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A STRUCTURAL VALIDITY STUDY OF STUDENTS' ATTITUDES TOWARDS STATISTICS: AN INITIAL EMPIRICAL INVESTIGATION

(Kajian Keesahan Struktur ke atas Sikap Pelajar Terhadap Statistik:
Suatu Kajian Empirikal Permulaan)

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ABSTRACT

Previous studies have shown that students' positive attitudes towards statistics are as important as good teaching and learning method in a course in statistics. Both are required for students to achieve good grade in the course. The objective of this study is to test the structural relationship of attitudes towards statistics using the Survey of Attitudes towards Statistics© or SATS© instrument among a sample of students in Universiti Kebangsaan Malaysia (UKM). The instrument comprises of six components that measure attitude i.e. affect, cognitive, value, difficulty, effort and interest. A survey was conducted among 102 first year students in the Faculty of Information Science and Technology of UKM to assess early attitudes towards statistics. The model involving six components which describe attitudes towards statistics is found to be adequate. The relationship between components is also investigated and discussed.

Keywords: Attitudes towards statistics; confirmatory factor analysis; structural model

ABSTRAK

Kajian terdahulu menunjukkan bahawa sikap positif pelajar terhadap statistik adalah sama penting dengan kaedah pengajaran dan pembelajaran yang baik dalam kursus statistik. Kedua-duanya diperlukan untuk pelajar mencapai gred yang baik dalam kursus tersebut. Objektif kajian ini adalah untuk menguji hubungan struktur sikap terhadap statistik menggunakan instrumen *Survey of Attitudes toward Statistics*© atau SATS © dalam kalangan sampel pelajar di Universiti Kebangsaan Malaysia (UKM). Instrumen tersebut terdiri daripada enam komponen yang mengukur sikap, iaitu afek, kognitif, nilai, kesukaran, usaha dan minat. Suatu kajian tinjauan telah dijalankan ke atas 102 orang pelajar tahun pertama di Fakulti Teknologi dan Sains Maklumat, UKM untuk menilai sikap mereka terhadap statistik. Model dengan enam komponen yang menghuraikan sikap terhadap statistik didapati memadai. Hubungan antara komponen juga disiasat dan dibincangkan.

Kata kunci: Sikap terhadap statistik; analisis faktor pengesahan; model struktur

1. Introduction

Statistics is an important component in Science as well as Social Science. In Malaysian universities, most Engineering and Science students undertake statistics courses as it is considered as the foundation for many programmes. Many students are facing problems in undertaking this course and do not perform well.

There has been a concerted effort to improve the teaching and learning of statistics to overcome the poor performance of students (Mills 2004). Comparison on attitude toward statistics between students who take statistics courses on-campus and online finds decreases in anxiety and increases in attitudes by online students (DeVaney 2010). This finding encourage instructors to use suitable materials and techniques in order to reduce anxiety and

hopefully enhance learning. Meanwhile, proper teaching and learning method in delivering statistics course may contribute to better attitude towards statistics. Study by Zamalia and Nor Hasmaniza (2010) has shown that students' attitudes were more positive after teaching and learning statistics sessions than before the session.

There are various reasons for the poor performance in statistics. One of them is related to students' lack of understanding in the underlying concepts of statistics (Gal & Ginsburg 1994). This factor is due to students' weak foundation in the subject and failure to master statistics basic concepts. The vagueness of definition in statistics also contributes to the issue. There is emergence need in the teaching and learning statistics to foster active learning by emphasising statistical thinking and incorporating data, instead of using theory and formula only (Moore 1997).

The other factor is related to the attitudes toward statistics. Tapia and Marsh (2001) shows that attitude plays an important role in Mathematics performance. Positive attitudes toward Mathematics is positively related to achievement (Papanastasiou 2000). A positive relationship was found between students' attitudes toward the use of statistics in their field of study and their grades (Rhoads & Hubele 2000; Vanhoof *et al*. 2006). Nolan (2002) examines whether three factors influence student performance in statistics: attitude towards statistics as a service subject, English language ability of students, and Mathematical ability of students. The results show deficiencies in students' competencies with respect to both language and mathematical ability, while mathematical ability is their major problem.

