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Reliability Generalization Meta-Analysis of Mathematics Anxiety Scale for Primary School Students

Ömer Şahin ASLAN * Salih GÖCEN ** Sedat ŞEN ***

Abstract

The purpose of this study was to estimate the mean value for the reliability coefficients reported by the studies using the Mathematics Anxiety Scale for Primary School Students (MASPSS) and to examine the sources of the variation of the reliability coefficients reported in each study. A reliability generalization meta-analysis study was conducted by combining the Cronbach's alpha values of 34 studies that met the inclusion criteria. The Cronbach's alpha values used in the studies were converted to the transformed coefficient values by applying the Bonett transformation, and the analyses were carried out under the random-effects model. The mean Cronbach's alpha value of the MASPSS across 34 studies was found to be .855 (95% CI: .841-.869), and this result was statistically significant (p<.01). According to the results, there was a lack of publication bias in this meta-analysis study. Moderator analyses were conducted to explain the possible sources of heterogeneity across the individual studies. Findings revealed that the Cronbach's alpha estimates did not show any statistical differences based on publication year, female percentage, publication type and research method variables. It was found that the sample type affected the estimation of Cronbach's alpha coefficient. In addition, suggestions were made for psychometric studies that would use the MASPSS in the future.

Keywords: mathematics anxiety, reliability generalization, meta-analysis

Introduction

The concept of anxiety has been included in different areas as an indispensable element of daily life for many communities in the world. Our formal schooling period, which covers a certain part of many people's lives, is one of these areas. It is known that some people are more anxious during these periods. Although the concept of anxiety is attributed to different meanings by people, the concept that is most confused is the fear (Manav, 2011). So what does the concept of anxiety really mean? While the anxiety was previously accepted as a biological concept, it has entered the psychological literature with its definition by Freud as a function of the ego (Manav, 2011). Anxiety is a reflection of the fear of any danger and is defined as a state of uneasiness or irrational fear that manifests itself in people and differs from fear as it is objectless (Budak, 2000, p. 437).

Throughout the formal education life, mathematics has been one of the most encountered fields, because it is universal and penetrates many areas of life. During their formal education years, many people may have encountered people with anxiety in math classes. This state of anxiety, which we see in mathematics lessons, is called mathematics anxiety. Different definitions of this concept have been made in previous studies (Newstead, 1998; Richardson & Suinn, 1972; Tobias & Weissbrod, 1980). Richardson and Suinn (1972) defined mathematics anxiety as “a feeling of tension and anxiety that interferes with the manipulation of numbers and solving math problems in a variety of life and academic situations” (p. 551).

Students' mathematics anxiety is among the important factors affecting math achievement (Bozkurt, 2012; Dursun & Bindak, 2011; İlhan & Öner Sünkür, 2012; Kutluca et al., 2015; Kuzu, 2021; Mutlu et

* Graduate student., Harran University, Faculty of Education, Şanlıurfa-Turkey, omersahinaslan63@gmail.com, ORCID ID: 0000-0003-1330-1251
** Graduate student., Harran University, Faculty of Education, Şanlıurfa-Turkey, salihgocen48@gmail.com, ORCID ID: 0000-0001-6594-4967
*** Assoc. Prof., Harran University, Faculty of Education, Şanlıurfa-Turkey, sedatsen@harran.edu.tr, ORCID ID: 0000-0001-6962-4960

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al., 2017; Şad et al., 2016). Previous studies have stated that as the mathematics anxiety level increases, students' math achievement decreases and it affects learning negatively (Bozkurt, 2012; Dursun & Bindak, 2011; İnci Kuzu, 2021; Kutluca et al., 2015; Mutlu et al., 2017; Tooke & Leonard, 1998; Wadlington & Wadlington, 2008). A recent meta-analysis study examining the relationship between mathematics anxiety and math achievement has concluded that students with higher mathematics anxiety levels had lower math achievement levels (Şad et al., 2016). In a different study, a negative and high-level correlation was also found between the students' readiness for mathematics lesson and their mathematics anxiety (Ergenç, 2011). The concept of mathematics anxiety that develops in students can be caused by four main reasons: teachers, students themselves, their families and friends (Alkan, 2011). It has also been stated that mathematics anxiety can occur due to more than one reason (Alkan, 2011). According to this information, it can be interpreted that anxiety can be caused by more than one variable and different variables can affect anxiety at the same time. For instance, when we consider the studies examining the effect of the gender variable on mathematics anxiety, statistically significant differences were observed in some studies (Arı et al, 2010; Şahin, 2008), while in others, no statistically significant difference was observed (Dede & Dursun, 2008; Dursun & Bindak, 2011; Gündüz Çetin, 2020; Kandal & Baş, 2021; Kutluca et al., 2015; Mutlu et al., 2017; Şimşek et al., 2017; Tan, 2015; Taşdemir, 2015; Yetgin, 2017). When we look at the studies examining the effects of the grade level variable on mathematics anxiety, some studies have stated that grade level has a significant effect on mathematics anxiety (Dursun & Bindak, 2011; Taşdemir, 2015), while some others have stated that grade level has no significant effect (Bozkurt, 2012; Dede & Dursun, 2008; Kandal & Baş, 2021). Some studies showed that families could also be the cause of mathematics anxiety in students (Kesici, 2018b; Maloney et al., 2015). According to Yetgin (2017), students who received private lessons or study training center support had less mathematics anxiety than students who did not receive support.

