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"Convergent and Divergent Validity of Teachers' Sense of Efficacy Scale: A Multitrait Multimethod Matrix Approach"

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ABSTRACT

There are two types of evidence that can be used to determine the degree to which an instrument measure a particular construct are convergent validity and discriminant validity. Convergent and discriminant validity evidence can be assessed systematically and quantitatively using the Multitrait-Multimethod (MTMM) matrix approach proposed by Campbell and Fisk (1959). A Multitrait multimethod (MTMM) matrix approach was used to investigate the convergent and discriminating validity of the Teacher Sense of Efficacy Scale (TSES). Results indicated that partial convergent validity is established for the three constructs TSES instrument using the MTMM approach. This paper demonstrates the convergent validity procedure using the MTMM approach which can be useful tool for many potential authors for Journal of Quantitative Methods and for other researchers of various fields whose primary focus of research is instrument development and validation.

Introduction

The empirical research in quantitative research paradigm is highly depends on the availability of valid and reliable measures of construct. There are various types of validity procedures for survey type instruments including content validity, face validity, constructs validity and predictive validity. Construct validity demands complex internal and external evidence (Haller & Klein, 2001). Internal validity shows the basic structure of a measure such as item content and its relationship to a broader theoretical framework While external validity exists when measures share a consistent relationship with its theoretical expectations (Wasserman & Bracken, 2003).

There are two types of evidence that can be used to determine the degree to which an instrument measure a particular construct are convergent validity and discriminant validity. Convergent validity is established by the strong relationship between proposed construct and other measures of the same construct. On the other hand, discriminant validity is established by the weak relationship between proposed construct and measures of different constructs. Convergent and discriminant validity evidence can be assessed systematically and quantitatively using the Multitrait-Multimethod (MTMM) matrix procedure.

The simplest form of MTMM procedure requires minimum two traits /constructs that is measured by minimum two different methods (2 method ×2 traits). The procedure involves correlating proposed constructs with other measure of the trait/ construct purportedly measured by the instrument (i.e., monotrait correlations) as well as with measures of different traits (i.e., hetrotrait correlations). There are four correlation blocks including: same trait vs same method, same trait vs different method, different trait vs same method, and different trait vs different method (Furr, 2011; Koch et al., 2018).

The MTMM procedure is used in quantitative research where the primary purpose is instrument validation including medical sciences (Baig, Violato, & Crutcher, 2010), psychology (Yang, Hinkle, , Wyckoff, 2018), human resource management (Hamdani, Vâlcea, & Buckley, 2016). In Pakistan, the MTMM received a little or no use in quantitative research studies in Pakistan. This paper demonstrates the application of MTMM for convergent and discriminate validity of research instrument.

In this study, a teacher efficacy instrument which is widely used by researcher, has been assessed using MTMM procedure. In general, teacher self-efficacy refers to teachers' beliefs in their capability to inspire their students' achievement (Skaalvik & Skaalvik, 2007). Teachers with a high sense of efficacy are motivated to achieve their goals and they are comparatively optimistic about future learning than those who have lower sense of efficacy.

Several researchers have proposed conceptual definitions of teacher efficacy and developed scales to measure level of teachers' efficacy (Fives & Buehl, 2010). Tschannen-Moran and Woolfolk Hoy (2001) constructed a scale to measure teachers' sense of efficacy through rigorous process. The developed instrument to measure teachers' teaching

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efficacy is called "Teachers' Sense of Efficacy Scale" (TSES). The TSES has been widely used and validated for its use with different context for different population from a number of countries including: Singapore (Nie, Lau, & Liau, 2012), Singapore and Europe (Klassen et al., 2009), China, Korea, and Japan (Ruan et al., 2015), and United States (Five & Buehl, 2010).