As stated by Tapia and Marsh (2001), it is essential to realise the importance of attitude, and to study students' attitudes toward statistics. Vargas-Vargas *et al*. (2011) agree with the necessity to do a reflection on students' attitude to statistics, because it could be an obstacle or an advantage in their learning process. This paper discusses two related questions about attitudes toward statistics. First, what are the components that measure attitudes toward statistics? Second, how confident are we on the structure of the instrument? The first section of this paper discusses the factors that contribute to attitudes toward statistics. The section that follows illustrates methods of data gathering and the results.

2. Attitudes toward Statistics and Its Measurement

Students' attitudes toward statistics is important because they may influence the learning process. According to Gal *et al*. (1997) students' attitudes toward statistics can affect to the extent to which students will develop statistical thinking skills, whether they will apply what they have learned outside of the lecture hall, and whether or not students will choose to enroll in further statistics course. Whereas, negative attitudes toward statistics may create a major obstacle for effective learning (Fullerton & Umphrey 2001). Students with negative attitude would find statistics class dull and bored (Ahmad Fauzi *et al*. 2005), may not be able to focus and would disturb other students. Thus, instructors should be attentive to the various components of teaching methodology and the effective delivery of statistics contents to cater for this group of students (Zamalia 2009).

In general, attitude could be classified into three categories i.e. affect, cognition and behaviour (Eagly & Chaiken 1998). Affect is related to the evaluation of the feelings toward the attitude object. Affect may reflect the positive and negative feelings toward statistics. This may include liking to statistics, anxiety and insecure with statistics problems, under stress in statistics lecture, and fear of statistics (Schau *et al*. 1995). Cognition is the perception of information about the attitude object. In the context of attitudes toward statistics, cognition refers to how students perceive statistics, include the usefulness of statistics in their lives or relate statistics to their daily lives. It might be measured by their perception on intellectual knowledge and skills when applied to statistics (Schau *et al*. 1995). Among the related items

that measure this component are; difficulty in understanding statistics, clueless in statistics course, making errors in statistics, confidence to learn statistics, including statistical equations and concepts.

Behaviour reflects the commitments and actions toward the attitude object. In this study, behaviour may represent how students react to statistics. It may include the value of statistics in students' life, the difficulty of statistics as a subject, students' level of individual interest in statistics, and their effort to learn statistics. The value component might be represented by the usefulness, relevance, and worth of statistics in students' personal and future professional life.

Various items may be used to measure difficulty including easiness to understand statistics formula, statistics could be learned quickly, assumption that statistics is a complicated subject, assumption that statistics require high discipline, statistics involve massive computations, statistics is highly technical, and statistics require new way to master the subject (Schau 2003). Student's level of individual interest might be measured by their capability to communicate statistical information to others, their interest to understand statistical information and learn statistics. The last component could be measured using the amount of work the students spend to learn statistics (Schau 2003). Among the items are effort to complete assignments, attempt to work and study hard, and attend each class session.

Schau (2003) proposes an instrument, Survey of Attitudes Toward Statistics (SATS) which comprises of six components: affect, cognitive, value, difficulty, interest and effort. Other instrument is the Attitudes Toward Statistics (ATS) questionnaire which consists of two subscales: Attitudes Toward the Field of Statistics and Attitudes Toward the Statistics Course (Wise 1985). The Field subscale is intended to measure students' attitudes toward the use of statistics in their chosen field of study. The Course subscale is intended to measure students'attitudes toward the statistics course itself. ATS anchors start with strong agreement, thus a low score indicates a more positive attitude.

Such instrument should not focus on examining the effect of the cognitive factors only, but also on non-cognitive factors (Aldogan & Aseeri 2003). Students' feelings, attitudes, beliefs, interests, expectations and motivations were proposed by these researchers to examine students' attitudes towards statistics. Ramirez *et al*. (2010) emphasise the use of educational achievement motivation models, especially Expectancy-Value Model (EVM), to assist researchers in understanding students' attitudes toward statistics. EVM was found to be congruent with SATS. SATS instrument seems to be compresensive to measure attitude towards statistics. Thus, it is chosen in this study.