Many scale development and adaptation studies have been conducted to determine students' mathematics anxiety levels and to explain which variables would cause anxiety (Alexander & Martray, 1989; Bai et al., 2009; Fennema & Sherman, 1976; Hopko et al., 2003; Hunt et al., 2011; Ikegulu, 1998; Plake & Parker, 1982; Richardson & Suinn, 1972; Sandman, 1980; Suinn & Edwards, 1982; Suinn et al., 1988). Some of these scales were adapted into Turkish (Akçakın et al., 2015; Baloğlu & Balgalmış, 2010; Baloğlu, 2005).

In Turkey, some scale development and adaptation studies were also carried out in order to measure the mathematics anxiety of students, teachers and parents (Akçakın et al., 2015; Akın et al., 2011; Baloğlu, 2005; Baloğlu & Balgamış, 2010; Bindak, 2005; Mutlu & Söylemez, 2018; Mutlu et al., 2018; Peker, 2006; Sarı, 2014; Şan & Akdağ, 2017; Üldaş, 2005; Yıldırım & Gürbüz, 2017). For instance, Akçakın et al. (2015) adapted the Mathematics Anxiety Scale (MAS; Bai et al., 2009) into Turkish. Similarly, Akın et al. (2011) also adapted the Revised Mathematics Anxiety Rating Scale (RMARS; Plake and Parker, 1982) into Turkish. In another study, Baloğlu and Balgalmış (2010) adapted the Mathematics Anxiety Rating Scale Primary Education Form (MARS-E; Suinn et al., 1988) scale into Turkish. The Mathematics Exam Anxiety Scale (MEAS) was developed by Şan and Akdağ (2017) to determine the mathematics test anxiety of middle school students. The Mathematics Anxiety Scale for Primary School Students, developed by Bindak (2005), was also developed to determine the mathematics anxiety levels of primary school students. When we look at the scale adaptation and development studies to determine students' mathematics anxiety levels, it was seen that the scale developed by Bindak (2005) was used in more studies compared to other Turkish scales.

In this meta-analysis study, Mathematics Anxiety Scale for Primary School Students (MASPSS), developed by Bindak (2005), was examined as it is the most cited scale among Turkish scales measuring mathematics anxiety. Bindak (2005) developed a 10-item mathematics anxiety scale as a result of his analysis. With this scale developed, it was aimed to determine the levels of mathematics anxiety in primary school students (Bindak, 2005). In the first draft of the scale, there were four items to obtain students' personal information and 16 items in a 5-point Likert type format that can express mathematics anxiety. Each student responding to the scale selects one of the five categories (*always, most of the time, sometimes, almost never* and *never*). Positive items for anxiety in the scale were scored as 5-4-3-2-1 and negative items for anxiety were scored as 1-2-3-4-5. Thus, an anxiety score is obtained for the whole scale. Higher scores obtained from the scale indicate higher mathematics anxiety. Based on the item-total correlation (two items) and factor analysis (four items) with the preliminary scale, six items were eliminated and a final scale of 10 items was constructed in Bindak (2005). In this case, the anxiety score formed by the scale ranges from 10 to 50 points.

As a result of the factor analysis, the explained total variance of the scale with 10 items was 51.7% (Bindak, 2005). In addition, Bindak (2005) reported that the internal consistency coefficient (i.e., Cronbach’s alpha) of the scale was .84. After this original scale development study, the scale (MASPSS) has been used in several studies. It has been observed that studies using this scale have reported different Cronbach's alpha values. Using the scale developed by Bindak (2005), several studies have been carried out in different cities and districts, at different grade levels, in different years and with different research methods (Aydın & Keskin, 2017; Berber, 2021; Dede & Dursun, 2008; Küçük, 2019; Yurt & Kurnaz, 2015). However, while some studies found the Cronbach's alpha coefficient to be around .70 (Erdik, 2018; Şimşek et al., 2017; Tuncer & Yılmaz, 2016) some studies had values of .80 and above (Akgül & Nuhoğlu, 2020; Aydın & Keskin, 2017; Küçük, 2019; Şahin, 2018). For this reason, a number of different Cronbach's alpha coefficient has been reported in these studies. Some studies also reported the reliability value obtained from previous studies that used that scale before, rather than calculating based on their own sample. In this case, it is assumed that reliability is a fixed and stable characteristic of the scale itself, not the measurement results. This is called reliability induction (Vacha-Haase, et al., 2000). Since the reliability values reported in previous studies vary, it may not be appropriate to generalize a reliability value over the studies without necessary analyses. As a result, the reliability of the scores should be confirmed due to the variability in reported reliability values with its widespread use in different environments and populations. A reliability generalization study was needed to learn the general condition of the reliability coefficient obtained from the MASPSS and to help researchers who may want to induce a reliability value. In this study, a “reliability generalization (RG)” (Vacha-Haase, 1998), which is a meta-analytic technique, was conducted for the review, integration and analysis of research results. Our aim in this study is to obtain an overall reliability coefficient inference of the MASPSS developed by Bindak (2005) and to examine how the reliability coefficients change between the uses of the scales in different samples. More precisely, the aims of this study are: a) to examine the generalizability of reliability estimates in studies using the MASPSS and to investigate the variables that may explain this heterogeneity if heterogeneity is found in the estimates of this parameter. In order to achieve these aims, studies reporting alpha coefficients were determined using the aforementioned scale, and subgroup analyses were carried out by examining some variables as well.

