Jurnal Pendidikan Malaysia 45(1) Isu Khas (2020): 17-24
DOI: http://dx.doi.org/10.17576/JPEN-2020-45.01SI-03

Validity and Reliability of the Survey of Attitudes Toward Statistics (SATS) Instrument

(Kesahan dan Kebolehpercayaan Instrumen *Survey of Attitudes Toward Statistics* (SATS)

YONG CHEA SIN & ROSLINDA ROSLI*

ABSTRACT

In social science research, statistics play an imperative role. However, social science students' attitude towards statistics is not widely investigated. This cross-sectional survey validated the Survey of Attitude towards Statistics 28 (SATS-28) instrument, which contains 27 items, in the context of 143 graduate students. Confirmatory Factor Analysis (CFA) was used to determine the compatibility of the hypothetical measurement model with the data obtained and to determine the model's construct reliability. All factors were successfully replicated in the Malaysian sample. From the initial model, 13 items with low factor loading index were dropped to achieve a good fit, leaving the final model with 14 items within four constructs, which are Affect, Cognitive Competence, Difficulty, and Value. The final model resulted in a lower chi-square (107.455) and AIC (203.455) values, while a higher PNFI value (0.599). Other than that, the cut off value of CFI (0.956) was increased. The RMSEA value (0.050) also fulfilled the suggested threshold of <0.08. Findings also revealed that Construct Reliability (CR) of the final model was acceptable, which ranges from 0.70 to 0.80. The findings implicate that the model is valid and suitable to evaluate Malaysian student's attitudes towards statistics. It is suggested that similar studies be done on other extended models of the SAT's instrument.

Key Words: Measurement model, Confirmatory Factor Analysis, Statistics anxiety, Survey of Attitude towards Statistics

ABSTRAK

Dalam penyelidikan sains sosial, statistik memainkan peranan penting. Walau bagaimanapun, sikap pelajar sains sosial terhadap statistik tidak banyak dikaji. Tinjauan keratan rentas ini mengesahkan instrumen Tinjauan Sikap Terhadap Statistik 28 (SATS-28), yang mengandungi 27 item, dalam konteks 143 pelajar siswazah. Analisis Faktor Pengesahan (CFA) digunakan untuk menentukan kesesuaian model pengukuran hipotetikal dengan data yang diperoleh dan untuk menentukan kebolehpercayaan konstruk model. Semua faktor berjaya dicerminkan dalam sampel Malaysia. Dari model awal, 13 item dengan indeks pemuatan faktor rendah digugurkan untuk mencapai kesesuaian, meninggalkan model akhir dengan 14 item dalam empat konstruk, iaitu Afek, Kompetensi Kognitif, Kesukaran, dan Nilai. Model akhir menghasilkan nilai chi-square (107.455) dan AIC (203.455) yang lebih rendah, sementara nilai PNFI yang lebih tinggi (0.599). Selain itu, nilai penanda aras CFI (0.956) dinaikkan. Nilai RMSEA (0.050) juga melepasi penanda aras <0.08. Hasil kajian juga menunjukkan bahawa Kebolehpercayaan Konstruk (CR) model akhir dapat diterima, yang berkisar antara 0.70 hingga 0.80. Hasil kajian menunjukkan bahawa model yang dihasilkan sah dan sesuai untuk menilai sikap pelajar Malaysia terhadap statistik. Disarankan agar kajian serupa dilakukan pada model instrumen SATS yang lain.

Kata Kunci: Model pengukuran, Analisis Faktor Pengesahan, kebimbangan statistik, Survey of Attitude towards Statistics

INTRODUCTION

In many areas such as Science, Technology, Engineering, and Mathematics (STEM) as well as the social sciences, the need for statistics is crucial (Hommik & Luik 2017). Statistics classes are often provided in secondary education, but many school students are not aware of the significance of this knowledge in everyday life (Peters et al. 2013). In line with that, many students perceive statistics to be a challenging course that is both uninteresting and difficult (Nielsen 2018; Sack et al. 2016). By default, Peters et al. (2013) asserted that statistics require a lot of logical reasoning, critical thinking, and interpretative abilities.

Understanding the accomplishment of logical

reasoning among learners is essential to understand their attitude towards learning statistics (Peters et al. 2013). In knowing the students' "attitude", we can predict and comprehend their response and investigate how a teaching and learning conduct can be affected (Nielsen 2018). Positive attitudes or adverse attitudes towards statistics can significantly influence the success of students, as was found by Gopal et al. (2018). Students with a favourable attitude were seen to be ready to engage in statistics-related lessons that will result in better achievement in statistics relative to others, which causes them to be more confident in solving mathematical problems as a result (Razali et al. 2015). In relation to this, it was found that gender plays no roles in differentiating attitudes towards statistics among Malaysian learners, as suggested by Hairulliza et al. (2011), as well as among Balkans and Irish learners, as suggested by Milic et al. (2016), and Hannigan et al. (2014).

