

**STUDENT'S ATTITUDE TOWARDS INTRODUCTORY STATISTICS  
COURSE AT PUBLIC UNIVERSITIES USING  
PARTIAL LEAST SQUARE ANALYSIS**

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**ABSTRACT**

Since beginning 20<sup>th</sup> century, students are introduced with statistics courses in universities. The purpose of this study was to conceptualize and empirically test a model to analyze the relationships among mathematics achievement, attitude towards statistics, and statistics outcomes. A survey using Survey of the Attitude towards Statistics (SATS) was used to collect data. A new SATS consists of 41 items with self-efficacy scale was used on the hypothesized model, "Statistics Attitude-Outcomes Model". Data collected from this research was analyzed using the Partial Least Square (PLS) modelling method. The results from this study will be used as a guidance in producing an effective and innovative teaching and learning method to cultivate students' interest towards statistics subject.

**Keywords:** Attitudes towards statistics, Mathematics achievement, Statistics outcomes, Partial Least Square (PLS), SATS.

**1. INTRODUCTION**

"Attitude is the key to success" this age old-saying has been frequently heard by most people. Student attitudes towards a subject lead to academic success (Popham, 2005; Royster et al., 1999). In recent years, attitude towards statistics have received increasing attention in statistics education. The ultimate goal of statistical education is to provide an appropriate use of statistical thinking (Schau et al., 1995).

Attitude towards statistics can be defined as 'a disposition to respond favorably or unfavorably to objects, situations or people related to statistics learning' (Chiesi et al., 2009, p. 309). In the early practice of statistics courses, the instruction was mostly traditional. The focus was on probability theory and on specific statistics procedures. Statistics was studied from a

mathematical perspective. Students were expected to memorize statistical knowledge and follow rules and procedures in standard contexts (Vanhoof, 2010). In 1990s, statistics instruction had undergone another revolution primarily as a consequence of the inclusion of computers (Hand, 1998). Statistical software tools enhanced statistical applications and reduced the overemphasis of mathematics in statistics courses. Currently, many changes have been implemented in statistics courses as more technological devices become available for data analysis and simulations. Accordingly, the goal of statistics education tend to emphasize more on conceptual understanding and less on mechanics of the mathematical procedures (American Statistical Association, 2010).

Today, statistics courses are compulsory for most of the students from a broad spectrum of Social and Natural Sciences fields. University students often hold negative attitudes regarding mathematics and science courses, including statistics courses, which many face as a compulsory part of their degree (Mallow et al.,2010). Statistics is about solving real world problems (Hand, 1998). Therefore, it is not only needed for conducting scientific research but also needed for being an informed citizen and for advancing in technology as a society. Statistics is in our everyday lives. It is on internet, newspapers, television, and everywhere. The reports of political elections, sports games, advertisements, census records, weather forecasts, and many situations, which we come across everyday use basic statistics knowledge.

In the current study, a statistics course refers to the service course offered to undergraduate or graduate students who are not majoring in statistics. In statistics, students need to recognize when they should apply statistical thinking, accurate use the skills they possess, know when they require additional statistical knowledge and skills, and obtain this additional statistical understanding. During their introductory statistics course, students need to believe that they can understand and use statistics, the students should think that statistics is useful both in their professional and personal lives, recognize that statistics can be interesting, be willing to invest the effort needed to learn statistical thinking and skills and realize that statistics is not easy but it also is not too difficult to learn (Gal, Ginsburg, & Schau, 1997; Garfield, Hogg, Schau, & Whittinghill, 2002; Schau, Stevens, Dauphinee, & Del Vecchio, 1995). Negative attitudes towards statistics influence student learning and adoption of statistical thinking, student's achievement in these courses, and the likelihood that students will apply their statistical knowledge outside of the classroom, including in their professional lives (Gal et al., 1997; Schau, 2003b). Many students express strong negative attitudes when they enter their required introductory statistics course (e.g.,

Schau, Stevens, Dauphinee, & Del Vecchio, 1995). These students view these courses as overwhelming learning and survival tasks that cause a great deal of stress (e.g., Onwuegbuzie & Daley, 1999). For many students, the prospect of taking an introductory statistics class is daunting. Kirk (2002) reported that students believe an introductory statistics course to be demanding, to involve lots of maths, and to be irrelevant to their career goals. Many students who complete an introductory statistics course often have negative perceptions of the course and are dissatisfied with the experience (Garfield 1997). In addition, many non-statistics majors in algebra-based introductory statistics courses suffer from statistics anxiety (Bradstreet 1996). Due to their negative attitude some colleges and universities are now using an introductory statistics course as a primary way to meet the general education requirement for mathematics.

Therefore, understanding their attitudes and their relationship with learning and achievement in statistics, it is important to foster positive attitudes, better achievement, and a life-long embrace of statistical thinking. This has led to making statistics among the core subjects in Higher Education Institutes in Malaysia. The objective of a statistics course is to equip students with basic statistical skills in order to appreciate the value of statistics in their professional and personal lives (North et al., 2006).

According to Mills, (2004) some students reveal a positive attitude towards statistics, but evidence reveals that unfavorable responses far outweigh any favorable responses. Students frequently view statistics as one of the biggest footraces they face as graduate students. In this regard, opinion from Birenbaum et al., (1994) stated that statistics-related courses are considered by many students as the most dreadful courses in the curriculum and their experience of these courses can be rather onerous and anxiety-laden (Piotrowski, et al, 2002). Mostly students in the social and behavioral sciences tend to experience a course in statistics as intimidating and/or feel in-sufficiently competent in order to acquire the necessary conceptual understanding (Finney & Schraw, 2003). Evidence of this can also be traced to the titles of some statistics references such as 'Statistics anxiety over learning statistics'. A small but growing body of evidence showed that attitudes toward statistics contribute to the success in statistics courses (Chiesi & Primi, 2008; Dempster & McCorry, 2009; Limpscomb, Hotard, Shelley, & Baldwin, 2002; Sorge & Schau, 2002). The importance of attitudes in the context of introductory statistics courses is widely recognized (eg., Gal et al., 1997; Leong, 2006). Such negative attitudes are often considered a major obstacle for effective learning (Waters et al., 1988).