Method

Research Design

Glass (1976) defined meta-analysis as an analysis method for summarizing the results obtained from individual studies as a single result. In other words, meta-analysis is a type of quantitative study that combines the findings of more than one study and presents it as a single finding (Şen & Yıldırım, 2020). The meta-analysis study conducted on the reliability values of a specified scale is known as the reliability generalization meta-analysis (Vacha-Haase, 1998). Reliability generalization is known as a meta-analysis study that investigates the reliability values of the scores obtained from the scales and helps to determine what causes measurement error. This meta-analysis study for the reliability generalization of the primary school mathematics anxiety scale was presented following the REGEMA guidelines (Sánchez-Meca et al., 2021).

Data Collection

For the research data used in the study, National Thesis Center of the Council of Higher Education, Web of Science, and ERIC databases and Google Scholar search engine were scanned extensively. While searching the Turkish terms "matematik kaygı ölçeği" and "matematik kaygısı" and combinations of the English equivalents of these terms "Math Anxiety Scale", "Math Anxiety", "Mathematics Anxiety

Scale" and "Mathematics Anxiety" were searched throughout the text. In addition, via the "cited by" option in Google Scholar, references to the primary school mathematics anxiety scale (Bindak, 2005) were also reviewed in this study.

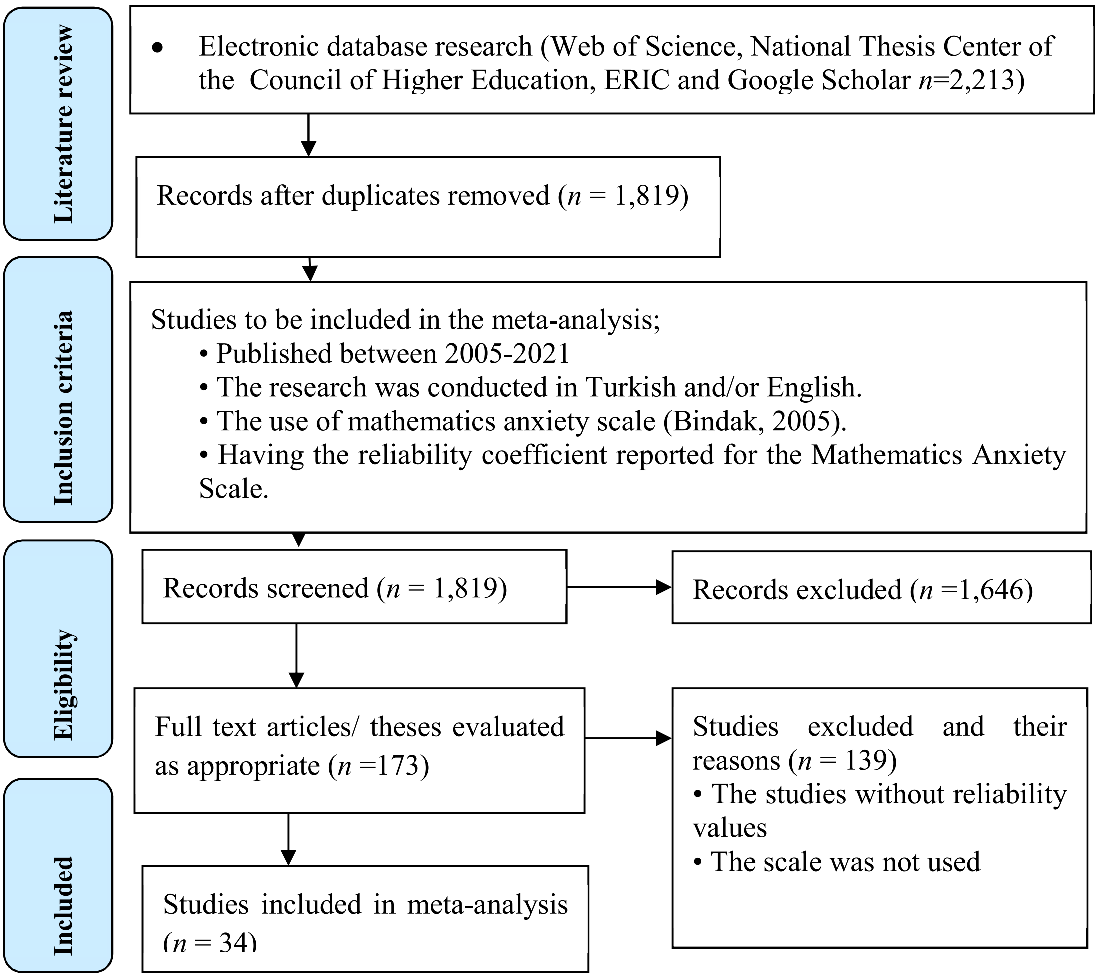
Inclusion/Exclusion Criteria

The following criteria were considered in determining the individual studies included in this study;

1) The articles must be written in Turkish and/or English.
2) The Mathematics Anxiety Scale for Primary School Students (Bindak, 2005) must be used.
3) Since the Mathematics Anxiety Scale for Primary School Students (Bindak, 2005) used in this study was published in 2005, the studies to be included can be either published or unpublished studies after 2005 until December 2021.
4) Having a reliability coefficient (e.g., Cronbach's alpha) reported on the sample in the study for the Mathematics Anxiety Scale for Primary School Students used in the studies.