Researchers around the world also translated the TSES and assess the validity of translated version for their specific population. In addition, the validation process used by some international researcher is also questionable. The instrument is also being used by researchers in some countries where the validity of instrument has not been evaluated in their context. Specifically, researchers in Pakistan have begun using the TSES for studies with secondary school teachers without review of the instrument's psychometric properties within Pakistan's context. Teacher self-efficacy is also related to other variables including job satisfaction, teachers job experiences, student achievement, and student attitude (Al-Alwan & Mahaseh, 2014; Klassen &, Chiu, 2010). The TSES has also been developed in multiple international versions: Arabic (Al-Khalaileh & Abu-Tineh, 2011), Turkish (Çapa, Çakıroğlu, & Sarıkaya, 2005), Greek (Tsigilis, Grammatikopoulos, & Koustelios, 2007), French (De Stercke, Temperman, De Lièvre, & Lacocque, 2014), Portuguese (Guerreiro-Casanova, Azzi, 2013), and Chinese (Tschannen-Moran, n.d.). TSES has never been validated for Pakistani teacher populations (either pre-service or in-service teachers). It is therefore, the main purpose of this study is to assess construct validity of TSES in Pakistan using the MTMM approach. Moreover, provides the methodological background information for researchers from diverse fields to validate their research instrument using the MTMM procedure.

Purpose

The main purpose of this study is to investigate the construct validity of the Teacher's Sense of Efficacy Scale (TSES) using the MTMM approach. TSES is based on three constructs (*classroom management*, *instructional strategies*, and *student engagement*), three similar constructs were adopted for MTMM matrix approach. This approach will be guiding principle for researchers of other fields to assess validity of instrument for their studies. I believe, the methodology, procedure and results of this findings will provide the guiding principle of potential authors of this journal (*Journal of Quantitative Methods*) to validate instrument using appropriate statistical procedure.

Research Questions

1. Do the three constructs of TSES: associate as proposed with their convergent validity counterparts of different method with same constructs in a multi-trait multi-method (MTMM) analysis?
2. What degree of convergent and discriminating validity establish between three constructs of TSES and thee alternative measures of same construct using MTMM approach?

Literature Review

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There are two types of evidence that can be used to determine the degree to which an instrument measure a particular construct are convergent validity and discriminant validity. Convergent validity is established by the strong relationship between proposed construct and other measures of the same construct. On the other hand, discriminant validity is established by the weak relationship between proposed construct and measures of different constructs. Campbell and Fiske (1959) suggested four criteria for assessing a MTMM (Multi-trait Multi-method) matrix. The MTMM correlation matrix (see figure 1) consists of four sets of correlations:

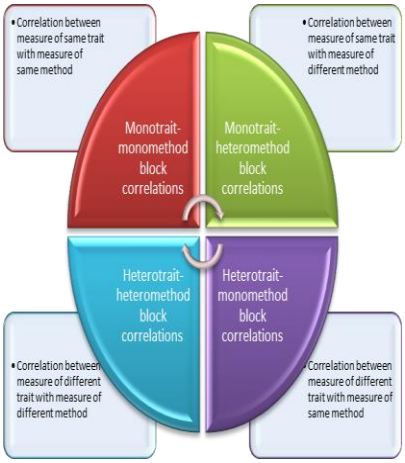

Figure 1. Four sets of correlation matrices in MTMM

Mainly, the correlation coefficients are divided into two different method blocks: Monomethod blocks and Heteromethod blocks (Brown, 2015; Trochim, 2002). The first criterion indicates evidence of convergent validity while other three criteria provides evidence of discriminant validity. In a recently published paper by Koch et al., (2020), they asserted that MTMM is a statistical method to determine the convergent and discriminant validity of psychological measuring instruments.

MTMM is a rigorous process to assess construct validity of psychological instrument that can be used in various fields of research including business studies, management, social sciences, medical sciences and humanities (Hamdani, Vâlcea, & Buckley, 2016). The MTMM approach, currently underutilized, it can be used to determine the degree of evidence for validation complex psychosocial constructs, Survey interview data (Alwin, 2011; Kyriazos, 2018).