Hence, the purpose of this study was to conceptualize and empirically test a model to analyze the relationships among mathematics achievement, attitudes towards statistics, and statistics outcomes towards students' perception on introductory statistics by performing Partial least squares (PLS) modelling. Partial least squares (PLS) were used to evaluate the proposed theoretical model by using the data collected from the modified Survey of the Attitude Towards Statistics (SATS) on the Malaysian students.

## **2. STATEMENT OF THE PROBLEM**

Students often consider statistics as a difficult subject to learn. It is often associated with students having negative feelings towards statistics. Statistics is often viewed by students as one of the biggest hurdles they face as graduate students. According to Birenbaum and Eylath (1994), many students often considered statistics-related courses as the most dreadful courses in the curriculum and their experience of these courses can be rather onerous and anxiety-laden (Piotrowski, Bagui & Hemasinha, 2002). Current studies suggest that statistics courses are needed to be revised in a way to motivate students to learn statistics (Carnell, 2008; Dempster & McCorry, 2009; Murtonen & Lehtinen, 2003; Wiberg, 2009).

It is believed that there are many factors affecting student's attitude towards introductory statistics course. This study is based on theoretical background and Eccles and colleagues' application of expectancy value theory of achievement motivation to the mathematics education (Eccles, 1983, 2005; Eccles & Wigfield, 2002; Wigfield, Tonks, & Klauda, 2009).

The researcher proposed this model in statistics course instead of mathematics to discover the outcomes and effect on student's attitude towards statistics. By testing the model, it is expected that this study would contribute to the literature in general by investigating the relationships among several variables by implementing the context in statistics education. The researcher modified the demographic and academic items to fit the Malaysian education system. Besides that, SATS was used for this study because the researcher wants to get the view on Malaysian students towards statistics outcome. By adding a new variable, it could give a new approach to the SATS for future studies. The researcher too found that there are lack of study on students' attitude towards mathematics achievement and statistics outcomes by using the SmartPLS software.

### 3. RESEARCH OBJECTIVES

Since there are lacks of study on students' attitude towards mathematics achievement and statistics outcomes by using the SmartPLS software, the researcher conceptualizes and empirically tests the proposed model with confirmatory factor analysis (CFA) under measurement model and structural model in partial least square (PLS). It is used to study the factors that affect students' attitude on statistics subject and investigate the relationship between the latent variables of the model. The researcher found that there was less research in investigating on self-reported mathematics achievement, attitudes towards statistics and statistics outcomes using SmartPLS software. Finally, the researcher scrutinizes about the students' perception on their statistics outcomes with the new variable known as self-efficacy. Thus in summary, the study attempts to achieve the following objectives:

- a) To conceptualize and empirically test a modified model on "Statistics Attitude-Outcomes Model" SAT-41 (SAOM-41).
- b) To test the measurement model for the proposed Statistics Attitudes-Outcomes Model (SAT-41) by using confirmatory factor analysis (CFA) under partial least square (PLS).
- c) To test the structural model for the proposed Statistics Attitudes-Outcomes Model (SAT-41) with partial least square (PLS).
- d) To investigate the relationship between the latent variable (affect, cognitive competence, value, difficulty, interest, effort and self-efficacy) attitude towards statistics with mathematics achievement and statistics outcomes in the proposed model.

### 4. METHODOLOGY

This study was carried out on non-statistics students taking Introductory Statistics at selected public universities in Kuala Terengganu. In this research, the study sample included 244 (68 male and 176 female) undergraduate respondents from selected public universities. The respondents were from different disciplines such as Food Technology, Animal Science, Biology, Chemistry, Software Engineering, Physics Electronic & Instrumentation, Computer Science and etc. Data was collected by distributing questionnaires to the respondents. The administration of answering the questionnaires took about 15 to 20 minutes.

Partial Least Square (PLS) modelling method was proposed to validate the measurement and structural model on students' attitudes towards statistics. The questionnaire was adapted and

modified from the Survey of Attitude Towards Statistics-36 (SATS-36; Shau, et al., 1995, Shau 2003) with the combination of 4 items on self-efficacy adapted from Bandura (2006).

After obtaining permission from Prof Candace Schau, the SATS-36 questionnaires were employed in this study during pilot study. For the main study, the researcher used SAT-36 questionnaires (Shau, et al., 1995, Shau 2003) which was adapted and modified with addition of 4 items from the self-efficacy scale adapted from Bandura (2006). SAT-36 was chosen for many reasons. Firstly this instrument is widely used to assess attitudes towards statistics. Second, psychometric properties of the instrument are well documented and supported by confirmatory analysis techniques (Chiesi&Primi, 2009; Tempelaar et al.,2007). Third, the generation of the subscales was based on a theoretical background (Schau, 2003). Fourth, the instrument is adaptable to different cultures as it has been used across different cultural contexts (Barkatsas, Gialamas, &Bechrakis, 2009; Chiesi&Primi, 2009; Coetzee & van der Merwe, 2010; Tempelaar et al., 2007; Verhoeven, 2009). Fifthly the researcher wants to implement this SATS to Malaysian students according to Malaysian education system and assess students' self-efficacy or their statistics outcomes towards statistics by adding a variable from self-efficacy scale.

The SATS-36 was designed to assess six components of attitude towards statistics as well as other construct including prior achievement (Schau, Steven, Dauphinee and Del Vecchio 1995). The six attitude components (affect, cognitive competence, value, difficulty, interest and effort) in SATS were assessed using 36 items with a 7-Likert point response scale that range from 1(strongly disagree) through 4(neither agree nor disagree) to 7(strongly agree). These six components included Affect (6 items), Cognitive Competence (6 items), Value (9 items) and Difficulty (7 items), interest (4 items) and effort (4 items).