The criteria listed above have been used in this study for selecting the possible studies. The inclusion/exclusion process is illustrated by the PRISMA flowchart (Figure 1). The number of studies found in searches was 2,213. Of these studies, 2,179 were excluded from the study due to the reasons such as being a duplicate study, not including the reliability (Cronbach's alpha) coefficient. After excluding the studies that do not meet the inclusion criteria, 34 studies remained.

Figure 1
Prisma Flow Chart: Studies Included in the Research



Coding of Data

In addition to the reliability coefficient and the number of items reported by the individual studies, the year they were published, the types of publications, the sample sizes, the school level in which the study was conducted, the percentage of female participants, the mean score and the standard deviation of MASPSS, the research method used in the studies were saved in an Excel file and coded accordingly. Information on the recorded variables is summarized in Table 1.

Table 1

Coding Method of Studies Included in the Meta-Analysis

Variable	Type	Coding Method
ID	Categorical	A unique number assigned to each study.
Year of publication	Continuous	Year of publication or report (for unpublished studies)
Publication type	Categorical	0= Thesis, 1= Article
Sample size	Continuous	The sample sizes specified in the studies were recorded.
Alpha	Continuous	The Cronbach's alpha values presented in the studies were recorded.
Number of items	Continuous	The number of scale items presented in the studies was recorded.
The average score	Continuous	The average anxiety scores presented in the studies were recorded.
Standard deviation	Continuous	The standard deviation scores of the means presented in the studies were recorded.
Sample type	Categorical	0= Primary School, 1=Middle School, 2= High School
Research method	Categorical	0= Experimental, 1= Non-experimental studies

Two researchers independently coded the data from individual studies. The inter-rater reliability was examined using the agreement index, which is a relatively simple way of checking the inter-rater reliability (Şen & Yıldırım, 2020). The percentage of agreement between the coders was calculated as 95%. Inconsistencies in coding were discussed and corrected by consensus. Then, the final data file created was transferred to the R software environment (R Core Development Team, 2021) for the statistical analyses.

Effect Size Calculation and Statistical Analyses

The focus of this study was the reliability generalization analysis used to estimate the mean reliability coefficient of the Mathematics Anxiety Scale for Primary School Students. An average value was calculated over the reliability coefficients reported in individual studies that used this scale. Since Cronbach's alpha value was predominantly used in these individual studies, only alpha coefficient was considered in the current study. While conducting reliability generalization studies, it is necessary to consider the transformation and weighting the alpha coefficients (Şen, 2021). Since the typical Cronbach's alpha values appeared to be skewed (Semma et al., 2019), Bonett's transformation formula (Bonett, 2002) was used to normalize the sample distributions and stabilize the variance. The calculation of the mean effect size in the meta-analysis literature is carried out with the either a fixed-effect model or the random-effects model (Borenstein et al., 2009; Şen & Yıldırım, 2020). It would be a more accurate approach to use the random-effects model for the studies conducted in social sciences (Borenstein et al., 2009). The random-effects model is needed in cases where results are desired to be generalized to the population (Schmid et al., 2021). In this respect, the mean effect size was calculated using the random-effects model in this study.

Whether there was heterogeneity among the studies included in the meta-analysis was examined by calculating Cochran's Q-test and I^2 value (Higgins & Thompson, 2002). A significant Q-statistic and an I^2 value of more than 75% can be taken as the evidence of the heterogeneity (Higgins et al., 2003). In cases where heterogeneity was detected, the relationship between Cronbach's alpha values and moderator variables would be examined using metaregression for continuous variables and weighted analysis of variance (analog to the ANOVA) models for categorical variables. All of the analyses in this study were carried out using the metafor (Viechtbauer, 2010) package in the R software environment.

Publication Bias Analyses

Publication bias term is used to describe that statistically significant results are more likely to be presented and published than nonsignificant results (Petitti, 2000). Since researchers generally tend to publish large effect sizes rather than small effect sizes, including only studies with large effect sizes in the meta-analyses raises a problem referred to as publication bias (Göçen & Şen, 2021). Publication bias is seen as a possible threat for meta-analysis studies (Rothstein et al., 2005). Moreover, publication bias, which is a widespread problem, can skew the effect size to be estimated (Thornton & Lee, 2000), and this might distort results of meta-analysis (Yumuşak & Korkmaz, 2021). In this study, publication bias was assessed using a funnel plot, Rosenthal's (1979) fail safe *N* and two statistical tests based on rank correlations (Begg & Mazumdar, 1994) and Egger's (Egger et al., 1997) regression method.