For centuries, measurements of cognitive and behavioural capacity have been researched. For instance, Abd Hamid and Sulaiman (2016) pointed out that measurement is essential for scientists and educators to display data about the performance of learners in statistics courses. In line with that, measuring statistics anxiety among students is, therefore, essential in improving statistics lessons. Tools used to measure anxiety in statistics in various countries had been created and validated. Lots of researchers had used different types of attitude towards statistics surveys in their studies, such as Roberts and Bilderback's Statistics Attitude Survey (SAS) (1980) and Wise's Attitudes towards Statistics (ATS) (1985). In statistics education literature, the Survey of Attitude towards Statistics (SATS) by Schau et al. (1995; 2003) had been commonly used to evaluate the attitude towards statistics.

In Malaysia, there is a limited study of the validation of SATS-28 using Structural Equation Modelling (SEM). Commonly, Rasch's model analysis was used to determine the validity of an instrument in social science. For example, Maat and Rosli (2016) documented that the Statistical Anxiety Rating Scale (STARS) is felicitous in determining students' anxiety levels. Krishnan and Idris (2015) also established the reliability and validity of SATS-36 among a sample of matriculation students. Meanwhile, Sinniah et al. (2015) used Confirmatory Factor Analysis (CFA) to confirm that the instrument Positive and Negative Suicide Ideation (PANSI) is a valid and reliable instrument to use among clinical outpatients.

Concisely, it can be seen that researchers in Malaysia had widely used the instrument SATS- 28. In validating an instrument, SEM methods had been commonly used. However, not many studies have been done using SEM methods to validate an instrument in the field of social science, so this presents a gap in the literature. This study aims to validate the Survey of Attitude towards Statistics 28 (SATS-28) using Confirmatory Factor Analysis (CFA) based on Malaysian sample. Also, this article seeks to develop the information gathered on Malaysian tertiary students to match the initial model of the four parts of SATS-28, which are i) value, ii) affect, iii) cognitive competence, and iv) difficulty using CFA. The objectives are as below:

1. To determine the compatibility of the hypothetical measurement model with the data obtained
2. To determine the model's construct reliability

SURVEY OF ATTITUDE TOWARDS STATISTICS (SATS)

In statistics education literature, the Survey of Attitude towards Statistics (SATS) by Schau et al. (1995; 2003) had been commonly used to evaluate the attitude towards statistics. The initial scale consists of four parts of attitude, namely: i) value, ii) affect, iii) cognitive competence, and iv) difficulty. The later version, which was the SATS-26, was subsequently modified by incorporating two additional variables, which were: i) effort and ii) interest (Schau 2003) based on the achievement model of Eccles' expectancy-value model (Eccles 1983; Eccles & Wigfield 1995; Eccles & Wigfield 2002).

The attitude towards statistics survey, SATS-28, and SATS-36 are the extended versions of Schau's SATS, which were adapted from 2009 onwards. The SATS-28 contains 28 items and was used in Italy (Chiesi & Primi 2009), and SATS-36 contains 36 items and was used in Russia (Khavenson et al. 2012), the Netherlands (Tempelaar et al. 2007; Vanhoof et al. 2012) and Serbia (Stanisavljevic et al. 2014). Although SATS was transacted into various languages across countries such as French (Carillo et al. 2016), Dutch (Vanhoof et al. 2011), and Serbian (Stanisavljevic et al. 2014), the result showed that all component scores were compatible. As a result, favourable attitudes are correlated with greater accomplishment in statistics (Emmioglu & Capa-Aydin 2012; Milic et al. 2016; Stanisavljevic et al. 2014; Zimprich 2012). Sarikaya et al. (2018); however, note that the magnitude of these connections might vary across geographic areas. For example, according to Tempelaar et al. (2006), it was discovered that females in the Netherlands had considerably reduced mean scores on the parts of difficulty, affect, and cognitive competence. Meanwhile, the participants had more excellent mean scores on interest and effort than men; however, both sexes had a significant mean difference. In short, outcome differences indicate that nation and culture are significant variables to consider when examining the attitudes of learners to statistics.

