*International Journal of Academic Research in Business and Social Sciences*
*2017, Vol. 7, No. 12*
*ISSN: 2222-6990*

# Assessing the Validity of the Elements for Pre-Service Mathematics Teacher Education Curriculum

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DOI: 10.6007/IJARBSS/v7-i12/3611 URL: http://dx.doi.org/10.6007/IJARBSS/v7-i12/3611

**Abstract**
This study was conducted to assess the validity of the elements for pre-service Mathematics teachers in Malaysia Teacher Education Curriculum (MTEC). A five-point Likert Scale survey questionnaire was conducted for 372 respondents from one (1) Public University and one (1) Institute of Teacher Education with Mathematics Education Programme in Malaysia. Data collected only involved the student teachers that are majoring in Mathematics Education. The validity of the items of the study was inspected with Elementary Factor Analysis (EFA) by using Statistical Package for Social Science (SPSS) Version 23.0. Principal Component Analysis (PCA) and Varimax Rotation (VR) were conducted in EFA for 46 items in the study, and 39 items remains with factor loading above 0.40, for the six constructs in the Mathematics Teacher Education Curriculum (MTEC), namely Professional Development (PDev), Psychological (Psy), Technology (Tech), Historical (His), Philosophy (Phi), and Social Re-Constructivist (SRC). The finding of the study will benefits in re-designing a curriculum structure for Mathematics Teacher Education. High reliability score with Cronbach' Alpha **(**α) overall was 0.924 for 39 items, with MTEC (α =0.743), PDev (α =0.752), Tech (α =0.753), His (α =0.887), Phi (α =0.733), and SRC (α =0.767) and Psy (α =0.667) have an acceptable reliability score after factor analysis were indicated that the instruments under each construct having a very strong strength in the study.
**Keywords**: Validity, Exploratory Factor Analysis, Mathematics, Teacher Education, Curriculum

## Introduction

Validity refers to the credibility or believability of the research. The validity of the instrument is related to the scope in which the instrument measures the content to be measured (Tavakol & Dennick, 2011). The validity for this study only refers as internal validity, which tested on the instruments used under constructs in the study. Exploratory Factor Analysis (EFA) is a specific factor analysis method used as the statistical approach to examine the basic relationships between variables in the specific hypothesis modal (Bryman & Cramer, 2005). The method of factor analysis known as reducing dimensionality (Bartholomew, Knott, & Moustaki, 2011), which it operates based on the conception that measurable and observable variables can be reduced to fewer latent variables, which share a common variance. The items will consider contributed to the construct with the correlation coefficients through EFA.

**Methodology of the Study**

**Instruments**

The research questionnaire commences with the cover page to inform the respondents about the aim of the research and the confidentiality of the respondents and feedback. Then follow by Part I, about the respondents demographic information, consists of respondent's information such as gender, age, race, highest education level, institutions and years of present study. Part II covers for six related exogenous constructs (independent variables) and one endogenous construct (dependent variable) for the curriculum of Mathematics Teacher Education. The instruments for the study were adapted from few studies and survey, including Brown (2006), 2000 National Survey of Science & Mathematics Education, Alpaslan et al. (2011, 2014), Ryan (2008), and Durmus and Bicak (2006) (Table 1).

Table 1
Items Adapted for the Constructs of Curriculum Factors for Pre-Service Mathematics Teacher Education

| No | Constructs | Number of Items | Adapted |
|---|---|---|---|
| (i) | Mathematics Teacher Education Curriculum | 5 | Brown (2006) |
| (ii) | Professional Development | 6 | Mathematics Questionnaire (2000 National Survey of Science & Mathematics Education) |
| (iii) | Psychological | 5 | Brown (2006) |
| (iv) | Technology | 6 | Brown (2006) |
| (v) | Historical | 9 | Brown (2006)<br>Alpaslan et al. (2011, 2014) |
| (vi) | Philosophy | 6 | Ryan (2008) |
| (vi) | Social Re-Constructivist | 9 | Brown (2006)<br>Durmus & Bicak (2006)<br>Ryan (2008) |

A total of 46 scale items was utilized to measure the variables in the model in this study. The survey was in scale of five-point Likert scale, which applied in most of the EFA study (Siqueira et al., 2010; Nair & Das, 2012; Omar, 2013). Respondents were required to rank their responses from "Strongly Disagree" as "1", "Disagree" as "2", "Unsure" as "3", "Agree" as "4", and "Strongly Agree" as "5" in the study respectively.