This SATS-36 (Shau, et al., 1995, Shau 2003) instrument was chosen because it represents important attitudes related to student's achievement (Elmore et al 1993). In real study, the SATS-36 with addition of 4 items from self-efficacy was formed. In this version, it contains 41 items that assess seven components; the original six components adapted from Prof Candace Schau and modified with one more component known as self-efficacy which was adapted from self-efficacy scale(Bandura 2006).

### 5.RESULTS & FINDINGS

The researcher used SPSS 16 to extract the reliability test on table 1 and normality test to find its skewness and kurtosis on table 2 as the first step to identify the reliability of each construct. Frequencies and percentage mean and standard deviations, skewness and kurtosis are presented in order to describe the characteristics and relationship between self-reported mathematics achievements, attitudes towards statistics and statistics outcomes among non-statistician students. The reliability test was conducted to estimate the reliability of the scales adopted in the present study. Then in order to conduct the statistical analysis, the data was checked for normality. The normality can be assessed by checking the normality from menu Analyse, Descriptive Statistics, Explore and then normality plots with test options. The Normality can be assessed by obtaining skewness and kurtosis value (Pallant, 2001) in figure 1. SPSS 16 software was used to run the descriptive statistics analyses.

Cronbach's Alpha	No of Items
0.852	44

Table1. Cronbach's alpha reliability of the overall measure

Construct	Observed Variable	Mean	s.d.	Skewness	Kurtosis
Effort	I plan to complete all of my statistics assignments.	5.52	1.392	-0.989	1.127
	I plan to work hard in my statistics course.	5.50	1.421	-1.027	1.003
	I plan to study hard for every statistics test.	5.19	1.400	-0.766	0.446
	I plan to attend every statistics class session.	5.43	1.396	-0.830	0.491
Affect	I will like statistics.	4.95	1.508	-0.695	0.231
	I will feel insecure when i have to do statistics problems.	3.50	1.498	0.356	-0.074
	I will get frustrated going over statistics tests in class.	3.88	1.497	0.130	-0.204
	I will be under stress during statistics class.	4.16	1.477	-0.109	-0.340
	I will enjoy taking statistics course.	4.41	1.252	-0.108	0.364
	I am scared by statistics.	4.29	1.645	-0.020	-0.639
Cognitive Competence	I will have trouble understanding statistics because of how i think.	3.68	1.544	1.544	-0.299
	I will have no idea of what's going on in this statistics course.	4.23	1.469	1.469	0.010
	I will make a lot of math errors in statistics.	3.99	1.511	1.511	-0.449

	I can learn statistics.	5.32	1.272	1.272	1.061
	I will understand statistics equations.	4.95	1.368	1.368	0.618
	I will find it difficult to understand statistical concepts.	3.82	1.423	1.423	0.144
Difficulty	Statistics formulas are easy to understand.	4.38	1.506	1.506	-0.134
	Statistics is a complicated subject.	3.90	1.572	1.572	-0.394
	Statistics is a subject quickly learned by most people.	4.25	1.471	1.471	-0.057
	Learning statistics requires a great deal of discipline.	3.12	1.457	1.457	0.484
	Statistics involves massive computations.	3.49	1.219	1.219	0.676
	Statistics is highly technical.	3.38	1.249	1.249	0.455
	Most people have to learn a new way of thinking to do statistic.	3.13	1.299	1.299	0.371
Value	Statistics is worthless.	4.80	1.603	1.603	-0.819
	Statistics should be required part of my professional training.	4.50	1.436	1.436	0.046
	Statistical skills will make me more employable.	4.83	1.338	1.338	0.202
	Statistics is not useful to the typical professional.	5.10	6.212	14.317	217.201
	Statistical thinking is not applicable in my life outside my job.	4.24	1.508	1.508	-0.223
	I use statistics in my everyday life.	3.88	1.437	1.437	0.000
	Statistics conclusions are rarely presented in everyday life.	3.52	1.249	1.249	0.359
	I will have no application for statistics in my profession.	4.16	1.383	1.383	0.220
	Statistics is irrelevant in my life.	4.34	1.416	1.416	0.021
Interest	I am interested in being able to communicate statistical information to others.	4.47	1.404	1.404	0.329
	I am interested in using statistics.	4.48	1.338	1.338	0.380
	I am interested in understanding statistical information.	4.55	1.280	1.280	0.761
	I am interested in learning statistics.	4.73	1.455	1.455	0.257
Math Achievement	Did you do well in your past mathematics course.	5.09	1.437	1.437	0.318
	Are you good at mathematics?	4.91	1.386	1.386	-0.101
Self-Efficacy	I am confident that I understand basic statistics concepts.	4.66	1.353	1.353	0.320
	I am confident that I can correctly interpret the meaning of the correlation coefficient $r$ for two variables in a set of data.	4.25	1.301	1.301	0.391



	I am confident that I can correctly use a linear regression equation to make predictions.	4.33	1.234	1.234	0.651
	I am confident that I can correctly identify the null and alternative hypotheses in preparation for conducting a t-test.	4.18	1.184	1.184	1.231
	Are you confident that you can master introductory statistics topics?	4.13	1.490	1.490	-0.076
Statistics Outcome	Will you use statistics in your future job?	4.32	1.419	1.419	0.126
	If you were given a choice to choose a course, will you select statistics.	3.46	1.698	1.698	-0.779