STRUCTURAL EQUATION MODELING (SEM)

Structural Equation Modelling (SEM) is a methodology combining qualitative causal hypothesis with statistics data for assessing and accessing causal relationships. SEM is an expansion from the general linear model (GLM) that is capable of efficiently replace multiple regression, time series analysis, path analysis, covariance analysis, and factor analysis. The most common methodologies used in various fields are regression, variance analysis (ANOVA), and panel information (Jenatabadi 2015; Noudoostbeni et al. 2010; Samimi & Jenatabadi 2014). Researchers discovered SEM is the preferred model for assessing causal relationships as compared to multiple regression models. Researchers use SEM analyses to examine and verify a full model by producing fit statistics, which allows researchers to access the overall fit of the complete model (Schumacker & Lomax 2004). Besides, SEM enables researchers to model mediator factors and mediator variables using distinct dependent and autonomous indicators, as well as analyse system-wide indicators and compare them with other accessible conservative multivariate methods, such as multiple regression modelling. Utilizing SEM, researchers can examine the measurement error of the assessment method, which ultimately helps to improve the reliability of the structural path coefficients (Ullman & Bentler 2003).

According to Brown and Moore (2012), Confirmatory Factor Analysis (CFA) is a model within SEM, which is specifically a measurement model. CFA is used to determine how factors are measured by indicators; or in other words, it is used to test how well the measured variables represent the number of constructs. Principles underlying CFA originated from the common factor model (Thurstone 1947), where each of the indicators must be a linear function of one or more factors and a specific factor in the set of the measurement observed. Thus, CFA offers a more frugal definition among a series of parameters because the number of factors is lower than the number of variables calculated (Brown & Moore 2012). Commonly, researchers use SEM to reduce the impact of Type 1 error in their quantitative research (Elsenhauer et al. 2015; Hair et al. 2014; Jeon 2015).

In the development of a measurement instrument, CFA is commonly used in the psychometric evaluation, as it can evaluate the measurement invariance and validate the constructs. In the process of scaling production, CFA is used to find the latent structure of an instrument and to assist in evaluating the instrument.

METHODOLOGY

RESEARCH DESIGN AND INSTRUMENT

This study used cross-sectional survey design. This research design allows the collection of large amounts of data from a large pool of respondents relatively quickly (Cohen et al. 2013).

The instrument used in this study is the international Survey of Attitude towards Statistics (SATS-28) instrument (Schau et al. 1995). The SATS-28 was used instead of other versions of the SATS, such as the SATS-36. The main reason is a lack of validity proof on the additional scales in SATS-36, according to Schau et al. (1995). In addition, empirical trials conducted by Cashin and Elmore (2005) and Vanhoof et al. (2011) revealed that four model variables were a better model compared to six model variables.

The SATS-28 consists of a total of 28 items intended to evaluate attitudes as a multidimensional structure. In this study, only 27 items in the instrument were utilized. The item "*I will feel insecure when I have to do statistics problems"* was dropped from the questionnaire. Four attitudes components made up the SATS-28, which are: i) affect, ii) cognitive competence, iii) value, and iv) difficulty. The scale used in the instrument was a 7-point Likert scale (1: Completely Disagree; 2: Mostly Disagree; 3: Somewhat Disagree; 4: Neither Agree Nor Disagree; 5: Somewhat Agree; 6: Mostly Agree; 7: Completely Agree). It can be seen that higher scores correspond to more favourable attitudes. In this study, the initial SATS-28 instrument was used without any translation to retain the original meaning. Before conducting the data analysis, items with negative wordings were inverted to show favourable attitudes in greater results.

A few extra items were included in the questionnaire to collect demographic and academic background data such as gender, study semester, the field of research, set of classes, and expectations towards statistics.

Reliability analysis (Cronbach's Alpha) was used to test the internal consistency between each item in the instrument. The results are shown in Table 1. It was revealed that each factor had a high index of reliability based on Hair et al. (2014).

TABLE 1. Cronbach' Alpha for each construct

Aspect	Number of Item	Cronbach's Alpha
Affect	5	0.759
Cognitive competence	6	0.759
Value	9	0.759
Difficulty	7	0.771

SAMPLE

A total of 143 graduate students (23 males and 120 females) of education studying at one of the Malaysian research universities were randomly selected as samples. Simple random sampling was used as there is an equal chance of selection; therefore, it could reduce researcher bias as well as offer an opportunity to perform data analysis that has less risk of carrying an error (Emerson 2015).

