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The Validation of Statistical Anxiety Rating Scale using Confirmatory Factor Analysis among Graduate Students

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Abstract: This statistics plays a vital role when conducting research particularly in analysing data. However, the anxiety in learning statistics has become one of the obstacles in understanding its fundamental concepts. The aim of this study is to validate the Statistical Anxiety Rating Scale (STARS) using Confirmatory Factor Analysis among graduate students. 246 graduate students from four different local universities were required to fill up 51 items of STARS using 5 point Likert Scale. These students are enrolled in graduate studies of various specializations particularly in education field. The Confirmatory Factor Analysis was used to determine psychometric characteristics through using fit index tests like TLI, CFI, GFI, NFI and RMSEA. The finding reveals that the CFA measurement model fits with the collected data.

Keywords: Statistical Anxiety, Confirmatory Factor Analysis, Postgraduate, Students.

1. INTRODUCTION

In preparing the 21st century learning skills, statistical literacy skills should not be neglected (Chew & Dillon, 2014). Statistical literacy is a combination of the ability to understand basic concept in statistics and apply it in reading, writing and critical thinking skills (Watson, 2006). It is essential in everyday life as it is applied everywhere such as while reading newspaper or watching news in television o. That is why students need to equip themselves with knowledge in statistics and the statistical literacy skill. Ograjenšek and Gal (2016) proposed that students' research should be included in the curriculum to improve statistics education.

At university level, there is no exception in learning statistics (Koh & Zawi, 2014). As for graduate students, they will need to apply this knowledge in their field of research. They should know which statistics tests are suitable to use the meaning of terms in statistical concept and analyse the data. Statistics courses or Research Methodology course have been introduced to help students with their research (Abdul Hamid & Sulaiman, 2014).

Statistical anxiety is associated with feeling worried and intolerant of the uncertainty in statistics (Williams, 2013). Anything that is associated with statistics includes interpreting data, attending a statistics course, answering statistics examination and doing statistics assignment. High levels of statistical anxiety tend to make student feel insecure and pressured (Cherney & Cooney, 2005).

Sesé, Jiménez, Montaño, and Palmer (2015) found that statistical anxiety can affect one's performance. There has been a study reported about declination in students' statistics achievement (Abdul Hamid & Sulaiman, 2014; Ashaari, Judi, & Mohamed, 2011). Students are unable to grasp the statistical concept due to lack of knowledge in statistics. It may be caused by the decreasing rate in students' class attendance (Ashaari et al., 2011) in statistics lecture.

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According to Chew and Dillon (2014), there are instruments developed just to measure students' statistical anxiety such as Statistical Anxiety Rating Scale (STARS), Statistics Anxiety Inventory (SAI), Statistics Anxiety Scale (SAS), Statistics Anxiety Measure (SAM) and Statistical Anxiety Scale. This study will focus on STARS as it claimed to have better reliability and validity (Devaney, 2016).

The justification of using CFA in the validation issues is based on its flexibility and clarification (Harun, Zaki, Ismail, & Awang, 2016). Thus, this study will focus on CFA reports on STARS. The STARS are reported to be suitable to measure the statistics anxiety for United Kingdom students' by the six-factor model (Hanna, Shevlin, & Dempster, 2008) as it was originally proposed by Cruise et al. (1985). Moreover, the reliability estimated are all consistently in high ranged. Devaney (2016) tested the 3 models of STARS and suggested that there should be correlations between the six factors to fit the data well.

However, when tested in the Malaysian context, it was not successful because the interpretation anxiety subscales was excluded (Abd Hamid & Sulaiman, 2016) although the reliability of the previous study was between .78 and .87. Hence, the purpose of this study is to validate the Statistical Anxiety Rating Scale (STARS) using Confirmatory Factor Analysis among four different local universities' graduate students.

2. METHODOLOGY

246 graduate students from four local universities were chosen to fill the Statistical Anxiety Rating Scale (STARS) voluntarily by using Google form link. 199 respondents were enrolled in education course and the remaining were from various field specializations. 191 of them are female students and 55 males. Data collection process was implemented from June 2016 to December 2016. Their demographic information, gender, institution, field of specialization and previous Cumulative Grade Point Average (CGPA) were asked. Only complete questionnaires were accepted and respondents with missing demographic details and missing response on Likert scale were discarded from the finalized data. The average graduate students' age is 28.5 years (SD=5.4). The STARS has 51 items of 5 point Likert scale which range from 1 as "Strongly Disagree" to 5 as "Strongly Agree" and it was adapted from Schneider (2011). Initially, the STARS was introduced by Cruise et al. (1985) to measure statistical anxiety using 89 items. In order to suit the instrument in local context then back to back translation to Malay language was used. Prior to data analysis, screening and cleaning data were applied to ensure that no outliers and extreme data affect further analysis. The collected data were entered into SPSS version 22 and AMOS version 22. In order to avoid misinterpretation of output, the cleaning and screening data were applied to the data particularly on the missing values. Then, the reliability of the STARS and its subscales was identified using Cronbach alpha value.

