics.

Institutional structures that will provide support for the measurement tools that researchers should use are quite limited in Turkey. For this reason, researchers have difficulty in reaching scales with proven validity and reliability, and in this case, they adapt a scale developed abroad or develop a new scale. When the scale development studies within the scope of mathematics teaching special field competencies (Aksu, 2008; Akyıldız and Çınar, 2016; Şan, 2013; Koyuncu, Güzeller and Akyüz, 2017) are examined, it is seen that these studies are very few and mostly carried out by working with teacher candidates. Dede (2008) developed a scale by adapting the efficacy belief scale developed for science teaching by other researchers abroad to mathematics teaching. The development of the scale was carried out with a limited number of mathematics teachers. The scale consists of three sub-scales called 'proficiency in teaching', 'motivating and taking responsibility', and 'effective teaching' and 14 items. Akyıldız and Çınar (2016) focused on a more subject-centered structure and focused on the scale that was developed to determine the competencies of primary school mathematics teacher candidates and dealt with it by specializing within the scope of linear algebra field language proficiency. With a similar specialization, Koyuncu, Güzeller, and Akyüz (2017) also developed a scale for pre-service mathematics teachers' perceptions of proficiency in mathematical modeling. Esendemir, Çırak, and Samancıoğlu (2015) on the other hand put forward the scale they developed to determine the mathematics teaching efficacy beliefs of primary school mathematics teachers in a limited scope by taking only one competence area within the scope of MEB Mathematics Teacher Special Field competences (Mathematics Lesson Skills Development Competence). Hacıömeroğlu and Şahin-Taşkın (2010), on the other hand, carried out the study of adapting a scale developed in another country (USA) into Turkish and stated that the original two-dimensional scale was adapted in three dimensions (personal competence, the role of the teacher ineffective teaching,

performance related to teaching) due to cultural differences.

In this study, a valid and reliable scale was adapted to Turkish language that will determine prospective and in-service mathematics teachers' efficacy beliefs towards teaching mathematics, in terms of self-efficacy and outcome expectancy.

The EFA revealed that the scale items were decomposed in two factors (PMTE, MTOE). Afterwards, the fit indices obtained as a result of the CFA revealed that the scale items met under these two factors. Reliability coefficient values of the scale were obtained by Cronbach's α, McDonald's **ω** (omega) and Two-Half Test (r) methods. These reliability values calculated for the whole scale are respectively; .91, .85, .83.

The lowest score that can be obtained from the entire scale is 21, the highest score is 105. The scores obtained from sub-factor of PMTE range from 13 to 65 and range from 8 to 40 for sub-factor of MTOE. The high score obtained from the scale means that the positive level of efficacy beliefs towards teaching mathematics are also high. Finally, it can be said that the *MTEBI*, which was adopted to Turkish language according to the analyzes made and the results obtained, is a valid and reliable scale. In addition, this adapted scale can be used to determine prospective and in-service mathematics teachers' efficacy beliefs towards teaching mathematics.

References

Acar Güvendir, M. and Özer Özkan, Y. (2015) Türkiye'deki eğitim alanında yayımlanan bilimsel dergilerde ölçek geliştirme ve uyarlama konulu makalelerin incelenmesi [The examination of scale development and scale adaptation articles published in Turkish academic journals on education]. *Elektronik Sosyal Bilimler Dergisi, 14*(52), 23-33.

Aerni, P.W. (2008). *Teacher self-efficacy and beliefs for teaching mathematics in inclusion settings*. Unpublished Doctoral Dissertation. The College of William and Mary in Virginia. UMI Number: 3353198.

Aksu, H. H. (2008). Öğretmen adaylarının matematik öğretimine yönelik öz-yeterlilik inançları [Prospective teachers' self-efficacy beliefs regarding mathematics teaching]. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 8*(2), 1610-170.

Aksu, Z. and Kul, U. (2019). The mediating role of mathematics teaching efficacy on the relationships between pedagogical content knowledge and mathematics teaching anxiety. *SAGE Open 9*(3), 1-10.

Akyıldız, P. and Çınar, C. (2016). İlköğretim matematik öğretmen adaylarının lineer cebir dersine yönelik tutumları ve alan dili yeterliklerinin incelenmesi [Investigation of pre-service primary mathematics teachers' attitudes towards linear algebra

course and competences of the field language]. *Türk Eğitim Bilimleri Dergisi, 14*(1), 1-22.

Allinder, R.M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher Education and Special Education, 17*, 86-95.

Allinder, R.M. (1995). An examination of the relationship between teacher efficacy and curriculum-based measurement and student achievement. *Remedial and Special Education, 16*(4), 247-254.