Table 2. Descriptive Statistics for Study Variables

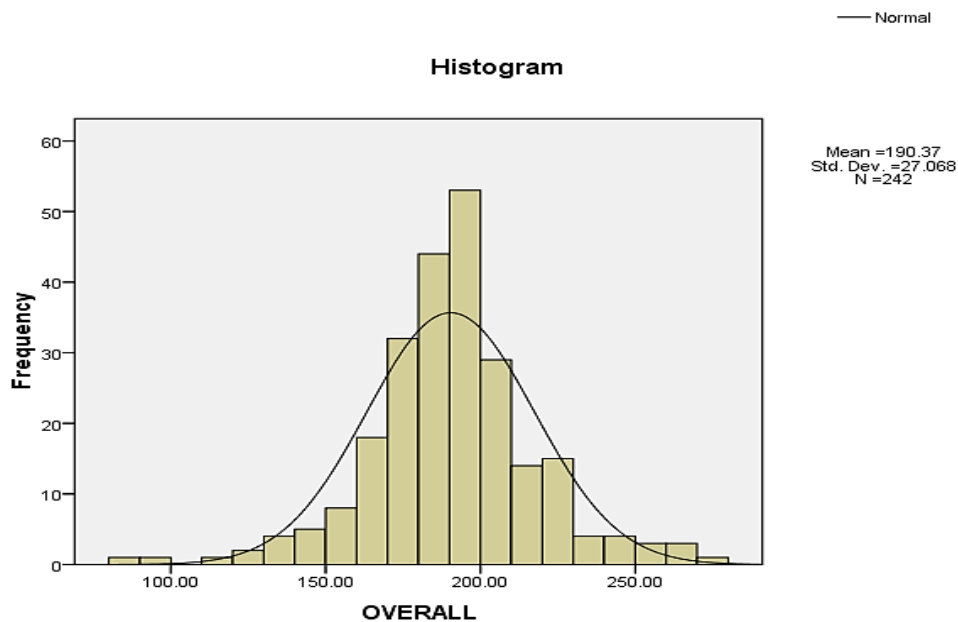


Figure 1. Overall view of skewed distribution of SAOM-41

Finally, the whole data was exported to SmartPLS software to analyze and evaluate on the measurement model and the structural model in order to investigate the relationship between self-reported mathematics achievement, attitudes towards statistics and statistics outcomes. A measurement model postulates the relationships between indicators or manifest variables (i.e., outer loadings or observed variable) and their corresponding constructs or latent variables. The measurement model in figure 2 was tested through valuation of validity and reliability of the construct in this model.

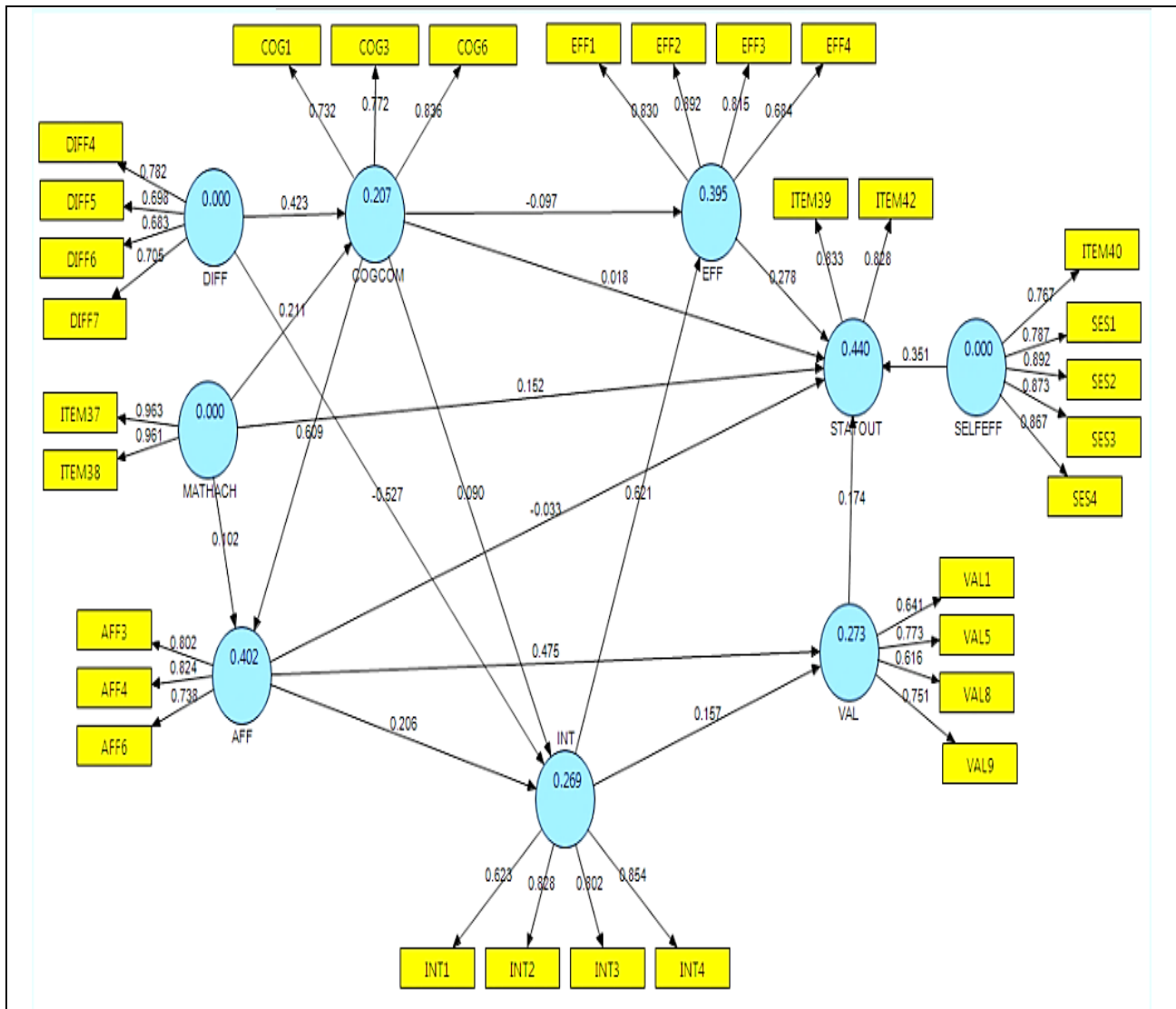


Figure 2 Evaluation of the measurement model SAT-41 (Outer loadings for each item)

In this study, the composite reliability coefficients of the constructs ranged from 0.791 to 0.961, which met the standard of 0.70 as suggested by Fornell and Larcker (1981) and Hulland (1999) thus indicating acceptable internal consistency and reliability of the respective measures. The factor loadings, indicator reliability ( $R^2$ ), Composite Reliability (CR) and Average Variance Extracted (AVE) values calculated by PLS algorithm are tabulated in table 3 below.