Tschannen-Moran and Woolfolk Hoy (2001) developed the TSES scale to measure teachers' sense of efficacy that included three-subscales: *Classroom Management* (CM), *Student Engagement* (SE), and *Instructional Practices* (IP). This instrument is widely used by social science researcher. In the current study, the TSES instrument is used to determine the construct validity using the MTMM procedure.

Research Methodology

The TSES and data used in this study are describe in this section, followed by the procedure used to construct the MTMM matrices. This study includes validation assessment and provides an evaluation of the latent structure of the Teacher Sense of Efficacy Scale (TSES) for in-service teachers in Pakistan. The MTMM procedure requires instrument representing at least two constructs, each of which were measured by at least two different methods, across a common group of people. In this study, the TSES has been selected for validation which consists of three constructs.

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Sample Size

Appropriate sample size is an important consideration for many statistical procedures when conducting an instrument validation study, and specifically an influential aspect in a multivariate analysis where **"**the adequacy of the test statistics is likely to be influenced by sample size" (Hoyle, 1995, p.87). Usually, there are two approaches used to determine the required sample size for the model analysis: 1) participants to item ratio and 2) minimum fixed sample size. There is no consensus to determine absolute appropriate sample size. Suggested minimum sample sizes include from 5 to 15 participants per observed variable or item in the instrument (Mundfrom, Shaw & Tian, 2005) or minimum 500 to 800 absolute sample size for minimum measurement error. A minimum of 15 participants per item was selected in this study for stable estimation. There are 24 items in the TSES instrument, thus 360 is the minimum requirement of sample size in this study.

Participants

Convenient sampling technique was adopted and participation in this study was on a voluntary basis. Participants were male and female in-service secondary school public sector teachers. There were total 549 sample size in this study including 378 (69%) female and 171 (31%) male in-service teachers. Participants were from all major cities of Pakistan from all provinces.

Instruments

Teacher Sense of Efficacy Scale (TSES). The TSES (Tschannen-Moran & Woolfolk Hoy, 2001) that measures teacher efficacy, is used in this study. The TSES instrument has two versions: short form with 12 items and long-form with 24 items. Both form of scale has three constructs. The 24-item long-form has also items of 12 item from short-form. In this study, 24 item long-form was used for data collection purpose.

The 24 items of the TSES scale measure the efficacy levels of teachers in three sub-scales (constructs) of teaching (i.e., student engagement, classroom management, and instructional practices). Each sub-scale is based on 8 items with 9-point Likert scale ranging from 1 (nothing) to 5 (some influence) to 9 (a great deal). Permission has been obtained from instrument developer for using the TSES for validation purpose.

Alternative Measures

Behavior Management Strategies Scale (Nie, Lau & Liau, 2012). The Behavior Management Strategies (BMS) scale is used to measure teachers' approaches to deal with classroom behavior. This scale contains 7 items with a 5-point Likert format from 1 (*never*) to 5 (*always*). The BMS scale is used to test the convergent validity of *Classroom Management* subscale of TSES. Nie, Lau and Liau (2012) study in Singapore context found that there is significant positive correlation between *Behavior Management Strategies* (BMS) and *Classroom Management* (CM) scale, r = .52, p < .001.

Personal Teaching Efficacy (Gibson & Dembo, 1984). *Personal Teaching Efficacy* scale was used to relate with *Instructional Strategies* (IS) of the TSES. The items related to PTE are closely related to items of Instructional

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strategies of TSES. The PTE is based on nine items scale with a 6-point Likert format from 1= *Strong Disagree* to 6= *Strongly Agree*. Tschannen-Moran & Woolfolk Hoy (2001) found significant correlation between PTE and *International Strategies* (IS), $r = .62$, $p < .001$.

Instructional Management Scale (Martin & Sass, 2010).

After a significant amount of literature review, the *Instructional Management* scale (Martin & Sass, 2010) was chosen to relate it with *Classroom Management* construct of TSES. *Instructional Management* (IM) scale is based on six items with a 6-point Likert scale from 1= *Strong Disagree* to 6=*Strongly Agree*.