The STARS internal reliability was to be at a good level of 0.96 which is more than the suggested value of 0.70 (Kline, 1999). The subscales of STARS is shown in Table 1 which indicates that Test and Class anxiety (TC) of 8 items has good reliability value of 0.87; Interpretation anxiety (IA) of 11 items has shown excellent reliability value of 0.91; Fear of asking help (FA) has the least value of items and has shown 0.84 as good reliability value and Worth of statistics (WS) of 16 items has the excellence reliability value of 0.93. However, the next subscale of Fear of statistics teachers (FT) produced the lowest reliability value of 0.78 with 5 items only and 7 items in measuring Computational self-concept (CS) has shown a good reliability value of 0.86 (Hair et al., 2010).

Subscales	Cronbach alpha value	Number of items
Test and class anxiety (TC)	0.87	8
Interpretation anxiety (IA)	0.91	11
Fear of asking help (FA)	0.84	4
Worth of statistics (WS)	0.93	16
Fear of statistics teachers (FT)	0.78	5
Computational self-concept (CS)	0.86	7

TABLE I: SUBSCALE OF STARS

Next, to proceed with the Confirmatory Factor Analysis (CFA) of STARS, the Analysis of Moment Structure (AMOS) version 22 was used (Arbuckle, 2012). Instead of validating the STARS, CFA was applied to determine the

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appropriateness of the scales in measuring the intended variable (Harrington, 2010). The CFA was used to validate the STARS measurement model by using the suggested fit measures. The fit measures included in this validation process are Comparative Fit Index (CFI), Incremental Fit Index (IFI), Tucker Lewis Index (TLI), Goodness Fit Index (GFI), the relative chi–square (CMINDF: the Chi–Square/Degree of Freedom) and Root Mean Square of Error Approximation (RMSEA). The fit measures are chosen based on three fitness criteria that include absolute fit, incremental and parsimonious fit (Hair et al., 2010). In order to achieve the model fit, the cut-off point of all fit measures must be fulfilled such as the CMINDF value must be within 1 and 5, while CFI, TLI, IFI and GFI should be more than 0.90; while RMSEA must not exceed 0.05 (Schumacker & Lomax, 2004). As such, when the CFI reaches the recommended threshold value, this assumes that no correlation exists among all the latent variables and sample covariance matrix can be compared with a null model. The parsimonious fit index refers to the ratio of Chi square and degrees of freedom, which has to be less than 5. Meanwhile, RMSEA sets the acceptance threshold to ensure that the model with the selected fit measures suits the population covariance matrix (Hooper, Coughlan, & Mullen, 2008; Awang, 2012)

Figure 1 shows the preliminary hypothesized measurement model of STARS using CFA with all the chosen fit measures. The output of CFA should be based on the standardized estimation as suggested by Hashim and Sani (2008). The oval shape represents the latent variables and the boxes represent the observed variables with each of the observed variable has measurement error which is represented by small oval or circle in shape. A single headed arrow goes into another latent which can be called as the endogenous variable. All the required fit measure was located at the bottom right of the AMOS interface.



Figure 1: The preliminary hypothesized measurement model of STARS

3. RESULTS AND DISCUSSION

In order to validate the STARS using CFA, the unidimensionality is part of the process which suggests any item with low factor loading value has to be removed. However, the decision in removing item has to be based on two criteria. If the item is newly developed, then the cut-off point is not less than 0.5. However, any established item must have a factor loading value of at least 0.6 (Awang, 2012). In addition, any item with high value of factor loading which exceeds 0.6 indicates the fulfilling criteria of convergent validity (Hair et al., 2010). An alternative to convergent validity is to calculate the value of average variance extracted (AVE) which should be at least 0.5 (Awang, 2012). While construct validity of the STARS measurement model can be achieved if all the fit measures reach the acceptable cut off point. For instance, RMSEA should be at most 0.08. In conclusion, these three methods of convergent, construct and discriminant validity were used to validate STARS.

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Fit measure	CMIN/DF	TLI	CFI	IFI	RMSEA
Value	2.818	0.716	0.730	0.731	0.806

TABLE 2: THE CFA	OUTPUT FOR THE INITI	IAL MEASUREMENT MODEL	OF STARS
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Figure 2 shows the initial measurement model of STARS which produced the CFA output. Since STARS items have been established from the previous study, the factor loading should be more than 0.6 in order to meet the convergent validity requirement.

Based on the diagram, C17, C37, C40 and C46 have to be removed from the respective construct due to low factor loading value of less than 0.60. Furthermore, without deleting those items, all the chosen fit measures as shown in Table 2 have not yet achieved the cut-off point. The item deletion criterion is based on the suggested cut-off point (Awang, 2014).