Allison, P.D. (2002). *Missing Data*. California: Sage Publication, Inc.

Ashton, P., Buhr, D. and Crocker, L. (1984). Teachers' sense of efficacy: A self- or norm-referenced construct? *Florida Journal of Educational Research, 26*(1), 29-41.

Ashton, P.T., and Webb, R. B. (1986). *Making a difference: Teachers' sense of efficacy and student achievement*. Longman Press.

Askar, P., and Umay, A. (2001). İlköğretim matematik öğretmenliği öğrencilerinin bilgisayarla ilgili öz yeterlik algısı [Perceived Computer Self-Efficacy of the Students in The Elementary Mathematics Teaching Programme]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 21,* 1-8.

Aydın, S., and Çelik, D. (2016). Preservice elementary mathematics teachers' beliefs about preparedness to teach mathematics: scale adaptation and validation study. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 10*(2), 469-510.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Başpınar, K., and Peker, M. (2016). The relationship between pre-service primary school teachers' mathematics teaching anxiety and their beliefs about teaching and learning mathematics. *Journal of Theoretical Educational Science, 9*(1), 1-14.

Borko, H., and Putnam, R.T. (1996). *Learning to teach.* In D. C. Berliner and R. C. Calfee (Eds.), *Handbook of educational psychology* (p. 673–708). Macmillan Library Reference; Prentice Hall International.

Bryman, A., and Cramer, D. (2001). *Quantitative data analysis with SPSS release 10 for windows: A guide for social scientists*. Routledge. https://doi.org/10.4324/9780203471548.

Bursal, M. (2010). Turkish pre-service elementary teachers' self-efficacy beliefs regarding mathematics and science teaching. *International Journal of Science and Mathematics Education, 8,* 649-666.

Büyüköztürk, Ş. (2017). *Sosyal bilimler için veri analizi el kitabı* [*Handbook of data analysis for social sciences*]. Ankara: Pegem Akademi Yayıncılık.

Cakiroglu, E. (2000). *Preservice elementary teachers' sense of efficacy in reform-oriented mathematics*. Unpublished Doctoral Dissertation, Indiana University, Bloomington, USA.

Can, A. (2013). *SPSS ile bilimsel araştırma sürecinde nicel veri analizi* [*Quantitative data analysis in the scientific research process with SPSS*]. Ankara: Pegem Akademi Yayınları.

Charalambous, C.Y., Philippou, G. N., and Kyriakides, L. (2008). Tracing the development of preservice teachers' efficacy beliefs in teaching mathematics during fieldwork. *Educational Studies in Mathematics, 67*(2), 125-142.

Chester, M., and Beaudin, B.Q. (1996). Efficacy beliefs of newly hired teachers in urban schools. *American Educational Research Journal, 33,* 233-257.

Comrey, A. L., and Lee, H. B. (1992). *A first course in factor analysis* (2nd ed.). Mahway: Lawrence Erlbaum Associates, Inc.

Dede, Y. (2008). Matematik öğretmenlerinin öğretimlerine yönelik öz yeterlik inançları [Mathematics teachers' self-efficacy belief towards teaching]. *Türk Eğitim Bilimleri Dergisi, 6*(4), 741–757.

Delice, A. and Ergene, Ö. (2015). Ölçek geliştirme ve uyarlama çalışmalarının incelenmesi: Matematik eğitimi makaleleri örneği. *Karaelmas Journal of Educational Sciences, 3*(1), 60-75.

Deniz, L., and Koç, T. (2020). Development of the mathematics teaching self-efficacy belief scale. *SDU International Journal of Educational Studies, 7*(1), 82-98.

Demir, E., and Parlak, B. (2012). Türkiye'de eğitim araştırmalarında kayıp veri sorunu [The problem of missing data in educational research in Turkey]. *Journal of Measurement and Evaluation in Education and Psychology*, *3*(1), 230-241.

Doruk, M., and Kaplan, A. (2012). Sınıf öğretmeni adaylarının matematik öğretimlerine yönelik öz-yeterlik inançlarının incelenmesi [Examining prospective primary school teachers' self-efficacy beliefs toward mathematics teaching]. *The Journal of Academic Social Science Studies., 5*(7), 291-302.

Enochs, L.G., Smith, P. L., and Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194-201.

Ergene, Ö. (2020). Matematik eğitimi alanında ölçek geliştirme ve ölçek uyarlama makaleleri: Betimsel içerik analizi [Scale Development and Adaptation Articles in the Field of Mathematics Education: Descriptive Content Analysis]. *Journal of Education for Life, 34*(2), 360-383.