3. Methodology

A survey has been conducted to 102 first year students of Faculty of Information Science and Technology (FTSM), UKM who enroll in statistics course. This survey was the first part of the research process to measure the attitudes toward statistics before enough information and exposure are given by the lecturers during the statistics course.

The SATS instrument is used in the survey and administered online. This instrument consists of demography variables and thirty five items on attitude. Each item was measured using a seven point Likert-type scale ranging from very strongly disagree (1) to very strongly agree (7). The instrument was translated to Malay language to ensure that this instrument is easily understood by students (Aldogan & Asseri 2003). A reliability analysis of the instrument gives a high value of Cronbach alpha, i.e. 0.901 for all items. The reliability index for each component is also high; affective (0.84); cognitive ability (0.71); value (0.77); difficulty (0.43); interest (0.85) and effort (0.85) as reported by Noraidah *et al*. (2010) and Hairulliza *et al*. (2010).

The instrument consists of some negatively worded items. These items were reversed for consistency during the analysis, so that higher scores correspond to more positive attitudes. The data were analysed using SPSS version 18 and AMOS 5.0 to test its reliability and structure, respectively.

The data were analysed using confirmatory factor analysis (CFA). CFA uses structural equation modeling that allows for a statistical test of the goodness-of-fit for the proposed confirmatory factor solution (Hair *et al*. 2006). There are various issues to be concerned in applying structural equation modeling technique, including sample size and overall fit indices (Hoe 2008). Among the generally agreed-on sample size is 10 participants for every free parameter estimated, although sample size needed is affected by the normality of the data and estimation method that researchers use (Schreiber *et al*. 2006). Westland (2010) observes a systematic bias towards choosing sample sizes that are significantly too small, in overall, 80% of the research articles in the study drew conclusions from insufficient samples. Inadequate sample size may limit research conclusion and generalisation.

Fit indices are used to assess model fit. A given model is properly specified if the true model, the one that generated the data, is considered consistent with the given model (Schumaker & Lomax 1996). The difference between the given and true model may be due to errors of omission and/ or inclusion of any variable or parameter. The fit indices used included the $\chi 2$ to df ratio, the goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI) and the root mean square error of approximation (RMSEA).

4. Results

The reliability results for six components and items that measure them are presented in Table 1. Among the six components, all of them show high score of Cronbach's alpha, except difficulty which shows lower score, i.e. 0.647. The results show high internal consistency and acceptable to high levels of reliability of the instrument.

Table 1: Attitudes toward statistics component

Component	Alpha
Affect	0.843
Cognitive	0.815
Value	0.806
Difficulty	0.647
Interest	0.843
Effort	0.847

The results of CFA on model fit is presented in Table 2. The fit indices used included the $\chi 2$ to df ratio, the GFI, the AGFI and the RMSEA. It indicates that the hypothesised model for attitude toward statistics, which comprises of six components, was a good fitting model. The statistics are: $\chi 2$ = 574.718, $\chi 2$/df ratio = 1.055, GFI=0.915, AGFI=0.902, and RMSEA= 0.030. However, some items in the instrument could not be retained, four of them (measuring difficulty) were discarded because of low factor loadings. The later model show better fit in comparison to the proposed model, with GFI=0.942, AGFI=0.932, and RMSEA= 0.030.

The final model for the data, including standardised coefficients, standardised item loadings, squared multiple correlations, correlation value between constructs, are presented in Figure 1. The factor loadings indicate the convergence between measures of the same construct to assess construct validity. The values are reasonably and statistically significant. Therefore, they show reasonable construct validity in the measures.