**Data Collection & Sample**

Researcher conducted a survey research during March 2017 to April 2017. This study only involved student teachers that majoring in Bachelor of Mathematics in Education. A five-point Likert Scale survey questionnaire used for 372 respondents from one (1) Public University and one (1) Institute of Teacher Education with Mathematics Education Programme in Malaysia. The consent letter and survey questionnaires were distributed and instructions given by the researcher before the respondents starting to answer the survey. The respondents were taken about 25 to 30 minutes to completed it. Lastly, the questionnaires were collected and proceeding to data analysis.

**Data Analysis**

The process of data collection started from March 2017 and completed in April 2017. 400 surveys had been collected. Raw data were manually entered into a simple data entry file in Statistical Package for Social Science (SPSS) software in Version 23.0. The data then screened for consideration of missing data, outliers and normality. Missing data may lead to over fitting of the data resulting into high correlation. According to Tabachnick and Fidell (2013), the procedure of detecting the outliers as incorrect data entry was important because outlier is not a member of population that intended to the sample for EFA or any statistical analysis. Z-score used as a basic form of outlier detection in this study. The threshold used a Z-score smaller than -4 or greater than 4 were considered an outlier (Hair et al., 2010). Out of 400 sets of surveys collected, 28 respondents recorded as missing data due to the out-of-range or outliers and administrative errors.

Normality test for the data distribution was performed to ensure that there was no violation of the assumption of normality that as basic conditions for inferential statistics (Chua, 2013). Skewness and kurtosis index were used to identify the normality of the data with SPSS (Pallant, 2005 & 2013). The data considered being normal for the range of skewness from -2 to +2 (Hair et al., 2010; Byrne, 2010; Garson, 2012) and kurtosis from -7 to +7 (Hair et al., 2010; Byrne, 2010). According to Hoyle (1995), for sample sizes greater than 300, either an absolute skewness value larger than 2 or an absolute kurtosis value larger than 7 may be used as reference values for determining substantial non-normality. There were no items that indicated abnormal distribution and abandoned from initial procedure. The skewness index range was from -0.945 to -0.214 and the kurtosis index range was from -1.140 to 0.602. Hence, this can be concluded that the collected data were normal distributed as both the skewness and kurtosis index of 46 items presented are within the normal distribution range as suggested.

The reliability of the items for each construct examine by using Cronbach's Alpha (α). Each of the Construct Validity in the study will analyze by Exploratory Factor Analysis (EFA) under Principal Component Analysis (PCA) and Varimax Rotation (VR). The items were extracted by using Eigenvalues greater than 1.0. Only the items in the survey questionnaires retained if the items of the constructs achieved the factor loading cut-off value of 0.400. And the items that did not load on any sub-construct, but also items loaded highly (>0.400) on more than one sub-construct were removed.

**Factor Analysis**

Exploratory Factor Analysis (EFA) is a specific factor analysis method used as the statistical approach to examine the basic relationships between variables in the specific hypothesis modal (Bryman & Cramer, 2005). The method of factor analysis acknowledged as decreasing dimensionality (Bartholomew, Knott, & Moustaki, 2011), which it operates based on the conception that quantifiable and observable variables can be reduced to fewer latent variables, which share a common variance. The items will consider contributed to the construct with the correlation coefficients through EFA.

Determining the requirements sample size for Exploratory Factor Analysis (EFA) was most challenge for researcher. Researcher needs a big sample in pilot study to run the EFA. Researcher had chosen one Public University and one Institution of Teacher Education for purpose of pilot study. There were wide ranges of recommendations regarding sample size chosen in EFA have been made. Various rules-of-thumb have been advanced. These are usually stated in terms of either the minimum sample size (N) for a particular analysis or the minimum ratio of N to the number of survey items being subjected to factor analysis MacCallum et al. (1999) and a much larger sample probably at least 300 was needed for low communalities. Gorsuch (1983) (as cited in Lingard & Rowlinson, 2006) and Kline (1979) (as cited in MacCallum et al., 1999) claimed that no samples should less than 100 even the number of variables or items are less than 20. It also recommended that the number of items should be five times the number of variables or at least 100 (Hatcher & Stepanski, 1994; O'Rourke & Hatcher, 2013). Guilford (1954) suggested that N should be at least 200 (as cited in MacCallum et al., 1999). Comrey and Lee (1992) suggested the Rules of 500 by provided the following guidance in determining the adequacy of sample size: 100 = poor, 200 = fair, 300 = good, 500 = very good, 1,000 or more = excellent. They urged researcher to obtain more samples whenever possible.