The samples are all graduate students in the field of education, such as teaching English as a second language (n=13), education psychology (n=6), guidance and counselling (n=24), history education (n=11), mathematics education (n=8), pre-school education (n=8), educational administration (n=15), special education (n=15), sociology of education (n=3), science education (n=9), sports management (n=6), Malay language education (n=4), Arabic language education (n=6), business and entrepreneurship education (n=4), Islamic education (n=4), medical education (n=1), economics education (n=1), curriculum and pedagogy (n=4), and information and communication technology education (n=1).

DATA ANALYSIS METHOD

Confirmatory factor analysis (CFA) was used to validate the SATS-28 instrument in terms of the compatibility, reliability, and validity of the measurement model based on the information acquired. In addition, CFA also used the theory interactions between various factors to determine to confirm or dismiss that can be empirically tested for a sample information collection (Hair et al. 2016).

Figure 1 showed the initial hypothetical measurement model. CFA was used to test the hypothetical four-factor structures. Basic goodness-of-fit indices such as root mean square error of approximation (RMSEA), Tucker-Lewisfit index (TLI) comparative fit index (CFI) was used to determine the model fit. According to Browne and Cudeck (1993), for the root mean square error of approximation (RMSEA), zero represents a perfect fit, and the fitness benchmark should be less than 0.08. According to Marsh et al. (1988), the value of TLI and CFI must be over 0.90 or 0.95 for it to be considered acceptable. Parsimony Normed Fix Index (PNFI) was also used to evaluate the model fit and compare the models. Persson et al. (2019) stated that the highest value of PNFI was suggested to be a better fit relative to the complexity of the model.

The internal reliability of the model was measured by Construct Reliability (CR) value, which is a value that reflects the composite reliability and internal consistency of a model. Hair et al. (2014) recommended value above 0.7 shows good internal reliability.

Attitudes towards statistics were analysed by using four constructs, which are i) affect, ii) cognitive competence, iii) value, and iv) difficulty. All of these aspects are emphasized in attitude towards statistics, and each dimension is measured using certain items.

IBM SPSS AMOS version 23.0 software was used for the analysis as well as the reliability and validity checking of the measurement items.

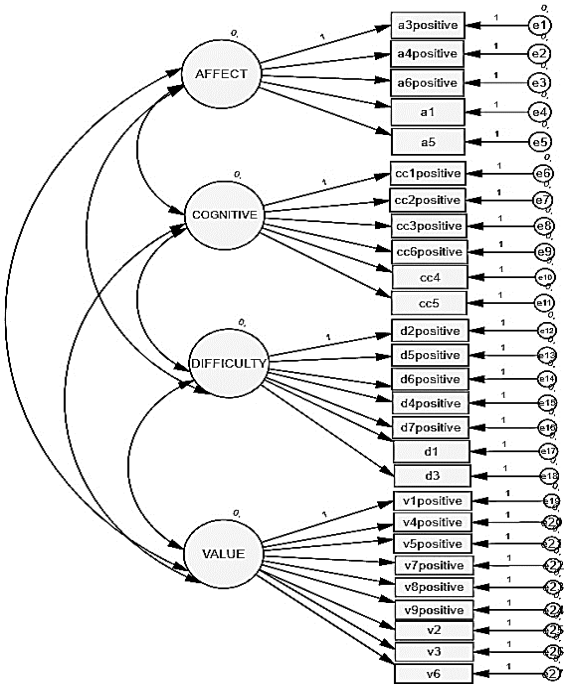

FIGURE 1. Initial hypothetical measurement model

FINDINGS AND DISCUSSION

COMPATIBILITY OF THE HYPOTHETICAL MEASUREMENT MODEL WITH THE DATA OBTAINED

Table 2 shows the fit indices for the SAT-28 initial model and the final model. All factors were successfully replicated in the Malaysian graduate students' sample. As showed in Table 2, the value of RMSEA for the initial model was 0.098, which is above the benchmark for a good model fit. Confirming this, the TLI (0.504) and CFI (0.582) values obtained also did not pass the recommended value. In short, the initial SATS-28 model does not meet the recommended cut off value. To conclude, the findings show that the initial SATS-28 is incompatible with the structure of SATS-28 among Malaysian graduate students.

This initial finding shows that the model needs to be modified to achieve a better fit. Hair et al. (2014) reported that items with factor loading values less than 0.6 should be dropped, as they will influence the validity and reliability of the whole model. Likewise, Li et al. (2018) reported that items with factor loading values beyond 0.6 would show a reliable and valid match with the model. Hence, in this study, the initial model was modified by deleting items with a factor loading value of less than 0.6. The items were A1, A2, A5, CC4, CC5, V1, V2, V3, V6, V7, D1, D2, D3, and D5 with the factor loading values of 0.25, 0.23, 0.20, 0.19, 0.12, 0.38, 0.21, 0.25, 0.07, 0.24, 0.10, 0.36, -0.10, and 0.57.