Erkuş, A. (2012). *Psikolojide ölçme ve ölçek geliştirme-1: Temel kavramlar ve işlemler*. Ankara: Pegem Akademi Yayıncılık.

Esendemir, Ö., Çırak, S., and Samancıoğlu, M. (2015). İlköğretim matematik öğretmen adaylarının matematik öğretimi yeterliklerine ilişkin görüşleri [Pre-service Elementary Math Teachers' Opinions About Mathematics Teaching Competencies]. *Gaziantep University Journal of Social Sciences, 14*(1), 217- 239.

Field, A. (2009). *Discovering statistics using SPSS (3rd Ed.)*. London: Sage Publications.

Fornell, C., and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research,* 48, 39-50.

Fraenkel, J. R., and Wallen, N.E. (2006). *How to design and evaluate research in education*. New York: McGraw-Hill Press.

Gibson, S., and Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*, 4, 569-582.

Graham, S., Harris, K. R., Fink, B., and MacArthur, C. A. (2001). Teacher efficacy in writing: A construct validation with primary grade teachers. *Scientific Studies of Reading, 5*, 177-202.

Gorsuch, R. (1983). *Factor analysis (2nd ed.)*. Mahwah: Lawrence Erlbaum Associates Press.

Guskey, T.R. (1988). Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching and Teacher Education, 4*(1), 63-69.

Guskey, T., and Passaro, P. (1994). Teacher efficacy: A study of construct dimensions. *American Educational Research Journal, 31,* 627-643.

Gül, Ş. and Sözbilir, M. (2015). Fen ve matematik eğitimi alanında gerçekleştirilen ölçek geliştirme araştırmalarına yönelik tematik içerik analizi [Thematic content analysis of scale development studies published in the field of science and mathematics education]. *Education and Science, 40*(178), 85-102. DOI: 10.15390/EB.2015.4070.

Hacıömeroğlu, G., and Şahin-Taşkın, Ç. (2010). Sınıf öğretmeni adaylarının matematik öğretimi yeterlik inançları [Elementary Preservice Teachers' Mathematics Teaching Efficacy Belief]. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi, 23*(2), 539-555.

Hackett, G., and Betz, N. (1989). An exploration of the mathematics self-efficacy/ mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*(3), 261-273.

Hair, J. F. Jr., Black, W. C., Babin, B. J., Anderson, R.E., and Tatham, R. L. (2006). Multivariate data analysis (6th ed). Hoboken: Prentice-Hall Press.

Harrington, D. (2009). *Confirmatory factor analysis*. Oxford: Oxford University Press.

Hoy, A.W. (2000). Changes in teacher efficacy during the early years of teaching. Paper presented at the Annual Meeting of the *American Educational Research Association*. New Orleans, LA. Retrieved from https://www.learningforwardpa.org/uploads/2/0/8/5/20859956/changes_in_teacher_efficacy.pdf.

Jöreskog, K.G., and Sörbom, D. (1993). *LISREL 8: Structural equation modeling with the SIMPLIS command language*. LINCOLNWOOD*:* Scientific Software International, Inc.

Kaiser, H. F. (1960). The applications of electronic computer to factor analysis. *Educational and Psychological Measurement*, *20*, 141-151.

Keith, T.Z., and Cool, V.A. (1992). Testing models of school learning: Effects of quality of instruction, motivation, academic coursework, and homework on academic achievement. *School Psychology Quarterly, 7*, 207-226.

Knapp, M.S., Copland, M.A., and Talbert J.E. (2003). Leading for learning: Reflective tools for school and district leaders. *Center for the Study of Teaching and Policy*. Washington: University of Washington.

Koyuncu, I., Güzeller, C.O., and Akyüz, D. (2017). The development of a self-efficacy scale for mathematical modeling competencies. *International Journal of Assessment Tools in Education, 4*(1), 19-36.

Koyuncu, İ., and Kılıç, A.F. (2019). The Use of Exploratory and Confirmatory Factor Analyses: A Document Analysis. *Education and Science, 44*(198), 361-388.

Little, R.J.A, and Rubin, D.B. (1987). *Statistical Analysis with Missing Data*, *2nd edition*. New Jersey: John Wiley and Sons, Inc.

Maasepp, B., and Bobis, J. (2014). Prospective primary teachers' beliefs about mathematics. *Mathematics Teacher Education and Development, 16*(2), 89–107.