Results

Characteristics of Individual Studies

This reliability generalization meta-analysis includes 34 individual studies conducted between 2005 and 2021 that have reported reliability coefficients based on their own sample. Seventy-four percent of the studies were published (*N* =25) and 26% were unpublished (*N* =9). The total population in individual studies consisted of 10,855 individuals. Sixteen percent of the studies were carried out at primary school level, 75% at middle school level and 9% at high school level. Some of the studies using this scale at different school levels have conducted confirmatory factor analysis (Erdik, 2018; Gündüz Çetin, 2020; Yetgin, 2017), however, most of them have used the scale without any validation analyses. The Cronbach's alpha coefficient as a reliability index in the studies was reported between .737 and .920. In addition, 79% of the studies were conducted with experimental design and 21% with non-experimental design. Summary information about the studies is shown in Table 2.

Table 2
Information about the Studies

ID	Author(Year)	Publication Type	*N*	*α*	Sample Level	Female (%)	Publication Year	Method
1	Bindak (2005)	Published	122	.840	MS		2005	Non-experimental
2	Dede and Dursun (2008)	Published	204	.800	MS	42.0	2008	Non-experimental
3	Dursun and Bindak (2011)	Published	266	.888	MS	45.5	2011	Non-experimental
4	Küçük (2019)	Unpublished	52	.870	MS		2019	Experimental
5	Yurt and Kurnaz (2015)	Published	260	.800	MS	51.5	2015	Non-experimental
6	Aydın and Keskin (2017)	Published	619	.860	MS	50.4	2017	Non-experimental
7	Kutluca et al. (2015)	Published	158	.800	MS	49.4	2015	Non-experimental
8	Kesici (2018a)	Published	463	.884	HS		2018	Non-experimental
9	Çoruk and Çakır (2017)	Published	31	.880	PS	59.0	2017	Experimental
10	Duran et al. (2017)	Published	51	.820	MS		2017	Non-experimental
11	Kandal and Baş (2021)	Published	124	.840	MS	49.2	2021	Non-experimental
12	Şimsek et al. (2017)	Published	437	.780		44.1	2017	Non-experimental
13	İlhan and Öner Sünkür (2012)	Published	201	.830	MS	50.7	2012	Non-experimental
14	Doruk et al. (2016)	Published	246	.870	MS	54.8	2016	Non-experimental
15	Tuncer and Şimşek (2019)	Published	72	.840	MS		2019	Experimental
16	Akgül and Nuhoğlu (2020)	Published	121	.910	PS	37.2	2020	Non-experimental
17	Yetgin (2017)	Unpublished	860	.910	HS	37.0	2017	Non-experimental
18	Gündüz Çetin (2020)	Unpublished	555	.890	HS	49.4	2020	Non-experimental
19	Erdik (2018)	Published	1563	.737	MS	51.4	2018	Non-experimental
20	Baklacı (2017)	Unpublished	204	.850	MS	42.2	2017	Non-experimental
21	Kesici (2018b)	Published	132	.879	MS		2018	Non-experimental
22	İlhan and Öner Sünkür (2013)	Published	348	.860	MS	49.7	2013	Non-experimental
23	Berber (2021)	Unpublished	40	.920	MS	57.5	2021	Experimental
24	Kuzu and Çalışkan (2018)	Published	375	.876		78.4	2018	Non-experimental
25	Tuncer and Yılmaz (2016)	Published	225	.795	MS	48.0	2016	Non-experimental
26	Taşdemir (2015)	Published	280	.850	MS	51.4	2015	Non-experimental
27	Ergenç (2011)	Unpublished	526	.890	MS	49.8	2011	Non-experimental
28	Çağırgan and Soytürk (2021)	Published	568	.865	MS	51.1	2021	Non-experimental
29	Gevrek (2009)	Unpublished	932	.800	MS	50.9	2009	Non-experimental
30	Tabakçı (2018)	Unpublished	415	.840	PS	52.0	2018	Non-experimental
31	Borlat (2018)	Unpublished	18	.860	PS	38.9	2018	Experimental
32	Şahin (2018)	Published	30	.830	PS		2018	Experimental
33	Birgin et al. (2010)	Published	220	.910	MS	51.4	2010	Non-experimental
34	Tok (2013)	Published	137	.860	MS	52.7	2013	Experimental