As can be seen in Table 2, the final model resulted in a lower value of the chi-square index (107.455) and AIC index (203.455), while a higher value of PNFI index (0.599). Other than that, the cut off value of CFI (0.956) was increased after the modified step. This result is similar to Wang et al. (2018), where they found that there was a good overall fit in the CFI index among business students in the United States of America (CFI=0.991) and China (CFI=0.992). Nevertheless, the RMSEA value in this study also fulfilled the suggested threshold of <0.08 (RMSEA =0.050). The final measurement model, with all the retained items and factor loading values exceeding 0.6, is shown in Figure 2.

TABLE 2. Fit indices for SATS-28 (n = 143)

Model	χ^2	df	RMSEA	CFI	PNFI	AIC
Initial	954.694	318	0.098	0.582	0.419	1128.694
Final	107.455	71	0.050	0.956	0.599	203.455

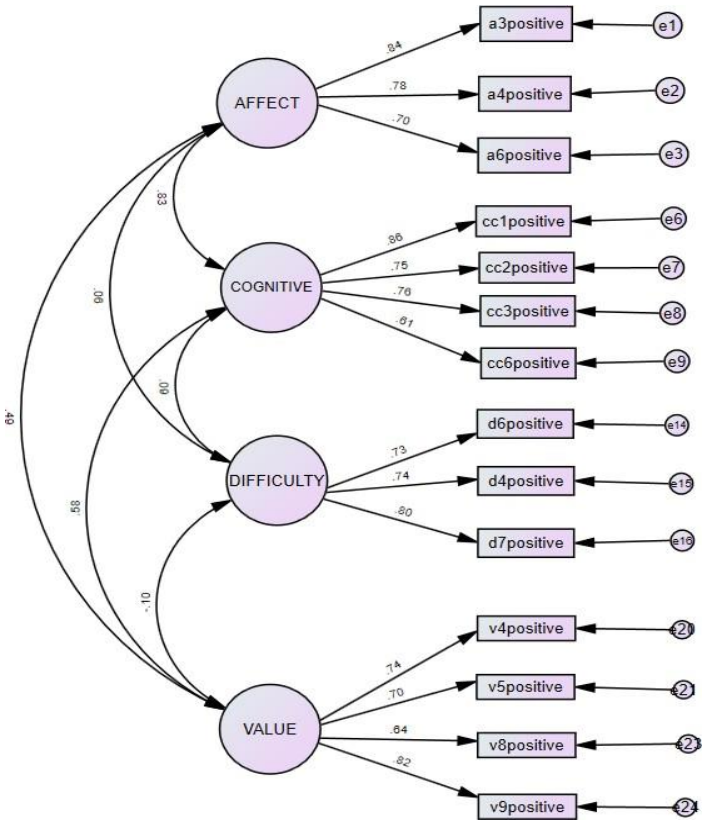

FIGURE 2. Final measurement model

Table 3 below shows the correlation between each latent factor for the final measurement model. From the table, all the components (Affect, Cognitive Competence, Value, and Difficulty) are significantly correlated. Furthermore, a strong correlation can be found between the components Affect and Cognitive Competence (0.825). The same finding was found by Clayton and Sankar (2009). This finding is also supported by Ncube and Moroke (2016), which have established a strong relationship between cognitive competences and affect in the SATS model.

CONSTRUCT RELIABILITY OF THE FINAL MODEL

Table 4 shows the Cronbach's Alpha values and Construct Reliability (CR) values obtained for the final SATS-28 model, which shows a measurement of the internal reliability and consistency for the final model. It can be seen that both the Cronbach's Alpha values and CR values, which range from 0.70 to 0.834, reached the suggested threshold of 0.70 (Hair et al. 2014).

Among the constructs, Cognitive competence showed the highest internal consistency (α=0.834), followed by value (α=0.810), difficulty (α=0.800), and affect (α=0.799). This finding is in line with Wang et al. (2018), who also reported that all the components in her study exceeded the recommended reliability coefficients. However, this result was opposite with Persson et al. (2019), which reported that the difficulty component (α=0.593) did not exceed the suggested threshold.