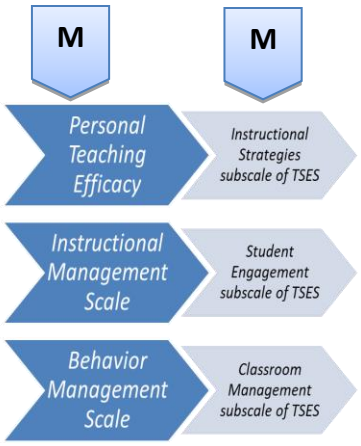

Figure 2 indicates three constructs of the TSES and three counterpart alternative measures

Data Analysis

Statistical Analysis System 9.4 (SAS Institute; Cary, NC) software was used for data analyses and statistical procedures. Data were first evaluated for potential errors. Analyses were begin with data normality tests, descriptive statistics of variables, assessments of reliability and proceeded with convergent and discriminant validity through the MTMM matrix approach.

Multitrait-Multimethod (MTMM) procedure

Convergent validity and discriminating validity were investigated using the Multitrait-Multimethod (MTMM) matrix procedure. The multitrait multimethod matrix is a two-dimensional cross classification of methods and traits (Maas, Lensvelt-Mulders, & Hox, 2009) developed by Campbell and Fisk in 1959. The MTMM matrix procedure is a correlation matric that helps to provide evidence of construct validity of an instrument having two or more than two constructs. The multitrait multimethod matrix approach has proven to be an important process in the past half century in various research fields that involve development and validation of psychological measurements (Byrne, 1994). When an instrument has two or more than two constructs and that is measured by two or more than two methods then the MTMM is the most appropriate method to assess the construct validity of the instrument. In this study, the MTMM approach was used to cross-compare the three constructs of TSES with alternative measures that hypothesized to be measuring the similar constructs. Tschannen-Moran and Woolfolk Hoy (2001) did scale validation in their study but they did not asses the convergent and discriminant validity of the three subscales of TSES. Hence, the findings of this study further provide empirical evidence for the suitability of the TSES measure (Nie, Lau, & Liau, 2010).

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The MTMM matrix can also be used to assess the divergent validity. Divergent validity is established when the correlation between two different constructs is smaller than the correlation between two similarly hypothesized constructs. Teacher Sense of Efficacy Scale (TSES) has three constructs (classroom management, instructional strategies, and student engagement) and these constructs have moderate correlation with each other.

The MTMM procedure provides two correlation matrices: correlation matrix without correction of attenuation and correlation matrix with attenuation (*also known as* disattenuation). The correlation for attenuation or disattenuation rectifies the potential concern about the impact of low reliability and influence of measurement error on raw score correlation coefficients. The disattenuated correlation coefficient between two constructs can be calculated using following formula,

$$\rho = \frac{Corr(XY)}{\sqrt{r_{XX} r_{YY}}}$$

Where,

p is the resulting correlation coefficient for correction of attenuation, Corr(XY) is the raw correlation between two constructs or scales, while r_{XX} and r_{YY} are the reliability coefficients for first and second scales respectively.

Thus, a second set of correlation coefficients were calculated in order to partial-out the effect of measurement error and lower reliability. The correlation for attenuation matrix further helps to assess the correlation among three constructs of the instrument after controlling the effect of reliability measure. Disattenuated correlation coefficients can be vital component and a primary attention in the instrument validation process.

Results

As mentioned previously, the TSES measures the efficacy on three key components of teaching: *efficacy on instructional strategies, efficacy on student engagement* and *efficacy on classroom management*. Each efficacy was measured by eight items with scaled from 1 = nothing to 9 = a great deal. Descriptive statistics for the three constructs of the TSES instrument are reported in Table 1. The average of TSES (24-items) instrument was 7.56. The average Efficacy of three constructs of TSES of *Classroom Management, Instructional Strategies,* and *Student Engagement*, were, 7.49, 7.49, and 7.54 respectively.