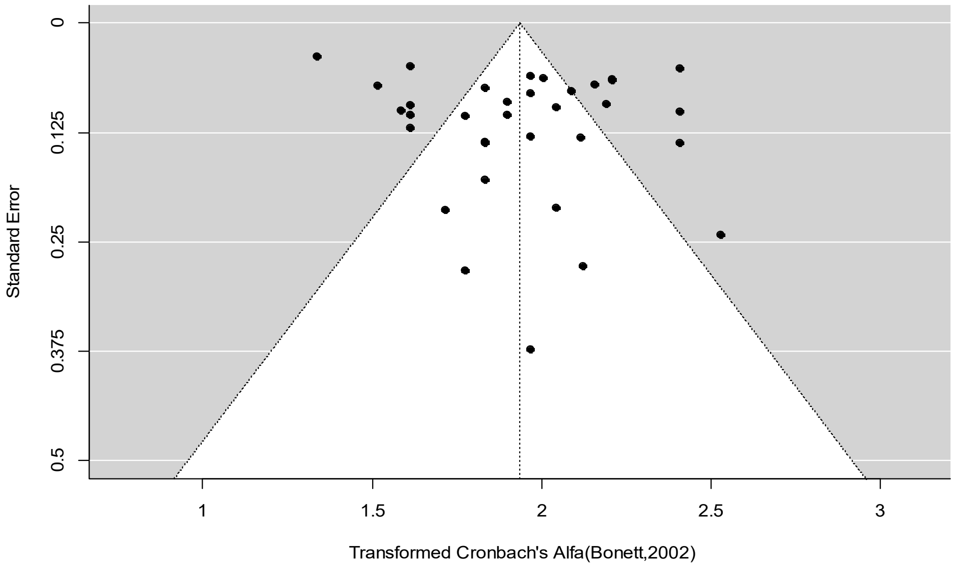
Notes. N=sample size, α=Cronbach's alpha, PS=Primary school, MS=Middle school, HS=High school. All studies had 10 items on the scale except that Tok (2013) had 9.

Results of Publication Bias

In the present study, the possibility of publication bias was investigated using the funnel plot, Rosenthal's (1979) fail safe *N* value and two statistical tests: Begg and Mazumdar (1994) rank correlations, and Egger's (Egger et al., 1997) linear regression method. An asymmetrical shape observed in the funnel plot indicates a possible publication bias (Borenstein et al., 2009). As seen in the funnel plot presented in Figure 2, Cronbach's alpha values of the studies appear to be symmetrically distributed according to the mean transformed alpha value. Therefore, it was found that the present study did not have publication bias. However, since it cannot be said that an asymmetrical funnel plot is formed as a result of publication bias, care should be taken while interpreting the chart (Üstün & Eryılmaz, 2014). When the publication bias was examined according to Rosenthal's classical fail safe *N* method, 7081 studies were required to turn the mean effect size value into statistically non-significant (p>.05) situation. If the Rosenthal's fail safe *N* value is NR >5*k*+10 (180 for this study), the possibility of publication bias is low (Şen & Yıldırım, 2020). Kendall's tau b statistic was observed to be nonsignificant (Tau b = -0.05; $p_{two\text{-}tails}$=.6565) according to Begg and Mazumdar's rank correlations. Finally, it was observed that the *t*-value was not statistically significant in Egger's linear regression test ($t_{(32)}$=0.7792, p =.4416). These findings showed that there was no indication of publication bias.

Figure 2

Funnel Plot Examining the Relationship between Transformed Alpha (Bonett, 2002) and Standard Error



Mean reliability

The mean value of raw reliability coefficient values reported in 34 studies, without weighting, was .851 (SD=0.04, Median=.86). A mean of .851 indicates good internal consistency for the mathematics anxiety scale among studies. A stem and leaf plot of the raw reliability coefficients is presented in Figure 3.

Figure 3

Distribution of Raw Alpha Values

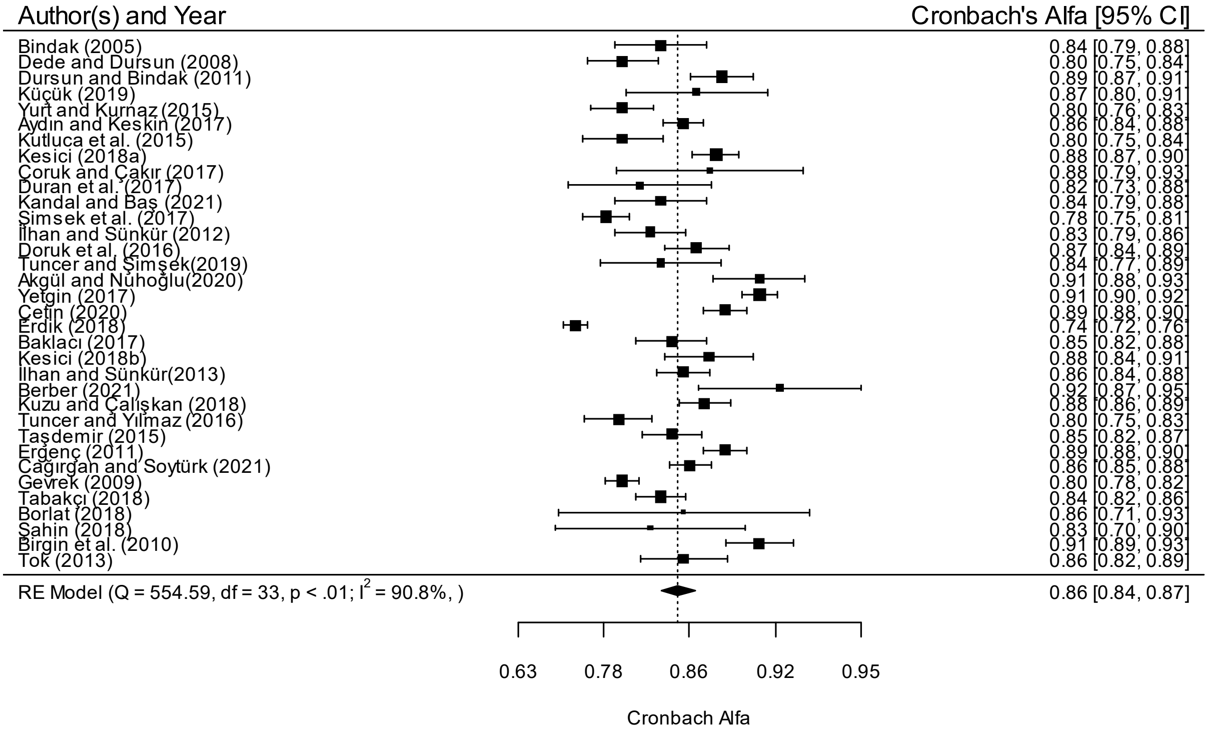
.73 | 7
.78 | 0
.79 | 5
.80 | 0000
.82 | 0
.83 | 00
.84 | 0000
.85 | 00
.86 | 00005
.87 | 0069
.88 | 048
.89 | 00
.91 | 000
.92 | 0