TABLE 3. Estimated latent factor correlation for the final measurement model

	Affect	Cognitive Competence	Value	Difficulty
Affect	1.00			
Cognitive Competence	0.825	1.00		
Value	0.490	0.578	1.00	
Difficulty	0.056	0.086	-0.101	1.00

TABLE 4. Cronbach's Alpha and Construct Reliability (CR) for the final model

Component	Cronbach's Alpha	CR
Affect	0.799	0.70
Cognitive Competence	0.834	0.70
Value	0.810	0.70
Difficulty	0.800	0.80

CONCLUSION

This study examined the validity and reliability of the Survey of Attitudes Toward Statistics 28 (SATS-28) instrument using confirmatory factor analysis (CFA) in the context of Malaysian graduate students. The initial hypothetical measurement model was modified to achieve a good fit, whereby 13 items with low factor loading index was dropped, leaving with 14 items in the final measurement model. The final SATS-28 instrument consisted of four constructs and 14 items; three items for Affect; four items for Cognitive Competence; three items for Difficulty; and four items for Value. Furthermore, the internal consistency of the constructs, which was measured using Construct Reliability (CR), was acceptable, which ranges from 0.70 to 0.80. This study provided an appropriate model (SATS-28) for use in determining the anxiety towards statistics among Malaysian graduate students. The SATS components can help identify anxiety among Malaysian graduate students, in which the data can facilitate the education administration and curriculum maker to develop a measurement to foster positive attitudes and achievement among students in a statistics course. This study suggests for more studies to be done on other extended models of the SATS instrument in the context of education among Malaysian students since SATS is the most common instrument used to study students' attitudes towards statistics. With statistics knowledge being imperative and required for advanced analysis, hence promoting a better mindset can create opportunities and future for all research students.

REFERENCES

Abd Hamid, H. S., & Sulaiman, M. K. 2016. Factor Structure of Statistics Anxiety Rating Scale (STARs): EFA and CFA Using Malaysian Undergraduate Psychology Students. In C. Y. Fook, G. K. Sidhu, S. Narasuman, L. L. Fong, & S. B. Abdul Rahman (Eds.), *7th International Conference on University Learning and Teaching (InCULT 2014) Proceedings* (pp. 149–156). Singapore: Springer Singapore.

Ali, R., & Buang, N. A. 2018. Kompetensi Keusahawanan Sebagai Mediator Kesediaan Penerapan Elemen Keusahawanan dalam Kalangan Pensyarah Institut Pendidikan Guru (IPG)(Entrepreneurship Competency as a Readiness Mediator in the Implementation of Entrepreneurship Elements Among Lecturers of Teacher Institute). *Jurnal Pendidikan Malaysia| Malaysian Journal of Education*, *43*(3), 123–130.

Brown, T.A. and Moore, M.T., 2012. Confirmatory factor analysis. *Handbook of structural equation modeling*, pp.361-379.

Browne, M. W., & Cudeck, R. 1993. Alternative ways of assessing model fit. *Testing structural equation models*, *154*, 136.

Carillo, K., Galy, N., Guthrie, C., & Vanhems, A. 2016. J'aime pas les stats!–Mesure et analyse de l'attitude à l'égard du cours de statistique dans une école de management. *Statistique et Enseignement*, *7*(1), 3-31.

Cashin, S. E., & Elmore, P. B. 2005. The Survey of Attitudes Toward Statistics scale: A construct validity study. *Educational and Psychological Measurement*, *65*(3), 509-524.

Chiesi, F., & Primi, C. 2009. Assessing statistics attitudes among college students: Psychometric properties of the Italian version of the Survey of Attitudes toward Statistics (SATS). *Learning and Individual Differences. 19*(2009), 309-313.https://doi.org/10.1016/j.lindif.2008.10.008

Clayton, H. R., & Sankar, C. S. 2009. Using spreadsheets to enhance learning in the affective domain for undergraduate statistics students. *INFORMS Transactions on Education*, *10*(1), 10-17.

Cohen, L., Manion, L., & Morrison, K. 2013. *Research methods in education*. Routledge.

Din, H. M., Arifin, W. N., Abdullah, S., Yusoff, M. S. B., & Aziz, A. A. 2018. The Internal Structure of New Attitudes towards Statistics Inventory among Postgraduate Students in Medical and Health Sciences. *Education in Medicine Journal*, *10*(4).

Eagly, A. H., & Chaiken, S. 2007. The advantages of an inclusive definition of attitude. *Social Cognition*, *25*(5), 582- 602.

Eccles, J. S. 1983. Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75- 145). San Francisco: W. H. Freeman and Company.