Reliability

The Cronbach's alpha reliability coefficient of the full TSES was .92. An instrument is considered reliable if the Cronbach's alpha reliability coefficient is ≥ .80 (Henson, 2001b). The internal consistency reliability coefficients for each construct of TSES(i.e., *Instructional Strategies*, *Classroom Management*, and *Student Engagement*) were also above .80, ranging from .82 to .84. The average reliability coefficient for the three constructs (traits) of the TSES (*method 1*) and three alternative traits (*method 2*) was .83 and .82 respectively.

Normality Assessment

Univariate and multivariate normality of variables were evaluated by

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assessing descriptive statistics values and by analyzing the data points on the graph. The skewness and kurtosis give the basic idea about the shape of the distribution of the variable. SAS (Statistical Analysis System) provides the Kolmgorov test and Shapiro-Wilk statistics values for univariate normality tests statistics. Shapiro test is relatively better for normality test when sample size less than 2000 and Kolmgorov test should be used for sample size larger than 2000. The null hypothesis of the Shapiro-Wilk normality test is that there is no significance departure from normality. Thus, a significant result ($p < .05$) indicates that data violates the normality assumptions and a non-significant result indicate that normality assumption holds. Multivariate normality was checked by Mardia's (1974) chi-square tests. I specially programmed a macro using Interactive Matrix Language (IML) in SAS to calculate Mardia's skewness and kurtosis values for multivariate normality test.

Multitrait Multimethod Matrix (MTMM) Results

Table 1 presents the MTMM matrix with raw Pearson correlation coefficients without correction for attenuation. The internal consistency reliability coefficients of each construct for both methods are presented in italicized text within parentheses on the main diagonal. Convergent validity coefficients (monotrait-heteromethod correlation) presented as bolded font. The highlighted values indicate correlation coefficients for different traits using the same method (heterotrait-monomethod coefficients). Whereas, plain text correlation values indicate correlation coefficients between different traits and different methods (heterotrait-heteromethod coefficients).

Table 1

Multitrait-Multimethod (MTMM) Raw Correlation Matrix (Without Correction for attenuation*)*

Method	Method 1 (TSES)			Method 2 (Alternative Measures)		
Scales	SE	IS	CM	IMS	PTE	BMS
TSES						
Student Engagement (SE)	*(0.82)*					
Instructional Strategies (IS)	0.62	*(0.85)*				
Classroom Management (CM)	0.57	0.58	*(0.86)*			
Alternative Measures						
Instructional Management Scale (IMS)	**0.42**	0.37	0.32	*(0.80)*		
Personal Teaching Efficacy (PTE)	0.41	**0.43**	0.36	0.49	*(0.85)*	
Behavior Management Scale (BMS)	0.40	0.39	**0.41**	0.36	0.40	*(0.81)*

Note:

i. Italicized text within parentheses in main diagonal are reliability coefficient coefficients of each scale.
ii. Bolded values shows Monotrait - heteromethod (Similar construct with different methods) convergent validity;
iii. Highlighted values indicates heteromethod-monotrait correlation (different traits using the same method).
iv. Plain values indicates the Hetrotraits-hetromethod correlation values (different scale with different method)

The inter-correlation coefficients among the three constructs of TSES were moderate, ranging from .57 to .62. The

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inter-correlation coefficients among three alternative traits (i.e. IMS, PTE and BMS) were also positive but comparatively smaller ranging from .36 to .49. The convergent validity block (monotrait-heteromethod correlation) indicates positive and significant correlations between three sets of similar scales (monotrait) and two methods.

There was a significance correlation between *Personal Teaching Efficacy* (PTE) and *Instructional Strategies* (IS), r =.43, p < .001, between the *Instructional Management Scale* (IMS) and *Student Engagement* (SE), r =.42, p < .001, and between *Behavior Management Scale* (BMS) and *Classroom Management* (CM), .41, p < .001.