Latent Variable	Indicators	Loadings	Indicator Reliability $R^2$	Composite Reliability CR	AVE
Affect (AFF)	AFF3	0.802	0.402	0.831	0.622
	AFF4	0.824			
	AFF6	0.738			
Cognitive Competence (COGCOM)	COG1	0.732	0.207	0.824	0.61
	COG3	0.772			
	COG6	0.836			
	DIFF4	0.782			
Difficulty (DIFF)	DIFF5	0.698	-	0.809	0.516
	DIFF6	0.683			
	DIFF7	0.705			
Effort (EFF)	EFF1	0.83	0.395	0.882	0.654
	EFF2	0.892			
	EFF3	0.815			
	EFF4	0.684			
Interest (INT)	INT1	0.623	0.269	0.861	0.611
	INT2	0.828			
	INT3	0.802			
	INT4	0.854			
Mathematics Achievement (MATHACH)	ITEM37	0.963	-	0.961	0.926
	ITEM38	0.961			
Self-Efficacy (SELFEFF)	ITEM40	0.767	-	0.922	0.733
	SES1	0.787			
	SES2	0.892			
	SES3	0.873			
Statistics Outcome (STATOUT)	SES4	0.867	0.365	0.816	0.689
	ITEM39	0.829			
	ITEM42	0.831			
Value (VAL)	VAL1	0.642	0.273	0.791	0.488
	VAL5	0.773			
	VAL8	0.616			
	VAL9	0.751			

Table 3. Factor loadings, indicator reliability ( $R^2$ ), Composite Reliability (CR) and Average Variance Extracted (AVE)

Table 4. Discriminant Validity Result

	INT	AFF	COG COM	DIFF	EFF	MATH ACH	STAT OUT	VAL
INT	<b>0.782</b>							
AFF	0.155	<b>0.789</b>						
COG COM	0.006	0.626	<b>0.781</b>					
DIFF	-0.449	0.204	0.404	<b>0.718</b>				
EFF	0.621	0.091	-0.094	-0.428	<b>0.809</b>			
MATH ACH	0.238	0.207	0.172	-0.091	0.232	<b>0.962</b>		
STAT OUT	0.609	0.244	0.127	-0.289	0.472	0.413	<b>0.830</b>	
VAL	0.230	0.499	0.371	0.013	0.196	0.094	0.310	<b>0.699</b>

Diagonal elements are square roots of AVE

After validating the measurement model, convergent and discriminant validity in table 4, PLS bootstrapping (BT) algorithm in figure 3 was run to find out the t-value to investigate the relationships between latent variables. In Partial Least Squares (PLS) method, structural model and hypothesis were tested by computing path coefficients ( $\beta$ ).