As can be seen in Figure 3, the reliability coefficient values reported in studies vary between .737 and .920. According to these values, the reliability coefficients appear to be at a sufficient level (>.70) in all samples.

The reliability coefficients are known to have a skewed distribution and cannot be directly used in reliability generalization studies. Thus, the reliability coefficient values of thirty-four studies were transformed using the Bonett (2002) transformation method in order to normalize the distribution of the coefficients and stabilize the variance. The mean reliability coefficient was obtained by analyzing them with the random-effects model. The pooled reliability coefficient value in this study was found to be .855 (95% CI: .841-.869), which was statistically significant (p<.001). This mean value was close to the first published reliability coefficient value of the scale (Bindak, 2005). Q-test value in this study was also statistically significant ($Q_{(33)}$ =554,588; p<.001). In addition, I^2 value of 90.80 showed that the heterogeneity among the studies was high. The variability in the reliability coefficients can also be observed in the forest plot (see Figure 4).

Figure 4

Forest Plot of Studies



Results of the Moderator Analyses

Considering the heterogeneity that emerged in this meta-analysis study, it is important to identify the possible sources of this heterogeneity. Therefore, the variables of publication type and publication year, sample level, female percentage, and research method given in Table 2 were determined as moderator variables. Three of the variables were categorical (type of publication, sample level and research method), and the remaining variables were continuous (year of publication and female percentage). Descriptive statistics of moderator variables are presented in Table 3. Categorical variables were analyzed with analog to the ANOVA approach and continuous variables were analyzed with meta-regression method to reveal whether there was a relationship between alpha values and the moderator variables.

Table 3
Characteristics of the moderators

Variable	*k*	%
Publication Type (*k*= 34)		
Published	25	73.53
Unpublished	9	26.47
Sample Level (*k* =32)		
Primary School	5	15.63
Middle School	24	75
High school	3	9.37
Research Method (*k* =34)		
Experimental	7	20.58
Non-experimental	27	79.42
	M	*S*
Year of publication	2016	3.95
Female percentage	49.84	7.77

M = Mean, *S* = Standard Deviation

The results of the analog to the ANOVA analyses of three moderators are presented in Table 4. As shown in Table 4, no statistically significant difference was found between the sub-categories of publication type and research method variables (p>.05). However, a statistically significant difference was found among the subcategories of the sample level variable (p<.05). While the reliability coefficient was found to be higher at high school level (.8958) than primary school level (.8694), the lowest value was found at middle school level (.8483) (See Table 4).

Table 4
Mixed Effects Analog to the ANOVA Results

Variable	**Category**	***k***	***α***	***95% CI*** **Lower Limit**	**Upper Limit**	***Q*** ***B***	***df***	***p***
Sample level	Primary school	5	0.8694	0.8266	0.9016			
	Middle school	24	0.8483	0.8308	0.8642	6.3690	2	**0.0414**
	High school	3	0.8958	0.8784	0.9108			
Publication type	Published	25	0.8490	0.8310	0.8652	2.3345	1	0.1265
	Unpublished	9	0.8731	0.8462	0.8954			
Research method	Experimental	7	0.8684	0.8286	0.8988	0.5457	1	0.4601
	Non-experimental	27	0.8533	0.8366	0.8684			

Notes. *k* = Number of studies, CI = Confidence interval.

Two continuous moderators, the year of publication and the female percentage, of the reliability coefficient were analyzed with meta-regression. Meta-regression results are given in Table 5. As can be seen in Table 5, none of the continuous variables were statistically significant predictors of the reliability coefficient (p>.05).

Table 5

Meta-Regression Results According to Moderator Variables

Moderator	*k*	b_j	*SE*	*p*	Q_E
Year	34	-21.6115	26,1454	0.3678	552.3145**
Female %	25	1.9227	0.4007	0.9754	516.9344

k=number of studies, b_j =Unstandardized regression coefficient, *SE* =Standard error, Q_E =Heterogeneity statistics, ** $p<.001$.