Eccles, J. S., & Wigfield, A. 1995. In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin*, *21*(3), 215-225. https://doi.org/10.1177/0146167295213003

Eccles, J. S., & Wigfield, A. 2002. Motivational beliefs, values, and goals. *Annual Review of Psychology 53* (1), 109-132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Eisenhauer, N., Bowker, M. A., Grace, J. B., & Powell, J. R. 2015. From patterns to causal understanding: structural equation modeling (SEM) in soil ecology. *Pedobiologia*, *58*(2-3), 65-72.

Emerson, R. W. 2015. Convenience sampling, random sampling, and snowball sampling: How does sampling affect the validity of research?. *Journal of Visual Impairment & Blindness*, *109*(2), 164-168.

Emmioğlu, E. S. M. A., & Capa-Aydin, Y. E. S. I. M. 2012. Attitudes and achievement in Statistics: A meta-analysis study. *Statistics education research journal*, *11*(2).

Gopal, K., Salim, N. R., & Ayub, A. F. M. 2018. Influence of self-efficacy and attitudes towards statistics on undergraduates' statistics engagement in a Malaysian public university. In *Journal of Physics: Conference Series* (Vol. 1132, No. 1, p. 012042). IOP Publishing.

Hair Jr, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. 2014. Partial least squares structural equation modeling (PLS-SEM). *European business review*.

Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. 2016. *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage publications.

Hairulliza, M. J., Noraidah, S. A., Hazura, M., Tengku Meriam, T. W. 2011. Students Profile Based on Attitude towards Statistics. *Procedia Social and Behavioral Sciences*, *18*, 266–272. https://doi.org/10.1016/j.sbspro.2011.05.038.

Hannigan, A., Hegarty, A. C., & McGrath, D. 2014. Attitudes towards statistics of graduate entry medical students: the role of prior learning experiences. *BMC medical education*, *14*(1), 70.

Hommik, C., & Luik, P. 2017. Adapting the Survey of Attitudes towards Statistics (SATS-36) for Estonian Secondary School Students. *Statistics Education Research Journal*, *16*(1).

Jeon, J. 2015. The strengths and limitations of the statistical modeling of complex social phenomenon: Focusing on SEM, path analysis, or multiple regression models. *Int J Soc Behav Educ Econ Bus Ind Eng*, *9*(5), 1594–1602.

Jenatabadi, H. S. 2015. A tutorial for analyzing structural equation modelling. *ArXiv Preprint ArXiv:1504.03430*.

Khavenson, T., Orel, E., & Tryakshina, M. 2012. Adaptation of survey of attitudes towards statistics (SATS 36) for Russian sample. *Procedia-Social and Behavioral Sciences*, *46*, 2126-2129.

Krishnan, S., & Idris, N. 2015. Investigating SATS-36 for a Matriculation Sample. *International Journal of Evaluation and Research in Education*, *4*(2), 84–88.

Lam, K. W., Hassan, A., Sulaiman, T., & Kamarudin, N. 2018. Evaluating the Face and Content Validity of an Instructional Technology Competency Instrument for University Lecturers in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *8*(5), 367–385.

Maat, S. M., & Rosli, M. K. 2016. The Rasch model analysis for statistical anxiety rating scale (STARS). *Creative Education*, *7*(18), 2820.

Marsh, H.W., Balla, J.R., & McDonald, R.P. 1988. Goodness-of-fit indexes in confirmatory factor analysis: The effect of sample size. Psychological Bulletin, 103, 319- 410.

Milic, N. M., Masic, S., Milin-Lazovic, J., Trajkovic, G., Bukumiric, Z., Savic, M., ... & Ilic, A. 2016. The importance of medical students' attitudes regarding cognitive competence for teaching applied statistics: multi-site study and meta-analysis. *PloS one*, *11*(10).

Ncube, B., & Moroke, N. D. 2016. Structural Equation Modelling applied to proposed Statistics Attitudes-Outcomes Model: A case of a University in South Africa. *Journal of Economics and Behavioral Studies*, *8*(5), 222-239.

Nielsen, T. 2018. Stat Anxiety, Self-efficacy & Motivation given student perception of math ability for learning stat. In *The European Association for Research in learning and Instruction-higher education (EARLI SIG 4) Conference*.