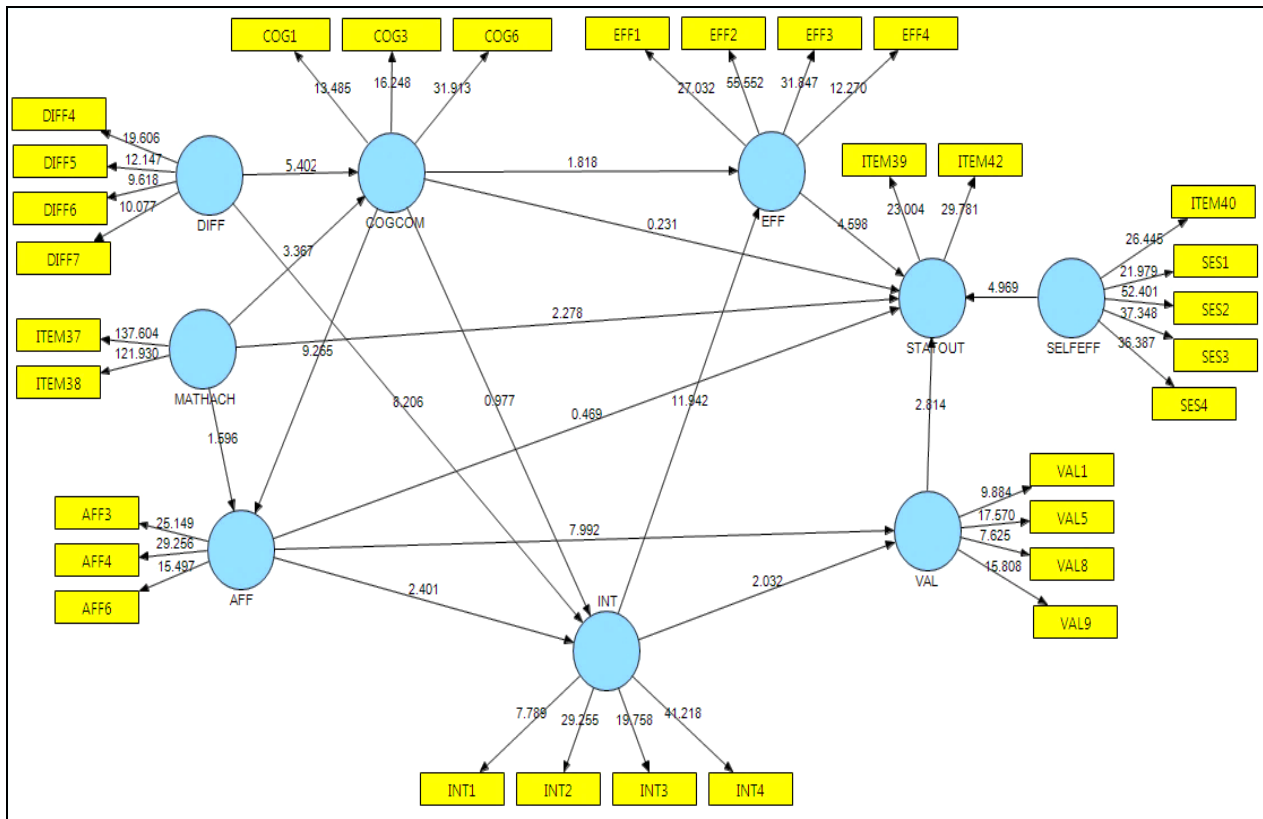


Figure 3. Bootstrapping model evaluation

Relationship	Hypothesis	Path coefficient	t-value	R <sup>2</sup>	Result Supported
AFF -> INT	H1 <sub>a</sub>	0.206	2.401*	0.269	Yes
AFF -> STATOUT	H1 <sub>b</sub>	-0.033	0.469	0.440	Not
AFF -> VAL	H1 <sub>c</sub>	0.475	7.992***	0.273	Yes
COGCOM -> AFF	H2 <sub>a</sub>	0.609	9.265***	0.402	Yes
COGCOM -> EFF	H2 <sub>b</sub>	-0.097	1.818	0.395	Not
COGCOM -> INT	H2 <sub>c</sub>	0.09	0.977		Not
COGCOM -> STATOUT	H2 <sub>d</sub>	0.018	0.231	-	Not
DIFF -> COGCOM	H3 <sub>a</sub>	0.423	5.402***	0.207	Yes
DIFF -> INT	H3 <sub>b</sub>	-0.527	8.206***		Yes
EFF -> STATOUT	H4 <sub>a</sub>	0.278	4.598***	-	Yes
INT -> EFF	H5 <sub>a</sub>	0.621	11.942***	-	Yes
INT -> VAL	H5 <sub>b</sub>	0.157	2.032*	-	Yes
MATHACH -> AFF	H6 <sub>a</sub>	0.102	1.596	-	Not
MATHACH -> COGCOM	H6 <sub>b</sub>	0.211	3.367***	-	Yes
MATHACH -> STATOUT	H6 <sub>c</sub>	0.152	2.279*		Yes
SELFEFF -> STATOUT	H7 <sub>a</sub>	0.351	4.969***		Yes
VAL -> STATOUT	H8 <sub>a</sub>	0.174	2.815**		Yes

t-values > 1.96\* (p < 0.05), t-values > 2.58\*\* (p < 0.01), t-values > 3.29\*\*\* (p < 0.001)

Table 5. Significance test on Path Coefficient (β), t-values, R<sup>2</sup> and Hypotheses

Based on Table 5, 12 positive strong relations were found. Therefore, H1<sub>a</sub>, H1<sub>c</sub>, H2<sub>a</sub>, H3<sub>a</sub>, H3<sub>b</sub>, H4<sub>a</sub>, H5<sub>a</sub>, H5<sub>b</sub>, H6<sub>b</sub>, H6<sub>c</sub>, H7<sub>a</sub> and H8<sub>a</sub> were accepted and support the hypotheses. It is also shown five paths are not significant. Hence, H1<sub>b</sub>, H2<sub>b</sub>, H2<sub>c</sub>, H2<sub>d</sub>, and H6<sub>a</sub> is not supported. It is shown that self-efficacy has positive relationship with statistic outcomes (SELFEFF->STATOUT). Hence, it supports the new model of Statistics Attitude-Outcomes Model (SAT-41).

## 6. DISCUSSION AND CONCLUSION

Partial Least Square (PLS) techniques were used to perform the data analysis to find the relationship of the proposed model “Statistics Attitude-Outcomes Model” -41 (SAOM-41).

Firstly, measurement model was determined. Confirmatory factor analysis (CFA) has been performed to validate the measurement model. From the proposed model, uni-dimensionality of each construct was maintained with CFA. The CFA resulted to correlate and eliminate some items from the proposed model. Hence, in this study the researcher use the benchmark of 0.50 recommended by Hulland (1996) was adopted for the retention of factors. An acceptable threshold for the loading according to Hair (2006) is 0.5 or above. The outer loadings based on table 3 ranged from 0.616 to 0.963 with 26 items.

Objective 1 : To conceptualize and empirically test a modified model on “Statistics Attitude-Outcomes Model” (SAOM-41).

To achieve the first objective, the researcher has studied and reviewed many models on student’s statistics outcomes on statistics subject. The researcher applied and modified the proposed model of “Statistics Attitude-Outcomes Model” -36 (SAOM-36) with addition of one variable known as self-efficacy which consists of 5 items. The new proposed model is known as “Statistics Attitude-Outcomes Model”-41 (SAOM-41). Hence this model was tested by using SmartPLS software. Under SmartPLS, measurement and structural model was analyzed to test the modified model.

Objective 2 : To test the measurement model for the proposed model with Confirmatory Factor Analysis (CFA) under Partial Least Square analysis.

To achieve the second objective, the researcher tested the measurement model for the proposed model by running the Confirmatory Factor Analysis (CFA). First there were seven variables with 41 components with mathematics achievement as exogenous variable (2 components) and statistics outcomes a dependent variable (4 components). After performing the CFA, the measurement model for all construct were modified and re-specified. The overall measurement model was seven variables with 31 components for measuring attitude, mathematics achievement with two components and statistics outcomes with two components. The measurement model reflected the reliability and validity of the observed variables. The result of

the loading illustrated that the overall measurement model data fit the proposed model. Hence, these findings answered the second research question.

Objective 3 : To test the structural model for the proposed model with Partial Least Square analysis.

The researcher tested the structural model for the proposed model by performing partial least square analysis to achieve the second third objective. Structural model and hypothesis were tested by computing path coefficients ( $\beta$ ) and t-value in partial least square (PLS). PLS bootstrapping (BT) algorithm was run to identify the t-values to determine the relationships between latent variables. The hypotheses results showed that there were 12 positive relationship affect and interest, affect and value, cognitive competence and affect, difficulty and cognitive competence, difficulty and interest, effort and statistics outcomes, interest and effort, interest and value, mathematics achievement and cognitive competence, mathematics achievement and statistics outcomes, self-efficacy and statistics outcomes and value and statistics outcomes.