According to Tabachnick and Fidell (2013), high loading marker variables (>0.800) do not require large sample size, but for lower loading should have at least 150 samples only sufficient to run the factor analysis. Bryant and Yarnold (1995) stated that the sample size should at least five times the number of the variables. The subjects-to-variables ratio should be five or greater. Furthermore, every analysis should base on a minimum of 100 samples regardless of the subjects-to-variables ratio. Based on the suggestion and guidelines, the sample size for EFA for this study was 372 respondents. The sample size for factor analysis achieved a general rule of thumb for sample to run the EFA for at least 300 cases for factor analysis, as recommended by MacCallum et al. (1999) and greater than 230 (five times of the 46 items) (Hatcher & Stepanski, 1994; Bryant & Yarnold, 1995; O'Rourke & Hatcher, 2013).

Kaiser-Meyer-Oklin (KMO) test used as a common approach of Measuring Sampling Adequacy (MSA). KMO refers to the ratio of squared actual correlation between variables to the squared partial correlation between variables. The possible values range of KMO from zero, 0 to one, 1. Values 0.500 and above are considered as "acceptable"; values 0.700 and above as "good"; values 0.800 and above as "great"; and values 0.900 and above considered as "excellent". KMO correlation with 0.500 is considered suitable for EFA (Hair et al., 1998; Tabachnick & Fidell, 2013). The sampling assessed by Kaiser-Meyer-Oklin (KMO) should exceed the recommended cut-off value of 0.600 (Kaiser, 1970, 1974). On the other hand, Netemeyer, Bearden and Sharma (2003) stated that a KMO correlation above 0.600 - 0.700 is considered acceptable for EFA. Moreover, the MSA values for individual variables are the diagonals of the anti-image correlation matrix (Field, 2009; Hair et al., 2010). The diagonals of the anti-image correlation matrix should all over 0.500 to supporting the inclusion of each item in the factor analysis (Field, 2009; Hair et al., 2010). And the initial communalities represent the relation between the variable and all other variables before rotation. The initial criterion of communalities <0.400 was established for deleting the item from the instrument, a minimum of 0.6 for the Kaiser-Meyer-Olkin index (KMO) for the sample to be deemed adequate and p<0.010 for Bartlett's test of sphericity. (Soares & Luís, 2016). The Bartlett's test of Sphericity (Bartlett, 1950) achieved statistical significance value with p<0.500 (Hair et al., 1998; Tabachnick & Fidell, 2013) and indicated that the items used in the analysis were suitable.

Principle Component Analysis (PCA) was the most commonly used for factors extracted (Tabachnick & Fidell, 2013; Henson & Roberts, 2006). According to Costello and Osborne (2005), principal components analysis in the factor analysis is a good approach in data reduction. PCA usefull to develop instruments with multiple items and is interested in reducing the number of items (Netemeyer, Bearden & Sharma, 2003). Proceeding to operating with PCA, the fitness of data for factor analysis was determined for the endogenous construct and exogenous constructs. The items summarised into each construct (Kline, 2011) and determine the unique contribution of each item based on the factor loading. Researcher had chosen a significant factor loading cut-off value, 0.400, as suggested by Suprapto and Chang (2016) that the retained items should preferably be weighted greater than 0.400 in EFA (Martsolf, Carle, & Scanlon, 2017). The elemtes of curriculum for Pre-Service Mathematics Teachers assessed through PCA utilizing SPSS Version 23.0 by construct.

**Findings of the Study**

**Exploratory Factor Analysis**

PCA used as primary purpose to identify and assess for the factors underlying for each construct as one endogenous construct: (i) Mathematics Teacher Education Curriculum (MTEC); and six exogenous constructs: (ii) Professional Development (PDev), (iii) Psychological (Psy), (iv) Technology (Tech), (v) Historical (His), (vi) Philosophy (Phi), and (vii) Social Re-Constructivist (SRC).

**(i) Mathematics Teacher Education Curriculum (MTEC)**

Five of the MTEC items have been tested collectively according to the suitability of sphericity and sampling adequacy. The item coded B05 eliminated, as it did not contribute to a simple factor structure and failed to meet communalities criteria of 0.40 or above even the factor loading achieved threshold of 0.4 and above. Researcher re-runs the factor analysis for another four items. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi 2$ = 313.553) and the KMO test for sampling adequacy was considered as "good" at 0.759 for the collective set of four MTEC items. For individual item, the anti-image correlation matrix revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image shows the partial correlations were above 0.500, which shows that each variable was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 then extracted a single factor for MTEC. The Total Factor Explained showed 56.5% of the variance with an Eigenvalue of 2.260. The factor loadings in SPSS Component Matrix for all four MTEC items were above 0.400 had justified that the four MTEC items would be retained.