The divergent validity is established when there is small correlation between different trait (hetrotrait) with different method (hetromethod). According to table, the divergent validity coefficients for *Student Engagement* (SE) are .40 and .41 from the heterotrait-heteromethod block and .57 to .62 from the heterotrait-monomethod scales (similarly traits with the subscales of TSES). Similarity, trends of result found for the *Instructional Strategies* (IS) and *Classroom Management* (CM) scales.

Another MTMM was constructed after correction for attenuation to minimize the effect of variations in reliability coefficients of each constructs. Results for the correction for attenuation is presented in Table 2.

Table 2
Multitrait Multimethod Correlation (MTMM) Matrix of Scales after Correction for Attenuation

Method	Method 1 (TSES)			Method 2 (Alternative Measures)		
Scales	SE	IS	CM	IMS	PTE	BMS
TSES						
Student Engagement (SE)	*(0.82)*					
Instructional Strategies (IS)	0.75	*(0.85)*				
Classroom Management (CM)	0.68	0.69	*(0.86)*			
Alternative Measures						
Instructional Management Scale (IMS)	**0.52**	0.45	0.39	*(0.80)*		
Personal Teaching Efficacy (PTE)	0.50	**0.50**	0.42	0.59	*(0.85)*	
Behavior Management Scale (BMS)	0.49	0.47	**0.49**	0.45	0.48	*(0.81)*

Note: Same description is used as presented below Table 1.

Discussions

Lack of construct validity in psychological instrument may lead to inaccurate measurements (Koch, Eid, & Lochner, 2018; Courvoisier, Nussbeck, Eid, Geiser, & Cole, 2008). The application of MTMM was employed in this study. The MTMM (Campbell & Fisk, 1959) procedure was adopted to evaluate the convergent and discriminant validity of the TSES scales. The MTMM approach requires minimum two constricts /traits using at-least two methods from the same participants. MTMM procedure was applied to assess the convergent and discriminating validity. According to Price (2017), in MTMM matrix, the convergent validity is established when there is a relationship between the same constructs (traits) using different methods while discriminant validity is established when the relationship between different constructs (traits) using different methods of measurement. Ideally, when the monotrait-heteromethod correlations is higher than

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the heterotrait-monomethod correlations then convergent validity is established. In the current study, convergent validity established. Convergent and discriminating validity were determined by evaluating the correlation between primary scale of measures and alternative scales of similar constructs.

The current study results are consistent with those of Raykov (2011). In an ideal MTMM matrix, the convergent validity correlation coefficient is higher than divergent validity correlation coefficients. In the current result, the different construct using same method (hetero-trait, mono-method) correlation coefficients that is required to be less than the same construct using different method (mono-trait, hetero-method) correlation was not supported. William (2006) also argue that some of the MTMM assumptions may not be tenable but even though it provides fairly robust strong construct validity. He further explained that in applied research settings, the evidence to support construct validity can be established without having an ideal correlation matrix to adherence all the assumptions of the MTMM.

There are several significant benefits of this research such as this study provides mythological procedure of conducting construct validity of scale using MTMM procedure. This procedure can be used by researcher from various fields whose primary interest is instrument development and validation. There are several limitations of this study as well. For example, the set of scales used in this study were in English and some teachers were hard time to fully comprehend items. Therefore, I had to explain each item to participants in a way that they could understand. In addition, the self-reported instruments were used in this study and participants were expected to be truthful in their response. In ideal situation, the MTMM procedure requires several traits measured by several methods in one study. Therefore, it is relatively hard for researchers to find suitable measure of a single trait with multiple methods. Future research can be conducted on using MTMM procedure to assess the construct validity of classroom test which are conducted via multiple methods (i.e., paper-based exam and online exam). Future research can also be conducted to run CFA (Confirmatory Factor Analysis) to Multitrait-Multimethod (MTMM) matrices. The application of CFA to MTMM is an extended process to assess the construct validity including convergent and discriminant validity.

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