Besides that, the researcher found five negative relationships between affect and statistics outcomes, cognitive competence and effort, cognitive competence and interest, cognitive competence and statistics outcomes and mathematics achievement and affect.

Objective 4 : To investigate the relationship between the latent variables(Attitude), mathematics achievement and statistics outcomes.

The researcher concluded that there were 12 positive relationships and 5 negative relationships from this study. The hypotheses results showed that :-

- a) Affect has positive relationship with interest and value but not with statistics outcomes. The relationship of affect with value is significant with the previous study Emmioglu et al., (2011) but the relationship between affect and statistics outcomes was contrary to the previous researcher. From this study, the researcher found that, when students have positive effect towards statistics, their interest and value on the subject increase and they can score higher in terms of their statistics outcomes.
- b) Cognitive competence has only one positive relationship with affect and negative relationships with interest, effort and statistics outcomes. This finding supported the “Statistics Attitude-Outcomes Model” and Bude’ et al (2007). Hence when higher the students’ cognitive competence in statistics, the higher they have positive affect toward statistics.

- c) Difficulty has positive relationship with interest and cognitive competence. When students overcome their difficulties in statistics, hence they will have lots of interest and increase their cognitive competence towards statistics. This finding was aligned with “Statistics Attitude-Outcomes Model”.
- d) Effort has positive relationship with statistics outcomes. When students’ put more effort in statistics, hence their statistics outcomes increased.
- e) Interest has positive relationship with effort and value. The researcher found that when students have interest in statistics, they put more effort on the subject and valued more on statistics subject.
- f) Mathematics achievement has positive relationship with cognitive competence and negative relationship with affect. This two findings were contrary to the “Statistics Attitude-Outcomes Model” and previous study Emmioglu et al., (2010). From this study, the researcher found that mathematics achievement has positive relationship with statistics outcomes. Hence, the researcher found that when students’ have high mathematics achievement, hence their cognitive competence or students’ perceptions about their intellectual skills and knowledge on statistics will increase. Finally, this will help students’ to achieve high statistics outcomes in statistics.
- g) Self-efficacy has a positive relationship with statistics outcomes. Self-efficacy refers to the student’s belief in his or her ability to understand and carry out statistical tasks. On the basic theory, the present research assumes that when one’s self-efficacy towards statistics is high, hence they will have high confidence level in mastering the subject. With such a positive self-efficacy, this will simultaneously affect students’ behaviour to work hard on statistics. Hence, it is expected that students’ will achieve positive result in statistics outcomes.
- h) Lastly, value has positive relationship with statistics outcomes which supported the previous model of “Statistics Attitude-Outcomes Model”. This showed that, the more students’ valued statistics, the higher their statistics outcomes were. Hence, this finding was consistent with Eccles’ model.

The current study was undertaken with non-statistics students from public universities in Kuala Terengganu. The current study showed that students’ relationships among students’ mathematics achievement (self-reported past and overall achievement) and attitudes play a crucial role in explaining students’ statistics outcomes in statistics. Students’ with positive attitudes towards statistics should be among the main goals of statistics education and accordingly, a



statistics curriculum should involve various instructional practices. It will enhance students' positive attitude towards statistics. Besides that, the researcher suggested that statistics educators should be trained and informed on the importance of the students' attitude and how to implement and evaluate the instruction in a way to enhance students' positive attitude towards statistics.

Statistics is an important tool for any individual who adapt himself/herself to the ever-changing world in which numerical data are increasing presented (Ben-Zvi& Garfield, 2010). However, there has been little attempt to attract students to statistics for many years (Gal & Ginsburg, 1994;Snee, 1993). Hence, students from a broad spectrum of disciplines especially in higher education ought to take statistics courses. According to methods (Acee& Weinstein, 2010), it is suggested statistics teachers adopt appropriate instructional methods such as value-reappraisal to enhance students' awareness about the importance of statistics both in professional and daily life; and therefore, help to increase students' appreciation and valuing of statistics. It is also suggested for statistics teachers to employ statistics activities that are interesting, enjoyable and fun for students to participate which would help students to have more interest and positive affect toward statistics (Berk& Nanda, 1998; Lesser & Pearl, 2008; Milburn, 2007). Statistics educators should be aware of the students' perceptions on their capabilities in statistics and deliver the instruction appropriately to the level of students.

Since attitudes towards statistics is important, researcher suggested that policy makers, statistics educator, educational practitioners should assess the students' attitudes towards statistics by evaluating the effectiveness of their statistics instruction in relations of cultivating students' positive attitudes. People forget what they do not use, but attitudes "stick" as stated Emmioglu (2011). With positive attitudes, it keeps us using what we had learned and encourages us to search for opportunities to learn more.

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**TABLES**

Table1. Cronbach’s alpha reliability of the overall measure

Cronbach’s Alpha	No of Items
0.852	44

Table 2. Descriptive Statistics for Study Variables

Construct	Observed Variable	Mean	s.d.	Skewness	Kurtosis
Effort	I plan to complete all of my statistics assignments.	5.52	1.392	-0.989	1.127
	I plan to work hard in my statistics course.	5.50	1.421	-1.027	1.003
	I plan to study hard for every statistics test.	5.19	1.400	-0.766	0.446
	I plan to attend every statistics class session.	5.43	1.396	-0.830	0.491
Affect	I will like statistics.	4.95	1.508	-0.695	0.231
	I will feel insecure when i have to do statistics problems.	3.50	1.498	0.356	-0.074
	I will get frustrated going over statistics tests in class.	3.88	1.497	0.130	-0.204
	I will be under stress during statistics class.	4.16	1.477	-0.109	-0.340
	I will enjoy taking statistics course.	4.41	1.252	-0.108	0.364
	I am scared by statistics.	4.29	1.645	-0.020	-0.639
Cognitive Competence	I will have trouble understanding statistics because of how i think.	3.68	1.544	1.544	-0.299
	I will have no idea of what's going on in this statistics course.	4.23	1.469	1.469	0.010
	I will make a lot of math errors in statistics.	3.99	1.511	1.511	-0.449
	I can learn statistics.	5.32	1.272	1.272	1.061
	I will understand statistics equations.	4.95	1.368	1.368	0.618
	I will find it difficult to understand statistical concepts.	3.82	1.423	1.423	0.144
Difficulty	Statistics formulas are easy to understand.	4.38	1.506	1.506	-0.134
	Statistics is a complicated	3.90	1.572	1.572	-0.394