**(ii) Professional Development (PDev)**

Six of the PDev items have been tested collectively according to the suitability of sphericity and sampling adequacy. The item coded B06 and B11 were eliminated because it failed to meet communalities criteria of 0.4 or above and did not contribute to a simple factor structure. Researcher re-runs the factor analysis for another four items. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi2 = 332.282$) and the KMO test for sampling adequacy was considered as "good" at 0.765 for the collective set of four PDev items. The anti-image correlation matrix of each item revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image for each item was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 then extracted a single factor for PDev. The Total Factor Explained showed 57.6% of the variance with an Eigenvalue of 2.304. The factor loadings in SPSS Component Matrix for all four MTEC items were above 0.400 had justified that the four PDev items would be retained.

**(iii) Psychology (Psy)**

Five of the Psy items have been tested collectively according to the suitability of sphericity and sampling adequacy. The item coded B12 was eliminated because of the lowest factor loading which it cause the Total Variance Explained failed to achieved the threshold of 50% and above. Researcher re-runs the factor analysis for another four items. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi2 = 214.446$) and the KMO test for sampling adequacy was considered as "acceptable" at 0.685 for the collective set of four Psy items. The anti-image correlation matrix of each item revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image for each item was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 then extracted a single factor for Psy. The Total Factor Explained showed 50.3% of the variance with an Eigenvalue of 2.011. The factor loadings in SPSS Component Matrix for all four Psy items were above 0.400 had justified that the four Psy items would be retained.

**(iv) Technology (Tech)**

Six of the Tech items have been tested collectively according to the suitability of sphericity and sampling adequacy. The item coded B22 was eliminated because it failed to meet communalities criteria of 0.400 or above and cause the Total Variance Explained failed to achieved the threshold of 50% and above. Researcher re-runs the factor analysis for another five items. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi2 = 398.530$) and the KMO test for sampling adequacy was considered as "good" at 0.792 for the collective set of five Tech items. The anti-image correlation matrix of each item revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image for each item was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 then extracted a single factor for Tech. The Total Factor Explained showed 50.7% of the variance with an Eigenvalue of 2.535. The factor loadings in SPSS Component Matrix for all four Tech items were above 0.400 had justified that the five Tech items would be retained.

**(v) Historical (His)**

Nine of the His items have been tested collectively according to the suitability of sphericity and sampling adequacy. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi2$ = 1377.736) and the KMO test for sampling adequacy was considered as "excellent" at 0.918 for the collective set of nine His items. The anti-image correlation matrix of each item revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image for each item was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 then extracted a single factor for His. The Total Factor Explained showed 52.7% of the variance with an Eigenvalue of 4.739. The factor loadings in SPSS Component Matrix for all nine His items were above 0.400 had justified. It was decided that all the nine His items would be retained.

**(vi) Philosophy (Phi)**

Six Phi items have been tested collectively according to the suitability of sphericity and sampling adequacy. The item coded B32 and B34 were eliminated because it failed to meet communalities criteria of .400 or above and cause the failed of Total Variance Explained. Researcher re-runs the factor analysis for another four items. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi2$ = 311.506) and the KMO test for sampling adequacy was considered as "good" at 0.753 for the collective set of four Phi items. The anti-image correlation matrix of each item revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image for each item was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 then extracted a single factor for Phi. The Total Factor Explained showed 56.1% of the variance with an Eigenvalue of 2.245. The factor loadings in SPSS Component Matrix for all four Phi items were above 0.400 had justified that the four Phi items would be retained.

**(vii) Social Re-Constructivist (SRC)**

Nine SRC items has been tested collectively according to the suitability of sphericity and sampling adequacy. Bartlett's Test of Sphericity was considered significant at $p<0.001$ ($\chi2$ = 679.545) and the KMO test for sampling adequacy was considered as "great" at 0.821 for the collective set of nine SRC items. The anti-image correlation matrix of each item revealed no off-diagonal partial correlations above the threshold of 0.500. The diagonal of the anti-image for each item was accepted at the level of MSA. PCA with Kaiser's Eigenvalue of 1.0 and the screen plot showed the inflexion before the third factor so it would seem reasonable that there are, indeed, two distinct components. The Rotated Pattern Matrix indicates a clear presence of two factors matching very well with the SRC construct. The extracted two sub-constructs accounted for 49.3% of the total variance, which for the SRC1 (B38, B39, B40, B42, B43) explained 27.5% of the variance with an Eigenvalue of 2.475 and SRC2 (B41, B44, B45, B46) explained for 21.8% of the variance with an Eigenvalue of 1.962. The factor loadings in SPSS Component Matrix were above 0.400 justified. It was decided that all nine SRC items would be retained in two sub-constructs (Table 2).