Table 2: Model goodness-of-fit indices

Model	χ^2	df	χ^2/df	GFI	AGFI	RMSEA
Optimal	-	-	<3.0[a]	>.90[b]	>.80[b]	<0.10[c]
Proposed model	574.718	545	1.055	.915	.902	0.030
Proposed model –4 items eliminated	481.510	419	1.149	.942	.932	0.023

a. Carmines & McIver (1981)
b. Sharma (1996)
c. Browne & Cudeck (1993)

The standardised items loadings range from 0.59 to 0.80 for affect, 0.44 to 0.86 for cognitive, 0.42 to 0.85 for value, 0.55 to 0.70 for difficulty, 0.40 to 0.94 for interest and 0.53 to 0.91 for effort. All items in each component are retained except in difficulty component. From the original seven items that measure difficulty, four were discarded due to low factor loadings. Thus, only three items are used to represent difficulty, as in Figure 1.

The squared multiple correlations (as R^2 in regression analysis) represent the percentage of variance explained by each observed variable (Holmes-Smith & Rowe 1994). In the sample, only six out of 31 observed variables show values below 0.30 (less than 30% of the variance is explained by that variable). Therefore, for most of the observed variables, a high percentage of the variance is explained by them. Out of thirty pairs of attitudes toward statistics components, only one pair indicate low correlation (as correlation value in correlation analysis), i.e. between value and effort. The rest show either high correlation or moderate correlation.

5. Discussions and Conclusions

The proposed model of attitudes toward statistics consist of 31 indicators fits the data from a sample of 102 students in FTSM. Though four items were eliminated from the instrument due to low coefficient, six components were retained in the final model. The components were affect, cognitive, value, difficulty, interest and effort. The reliability analysis on the component show that high internal consistency on the components except difficulty. Eventhough it has lower score than other components, the value is acceptable. This reliability finding is consistent with Zamalia (2009) who examine the profile identification among statistics learner.

This research employs the Malay language version of Schau's Survey of Attitudes Toward Statistics (SATS) scale, in measuring students' attitudes toward statistics. The result on reliability is consistent with Hong *et al*. (2010), which reports a high internal consistency, with values within ranges reported by previous researchers of the ATS scale. The Malay version of the ATS scale has two subscales identified as Attitudes toward Course and Attitudes toward Field, respectively as reported by Wise (1985). In relevant research, Rosseni *et al*. (2009a, 2009b) tested the diversity of the e-Learning Style Questionnaire (eLSE) dimensions using confirmatory factor analysis. The findings indicated that one of the six hypothesised dimensions acquire reliability less than 0.6. Thus the researchers have proposed only five of the six components as valid and reliable constructs for measuring e-learning styles.