Maddux, J.E., Norton, L.W., and Stoltenberg, C.D. (1986). Self-efficacy expectancy, outcome expectancy, and outcome value: Relative effects on behavioral intentions. *Journal of Personality and Social Psychology*, *51,* 783-789.

Mertler, C.A., and Vannatta, R.A. (2005), *Advanced and multivariate statistical methods: practical application and interpretation (3rd Ed.)*. Los Angeles: Pyrczak Publishing.

Midgley, C., Feldlaufer, H., and Eccles, J. (1989). Change in teacher efficacy and student self- and task-related beliefs in mathematics during the transition to junior high school. *Journal of Educational Psychology, 81*, 247-258.

Nunnally, J. C. (1978). *Psychometric theory (2nd ed.)*. New York: McGraw-Hill Press.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578.

Pajares, F., and Miller, M.D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology, 86*(2), 193-203.

Peker, M. (2009). Pre-service teachers' teaching anxiety about mathematics and their learning styles. *Eurasia Journal of Mathematics, Science and Technology Education, 5*(4), 335-345.

Peters, G. J. Y. (2014). The alpha and the omega of scale reliability and validity: why and how to abandon Cronbach's alpha and the route towards more comprehensive assessment of scale quality. *European Health Psychologist, 16*(2), 56-69.

Podell, D.M., and Soodak, L.C. (1993). Teacher efficacy and bias in special education referral. *Journal of Educational Research, 86,* 247-253.

Ross, J.A. (1994). Beliefs that make a difference: the origins and impacts of teacher efficacy. Paper presented at the *Annual meeting of the Canadian association for curriculum studies*.

Secada, W.G. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 623-660). New York: MacMillan Press.

Swackhamer, L.E., Koellner, K., Basile, C., and Kimbrough, D. (2009). Increasing the self-efficacy of in-service teachers through content knowledge. *Teacher Education Quarterly, 36*(2), 63-78.

Swars, S.L. (2005). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional Psychology, 32,* 139-147.

Şahin, M. G., and Boztunç Öztürk, N. (2018). Eğitim alanında ölçek geliştirme süreci: Bir içerik analizi çalışması [Scale Development Process in Educational Field: A Content Analysis Research]. *Kastamonu Eğitim Dergisi, 26*(1), 191-199.

Şan, İ. (2013). Matematik öğretmen adaylarının öğretimi planlama ve düzenleme yeterlikleri hakkında öz yeterlik düzeyleri [The level of self-efficacy of prospective mathematics teachers about competencies for planning and organizing instruction]. *International Periodical for the Languages, Literature and History of Turkish or Turkic, 8*(3), 517-537.

Tabachnik, B.G., and Fidell, L.S. (2013). *Using multivariate statics*. London: Pearson New International Edition.

Takunyaci, M., and Takunyaci, M. (2014). Preschool teachers' mathematics teaching efficacy belief. *Procedia – Social and Behavioral Sciences, 152*, 673–678.

Taşdemir, C. (2019). Examination of Teacher Candidates' Self-efficacy Beliefs for Mathematics Teaching, *Inonu University Journal of the Faculty of Education, 20*(1), 55-68.

Wertheim, C., and Leyser, Y. (2002). Efficacy beliefs background variables and differentiated instruction of Israeli prospective teachers. *Journal of Educational Research, 96*, 54-64.

Yıldırım, S. (2011). Öz-yeterlik, içe yönelik motivasyon, kaygı ve matematik başarısı: Türkiye, Japonya ve Finlandiya'dan Bulgular [Self-efficacy, Intrinsic Motivation, Anxiety and Mathematics Achievement: Findings from Turkey, Japan and Finland]. *Necatibey Eğitim Fakültesi Dergisi, 5*(1),277- 291.

Zimmerman, B.J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, *25*(1), 82-91.

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Konu : 30/24 Dr. Öğr. Üyesi Mithat TAKUNYACI

Sayın Mithat TAKUNYACI

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24. Dr. Öğr. Üyesi Mithat TAKUNYACI'nın "Çoktan Seçmeli Sorulara Dayalı Olmayan Bir Kitle Matematik Sınavı Sürecinin Değerlendirilmesi: Grup Uyumu Değerlendirme Modeli " başlıklı çalışması görüşmeye açıldı.

Yapılan görüşmeler sonunda Dr. Öğr. Üyesi Mithat TAKUNYACI'nın "Çoktan Seçmeli Sorulara Dayalı Olmayan Bir Kitle Matematik Sınavı Sürecinin Değerlendirilmesi: Grup Uyumu Değerlendirme Modeli '' başlıklı çalışmasının Etik açıdan **uygun** olduğuna oy birliği ile karar verildi.