Table 2
The Rotation of Varimax of SRC (n=372)

| Items | Factor Loading | |
|---|---|---|
| | 1 | 2 |
| B38 | .711 | |
| B39 | .708 | |
| B40 | .698 | |
| B43 | .623 | |
| B42 | .595 | |
| B46 | | .796 |
| B45 | | .675 |
| B44 | | .606 |
| B41 | | .533 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

**Result**

Based on the result of EFA for each construct, there were four items loaded under Endogenous Construct named Mathematics Teacher Education Curriculum (MTEC), which measure on the Mathematics teacher education context; four items loaded under Exogenous Construct named Professional Development (PDev), which measure on the processes and activities of pre-service teachers to enhance their teaching knowledge and skills; four items loaded for Psychology (Psy), which concerned with how learners develop human potential; five items loaded under Technology (Tech), which related to the transforming learning process of pre-service Mathematics teachers that need to observed; nine items loaded under History (His) as a tool for enriching in mathematical learning; four items loaded for Philosophy (Phi) as the objectives of Mathematics curriculum derived transmitted the basic values to the educational philosophy as the basic sources; and nine items loaded with two sub-constructs under Social Re-Constructivist (SRC) were related on how the curriculum reflects the culture and aspirations of society (Table 3).

Table 3
The Number of Items for Each Construct before and after Exploratory Factor Analysis (EFA)

| No | Constructs | Number of Items (Before EFA) | Number of Items (After EFA) |
|---|---|---|---|
| (i) | Mathematics Teacher Education Curriculum (MTEC) | 5 | 4 |
| (ii) | Professional Development (PDev) | 6 | 4 |
| (iii) | Psychological (Psy) | 5 | 4 |
| (iv) | Technology (Tech) | 6 | 5 |
| (v) | Historical (His) | 9 | 9 |
| (vi) | Philosophy (Phi) | 6 | 4 |
| (vii) | Social Re-Constructivist (SRC) | 9 | 9 |

As overall, the reliability of the study for 39 items after factor analysis was 0.924 indicated that the instruments having a very strong strength in the study and all the instruments could be acceptable in this study (Table 4).

Table 4
Cronbach's Alpha for Overall (n=372)

| N of Items | Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | Strength of Data & Internal Consistency |
|---|---|---|---|
| 46 | 0.932 | 0.934 | Very Strong, excellent |
| 39 | 0.924 | 0.926 | Very Strong, excellent |

The reliability after EFA according to constructs showed that the instruments under respective construct achieved the Cronbach' Alpha as requested having a very strong strength in the study and all the instruments can be accepted. The reliability for MTEC (0.743), PDev (0.752), Tech (0.753), His (0.887), Phi (0.733), and SRC (0.767) have presented an high reliability score and Psy (0.667) have an acceptable reliability score after factor analysis were indicated that the instruments under each construct having a very strong strength in the study and all the instruments could be acceptable in this study (Table 5).

Table 5
Cronbach's Alpha for Each Construct

| No | Construct | Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items | Strength of Data & Internal Consistency |
|---|---|---|---|---|---|
| (i) | Mathematics Teacher Education Curriculum (MTEC) | 0.743 | 0.742 | 4 | High & Good |
| (ii) | Professional Development (PDev) | 0.752 | 0.754 | 4 | High & Good |
| (iii) | Psychological (Psy) | 0.667 | 0.669 | 4 | Moderate, questionable |
| (iv) | Technology (Tech) | 0.753 | 0.756 | 5 | High & Good |
| (v) | Historical (His) | 0.887 | 0.887 | 9 | High & Good |
| (vi) | Philosophy (Phi) | 0.733 | 0.737 | 4 | High & Good |
| (vii) | Social Re-Constructivist (SRC) | 0.767 | 0.777 | 9 | High & Good |

**Conclusion**

All the items for endogenous construct: Mathematics Teacher Education Curriculum and six exogenous constructs: (i) Professional Development, (ii) Philosophy, (iii) Psychological, (iv) Technology, (v) Historical, and (vi) Social Re-Constructivist had extracted and loaded under the construct respectively. And all the items under each construct having a very strong strength in the study as all items could be acceptable in the elements in this study.

**Acknowledgement**

The authors acknowledge the Niche Research Grant Scheme (NRGS), Sultan Idris Education University (2014-0001-107-82-1) for the completion of this article.

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