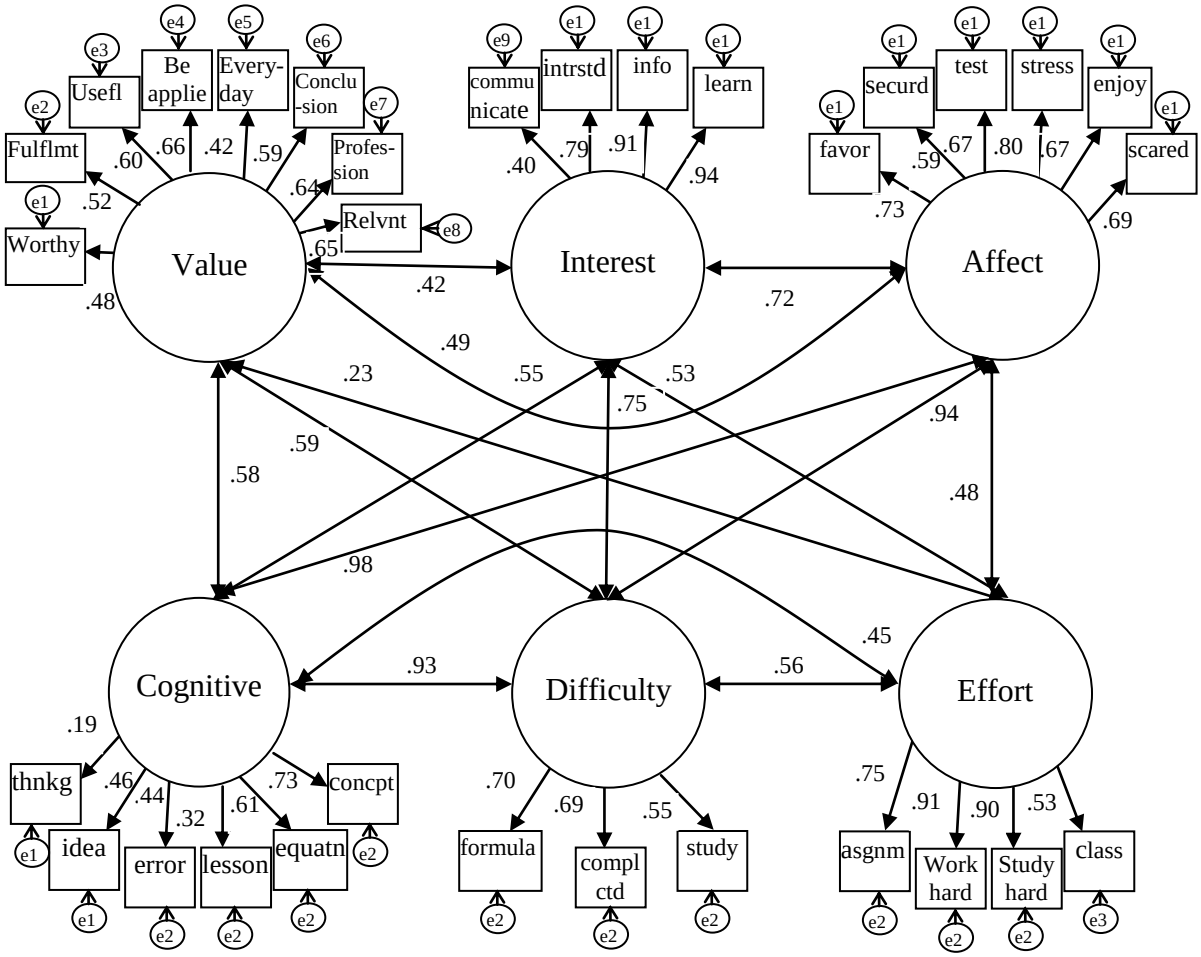

Figure 1: CFA Model of Attitudes toward Statistics (Standardised Estimations)

The GFI and AGFI indices show goodness of fit of the model. The results suggest that it was appropriate to presume attitudes toward statistics behind these six components. This finding provides empirical evidence that instrument developed by Schau (2003) are reliable and valid for determining the attitude of students towards statistics. As presented in Figure 1, all observed variables except worth, evrydy, comnc, and thinkg (factor loading less than 0.49) have factor loading above 0.50. According to Garson (2004), a finding that observed variables have high loadings on the predicted factors indicates construct validity. In general, the values signify construct validity for the data.

The correlation values for attitudes toward statistics components were also presented in the figure. There are three pairs of correlation that indicate high relationship i.e. between cognitive and difficulty, between affect and difficulty, and between affect and cognitive. This may indicate that the students in this sample feel their cognitive levels in statistics are constrained and tied by the difficulty element in statistics, and vice-versa. This also might show that cognitive and difficulty represents one construct, as the finding leads the researchers to think the two components overlap conceptually. The items that made up these two components might be related, for example, the ability of students to understand statistic equations (measure cognitive) is related to their easiness to understand statistics formula (measure difficulty).

The results show goodness of fit of the scale developed by Schau (2003). The validity and reliability of SATS offers a good instrument to measure students' attitudes toward statisics in a Malaysian students sample. The findings are consistent with Anastasiadou (2010) in measuring students' attitudes using Statistics and Technology Scale (SASTSc) among a Greek sample.

This paper aims to test the structural validity of attitudes toward statistics. Six components were used to measure attitude i.e. affect, cognitive, value, difficulty, effort, and interest. Though the results of this study are preliminary in nature, they provide some insights for researchers in measuring especially Malaysian students' attitudes toward statistics.

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