Discussion and Conclusion

The aim of the present reliability generalization meta-analysis study was to obtain the general reliability for the Mathematics Anxiety Scale for Primary School Students and to examine the moderator variables that would reveal the variability between studies. For this purpose, individual studies using the Mathematics Anxiety Scale for Primary School Students and reporting the alpha coefficient of the sample were examined. The pooled reliability coefficient from 34 studies was .855. Based on this value, the overall estimate of Cronbach's alpha can be said to be within reasonable limits (>.70) for exploratory research (Clark & Watson, 1995; DeVellis, 1991; Nunnally & Bernstein, 1994).

Heterogeneity was observed between studies (I^2 = 90.80). This shows that it would not be appropriate to generalize the reliability coefficients of the Mathematics Anxiety Scale for Primary School Students since they vary in different samples. Therefore, it is not recommended for researchers who will use this scale to apply reliability induction.

The moderator variables that could be the source of the resulting heterogeneity in the reliability coefficients were examined. Three categorical (publication type, sample level and research method) and two continuous (year of publication and female percentage) variables were examined. It was concluded that the mean estimate of Cronbach's alpha coefficient did not show statistical differences according to the subcategories of publication type and research method and there was no statistically significant relationship between alpha coefficient and two continuous moderators: publication year and female percentage. It was concluded that only the sample level variable statistically affected the estimates of Cronbach's alpha coefficient. When Cronbach's alpha reliability coefficients were examined for the sample level, it was observed that the highest estimate was observed in the studies applied at the high school level. Although the name of the scale is Mathematics Anxiety Scale for Primary School Students, this scale was applied to high school students and it was observed that higher reliability coefficients were obtained. One of the reasons for obtaining a higher reliability coefficient in high school students is that these students are older and may have a better understanding of what the items in the scale mean.

Reporting the reliability findings of the sample in the studies conducted is very important to increase the validity, generalization and quality of the results (Wilkinson, 1999). Despite this, studies that did not report the reliability coefficient were encountered during the search process of this study. In some of these studies, reliability coefficients were not included, while in others, the reliability coefficient reported in the original article (Bindak, 2005) was reported. Assuming that reliability is a fixed and unchanging property of the scale itself, not the results of the measurement, is called reliability induction (Vacha-Haase et al., 2000). It is not appropriate to apply reliability induction except in special cases where it can be applied (Crocker & Algina, 1986; Vacha-Haase et al., 2000).

In the meta-analysis study, only studies reporting the widely used Cronbach's alpha reliability coefficient for the Mathematics Anxiety Scale for Primary School Students were included. However, it is known that Cronbach's alpha coefficient has some unrealistic assumptions (McNeish, 2018). Although Cronbach's alpha is widely used, there are different reliability methods for scales: test-retest, parallel (equivalent) tests and split-half methods. Some studies showed that the coefficients of Omega (McDonald, 1970), H-coefficient (Hancock & Mueller, 2001), maximal reliability (Hancock & Mueller, 2001), and greatest lower bound" (Jackson & Agunwamba, 1977) may be better option than alpha in terms of examining the reliability of the measure produced by a scale in different situations. In this context, different reliability coefficients could be used to give better results for the study. Therefore, it would be useful to report different reliability coefficients in future studies to obtain better results. The use of only alpha coefficients in this study can be considered a limitation.

In the reliability generalization study, care was taken to include all studies conducted with the Mathematics Anxiety Scale for Primary School Students. The obtained Cronbach's alpha values were limited to the scope of the literature review. Therefore, it is possible that this reliability generalization study may have not included all studies using the Mathematics Anxiety Scale for Primary School Students. In addition, the inability to publish articles with low reliability values may have led to the underrepresentation of studies with lower reliability values. Besides, the fact that some studies do not report the sample level and female student percentages can be another limitation. Since the reliability coefficients may differ in each sample, it is important for researchers who use any scale in their own study to present detailed demographic and descriptive information about the sample from which this value was obtained, while reporting their reliability findings.

Considering the effect of mathematics anxiety on children in daily life, it is thought that the results obtained from current study would be useful for the researchers and practitioners. A properly performed reliability generalization meta-analysis can provide more precise estimates of score reliability. The findings of the current study would be useful for researchers who want to study mathematics anxiety and make informed decisions.

As a result, it has been observed that this study and studies using the Mathematics Anxiety Scale for Primary School Students produced Cronbach's alpha coefficients at an acceptable level. In addition, the scale provides reliable results at different sample levels. Results of the study revealed that the reliability coefficients produced from the scale used differ in terms of the sample level variable. We also believe that it would be useful to make some suggestions based on the experiences we have gained as a result of current study. It was observed that the reliability coefficients used in the study were not reported in all individual studies. Therefore, there is a need to strengthen reliability reporting studies. We think that researchers should be more careful when reporting reliability coefficient and characteristic information such as age, gender, ethnicity, and sample level. It would be beneficial to use not only Cronbach's alpha values but also consider other reliability indicators (e.g. Omega, composite reliability) in future research studies.

Declarations

Conflict of Interest: No potential conflict of interest was reported by the authors.

Ethical Approval: Reliability generalization meta-analysis using secondary data was carried out in the study. Therefore, ethical approval is not required.

Studies included in the current reliability generalization meta-analysis are marked with an asterisk (*).

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