Noudoostbeni, A., Ismail, N.A., Jenatabadi, H.S. and Yasin, N.M., 2010. An effective end-user knowledge concern training method in enterprise resource planning (ERP) based on critical factors (CFs) in Malaysian SMEs. *International Journal of Business and Management*, *5*(7),

p.63.
Persson, I., Kraus, K., Hansson, L. and Wallentin, F.Y., 2019. Confirming the Structure of the Survey of Attitudes toward Statistics (SATS-36) by Swedish Students. *Statistics Education Research Journal*, *18*(1).
Peters, P., Smith, A., Middledorp, J., Karpin, A., Sin, S., & Kilgore, A. 2013. Learning essential terms and concepts in statistics and accounting. *Higher Education Research & Development*, 33(4), 742–756.
Razali, S. N. A. M., Sufahani, S. F., & Arbin, N. 2015. Pencapaian kursus matematik dan statistik di kalangan pelajar uthm: faktor mempengaruhi dan teknik pengajaran dan pembelajaran yang lebih diminati. *Journal of Techno Social*, *7*(2).
Sack Illowsky, B., Hilton, J., Whiting, J., & Dale Ackerman, J. 2016. Examining student perception of an open statistics book. *Open Praxis*, *8*(3), 265.
Samimi, P. and Jenatabadi, H.S., 2014. Globalization and economic growth: Empirical evidence on the role of complementarities. *PloS one*, *9*(4).
Sarikaya, E. E., Ok, A., Aydin, Y. C., & Schau, C. 2018. Turkish Version of the Survey of Attitudes toward Statistics: Factorial Structure Invariance by Gender. *International Journal of Higher Education*, *7*(2), 121–127.
Schau, C. 2003. *Students' attitudes: The "Other" important outcome in statistics education*. Paper presented at the Joint Statistical Meeting, Section on Statistics Education, San Francisco, CA.
Schau, C., Stevens, J., Dauphinee, T. L., and Del Vecchio, A. 1995. The development and validation of the survey of attitudes toward statistics. Educational and Psychological Measurement, 55, 868-875.
Schumacker, R. E., & Lomax, R. G. 2004. *A beginner's guide to structural equation modeling*. Psychology Press.
Sinniah, A., Oei, T. P. S., Chinna, K., Shah, S. A., Maniam, T., & Subramaniam, P. 2015. Psychometric properties and validation of the Positive and Negative Suicide Ideation (PANSI) inventory in an outpatient clinical population in Malaysia. *Frontiers in Psychology*, *6*, 1934.
Stanisavljevic, D., Trajkovic, G., Marinkovic, J., Bukumiric, Z., Cirkovic, A., & Milic, N. 2014. Assessing attitudes towards statistics among medical students: Psychometric properties of the Serbian version of the Survey of Attitudes Towards Statistics (SATS). PLoS ONE, 9(11), 1-7. https://doi.org/10.1371/journal.pone.0112567
Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. 2007. *Using multivariate statistics* (Vol. 5). Pearson Boston, MA.
Teman, E. D. 2013. A Rasch Analysis of the Statistical Anxiety Rating Scale. *Journal of Applied Measurement*, 14, 414-434.
Tempelaar, D. T., Schim van der Loeff, S., & Gijselaers, W. H. 2007. A structural equation model analyzing the relationship of students' attitudes toward statistics, prior reasoning abilities and course performance. *Statistics Education Research Journal*, *6*(2), 78-102.
Thurstone, L.L., 1947. Multiple-factor analysis; a development and expansion of The Vectors of Mind.
Ullman, J. B., & Bentler, P. M. 2003. Structural equation modeling. *Handbook of psychology*, 607-634.
Vanhoof, S., Kuppens, S., Castro-Sotos, A.E., Verschaffel, L., & Onghena, P. 2011. Measuring statistics attitudes: Structure of the Survey of the Attitudes toward Statistics (SATS-36). *Statistics Education Research Journal, 10*(1), 35-51.
Wang, P., Palocsay, S. W., Shi, J., & White, M. M. 2018. Examining Undergraduate Students' Attitudes toward Business Statistics in the United States and China. *Decision Sciences Journal of Innovative Education*, *16*(3), 197–216.
Whitaker, D., Unfried, A., & Batakci, L. 2018. A Framework and Survey for Measuring Students' Motivational Attitudes toward Statistics. In *ICOTS 10th International Conference on Teaching Statistics*.
Zimprich, D. 2012. Attitudes toward statistics among Swiss psychology students. *Swiss Journal of Psychology*, *71*(3), 149–155. https://doi.org/10.1024/1421-0185/a000082

Yong Chea Sin
Faculty of Education
Universiti Kebangsaan Malaysia
Email: p93551@siswa.ukm.edu.my

Roslinda Rosli
Faculty of Education
Universiti Kebangsaan Malaysia
Email: roslinda@ukm.edu.my

*Author for correspondence, email: roslinda@ukm.edu.my