Figure 2: The initial measurement model of STARS

When C17 was deleted, the model has not yet achieved the required fit indices and all the fit measures have to be considered. After several processes of deleting items then Modification Indices values are required to achieve model fit. However, none of the items of Fear of Asking Help (FA) and Computational self-concept (CS) were deleted. All factor loadings for these two subscales ranged from 0.67 to 0.80 which are at a good rate. Test and class anxiety (TC) has the highest number of deleted items which comprised of 6 items. While both Fear of statistics teachers (FT) and Computational self-concept have two deleted items respectively.

Subscales	Original Number of items	Deleted Items
Test and class anxiety (TC)	8	C24, C36, C37, C40, C41, C42,
Interpretation anxiety (IA)	11	C1, C4, C8, C15, C21, C22
Fear of asking help (FA)	4	None
Worth of statistics (WS)	16	C14, C17
Fear of statistics teachers (FT)	5	None
Computational self-concept (CS)	7	C44, C46

TABLE 3: DELETED	ITEMS BASED	ON SUBSCALES
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Table 4 shows the correlation values among all the related constructs for STARS. All the correlations were found to be significant at the 0.01 level with the lowest correlation value was 0.24 between Fear of asking help (FA) and

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Computational self-concept (CS). While the highest correlation value of 0.818 which was between Test and class anxiety (TC) and Interpretation anxiety (IA). The correlations between TC and IA, WS, FT and CS respectively this study was slightly lower than the value which was obtained by DeVaney (2016 except the correlation between TC and FA). Such finding was due to the context of this study particularly the respondents. The involvement of graduate students in this study produced a lower rate of statistical anxiety due to their experiences in learning statistics.

Meanwhile good discriminant validity can be fulfilled using the accepted Average Variance Extracted (AVE) value which should be at least 0.50 (Awang, 2014). The AVE explains the percentage of variation which can be obtained from the finalised items of the respective constructs. The ratio of the summation of the squares of the factor loading to the number of items in the particular construct produced an AVE value. In this study, the AVE was counted using the suggested formula and the results were as follow; TC = 0.524; IA = 0.521; FA=0.587; CS=0.530; FT = 0.514 and WS = 0.50. All these values indicate that the discriminant validity requirement has been met.

In order to achieve an acceptable composite reliability (CR) value of more than 0.60 (Awang, 2014) the following formula was used;

 $CR = \frac{\sum (Factor \ loading)^2}{\sum (factor \ loading)^2 + \sum (1 - Factor \ loading)}$

The CR value for all the related constructs were as follows; TC = 0.767; IA = 0.950; FA=0.927; CS=0.959; FT =0.863 and WS =0.985. This shows that the internal consistency of the STARS latent constructs are at a good rate.

Subscales	TC	IA	FA	WS	FT	CS
Test and class anxiety (TC)		0.818**	0.726**	0.391**	0.399**	0.585**
Interpretation anxiety (IA)			0.799**	0.387**	0.367**	0.508**
Fear of asking help (FA)				0.426**	0.359**	0.240**
Worth of statistics (WS)					0.787**	0.815**
Fear of statistics teachers (FT)						0.717**
Computational self-concept (CS)						

 TABLE 4: CORRELATION AMONG STARS SUBSCALES

** Correlation is significant at the 0.01 level

Next, Figure 3 shows the finalized measurement model of STARS which indicates all factor loadings range from 0.68 to 0.80 which fulfil the convergent validity condition (Gefen et al., 2000).



Figure 3: The Finalized Measurement Model of STARS.



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Table 5 indicates that all the chosen fit measure has fulfilled the recommended cut off value. For instance, all fit measures of TLII, CFI and IFI have exceeded 0.90. The model fit measures were CMIND/DF=1.914; TLI=0.902; CFI=0.912; IFI=0.913 and RMSEA =0.061.

Fit measure	CMIN/DF	TLI	CFI	IFI	RMSEA
Value	1.914	0.902	0.912	0.913	0.061

TABLE 5: THE CFA FOR THE FINALIZED MEASUREMENT MODEL OF STARS

4. CONCLUSION

This study investigates the psychometric properties through measurement validation for STARS using second order Confirmatory Factor Analysis. The STARS has six constructs and the CFA produces a model fit which can be proven by the chosen fit measure of CMIN/DF, TLI, CFI, IFI and RMSEA. Data were obtained from postgraduates who enrolled in various programmes. The STARS has gone through CFA and the criteria has been fulfilled which indicates that the collected data fit with the suggested model.

Using CFA, this study can be considered as a revalidation of STARS since the process has been done by the previous researchers with different research settings. However, the contribution of this study focuses on the items that measure the STARS constructs which are not similar with the previous study. This is due to deletion of items which produce low factor loading value. In conclusion, although most related studies use similar fit measures, the output is different among all the STARS models. With this validation process, STARS can be applied to any suitable study with good construct validity and reliability in measuring the targeted respondents' statistical anxiety. Items that have been deleted d and the remaining undeleted items in this study can be improved with the respective constructs for future studies.

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