	subject.				
	Statistics is a subject quickly learned by most people.	4.25	1.471	1.471	-0.057
	Learning statistics requires a great deal of discipline.	3.12	1.457	1.457	0.484
	Statistics involves massive computations.	3.49	1.219	1.219	0.676
	Statistics is highly technical.	3.38	1.249	1.249	0.455
	Most people have to learn a new way of thinking to do statistic.	3.13	1.299	1.299	0.371
Value	Statistics is worthless.	4.80	1.603	1.603	-0.819
	Statistics should be required part of my professional training.	4.50	1.436	1.436	0.046
	Statistical skills will make me more employable.	4.83	1.338	1.338	0.202
	Statistics is not useful to the typical professional.	5.10	6.212	14.317	217.201
	Statistical thinking is not applicable in my life outside my job.	4.24	1.508	1.508	-0.223
	I use statistics in my everyday life.	3.88	1.437	1.437	0.000
	Statistics conclusions are rarely presented in everyday life.	3.52	1.249	1.249	0.359
	I will have no application for statistics in my profession.	4.16	1.383	1.383	0.220
	Statistics is irrelevant in my life.	4.34	1.416	1.416	0.021
Interest	I am interested in being able to communicate statistical information to others.	4.47	1.404	1.404	0.329
	I am interested in using statistics.	4.48	1.338	1.338	0.380
	I am interested in understanding statistical information.	4.55	1.280	1.280	0.761
	I am interested in learning statistics.	4.73	1.455	1.455	0.257
Math Achievement	Did you do well in your past mathematics course.	5.09	1.437	1.437	0.318
	Are you good at mathematics?	4.91	1.386	1.386	-0.101



Self-Efficacy	I am confident that I understand basic statistics concepts.	4.66	1.353	1.353	0.320
	I am confident that I can correctly interpret the meaning of the correlation coefficient $r$ for two variables in a set of data.	4.25	1.301	1.301	0.391
	I am confident that I can correctly use a linear regression equation to make predictions.	4.33	1.234	1.234	0.651
	I am confident that I can correctly identify the null and alternative hypotheses in preparation for conducting a t-test.	4.18	1.184	1.184	1.231
	Are you confident that you can master introductory statistics topics?	4.13	1.490	1.490	-0.076
Statistics Outcome	Will you use statistics in your future job?	4.32	1.419	1.419	0.126
	If you were given a choice to choose a course, will you select statistics.	3.46	1.698	1.698	-0.779

Table 3. Factor loadings, indicator reliability ( $R^2$ ), Composite Reliability (CR) and Average Variance Extracted (AVE)

Latent Variable	Indicators	Loadings	Indicator Reliability $R^2$	Composite Reliability CR	AVE
Affect (AFF)	AFF3	0.802	0.402	0.831	0.622
	AFF4	0.824			
	AFF6	0.738			
Cognitive Competence (COGCOM)	COG1	0.732	0.207	0.824	0.61
	COG3	0.772			
	COG6	0.836			
Difficulty (DIFF)	DIFF4	0.782	-	0.809	0.516
	DIFF5	0.698			
	DIFF6	0.683			
Effort (EFF)	DIFF7	0.705	0.395	0.882	0.654
	EFF1	0.83			
	EFF2	0.892			
Interest (INT)	EFF3	0.815	0.269	0.861	0.611
	EFF4	0.684			
	INT1	0.623			
Mathematics Achievement (MATHACH)	INT2	0.828	-	0.961	0.926
	INT3	0.802			
	INT4	0.854			
Self-Efficacy (SELFEFF)	ITEM37	0.963	-	0.922	0.733
	ITEM38	0.961			
	ITEM40	0.767			
Statistics Outcome (STATOUT)	SES1	0.787	0.365	0.816	0.689
	SES2	0.892			
	SES3	0.873			
Value (VAL)	SES4	0.867	0.273	0.791	0.488
	ITEM39	0.829			
	ITEM42	0.831			
	VAL1	0.642			
	VAL5	0.773			
	VAL8	0.616			
	VAL9	0.751			

Table 4. Discriminant Validity Result

	INT	AFF	COG COM	DIFF	EFF	MATH ACH	STAT OUT	VAL
<b>INT</b>	<b>0.782</b>							
<b>AFF</b>	0.155	<b>0.789</b>						
<b>COG COM</b>	0.006	0.626	<b>0.781</b>					
<b>DIFF</b>	-0.449	0.204	0.404	<b>0.718</b>				
<b>EFF</b>	0.621	0.091	-0.094	-0.428	<b>0.809</b>			
<b>MATH ACH</b>	0.238	0.207	0.172	-0.091	0.232	<b>0.962</b>		
<b>STAT OUT</b>	0.609	0.244	0.127	-0.289	0.472	0.413	<b>0.830</b>	
<b>VAL</b>	0.230	0.499	0.371	0.013	0.196	0.094	0.310	<b>0.699</b>

Diagonal elements are square roots of AVE

Table 5. Significance test on Path Coefficient ( $\beta$ ), t-values,  $R^2$  and Hypotheses

Relationship	Hypothesis	Path coefficient	t-value	$R^2$	Result Supported
AFF -> INT	H1 <sub>a</sub>	0.206	2.401*	0.269	Yes
AFF -> STATOUT	H1 <sub>b</sub>	-0.033	0.469	0.440	Not
AFF -> VAL	H1 <sub>c</sub>	0.475	7.992***	0.273	Yes
COGCOM -> AFF	H2 <sub>a</sub>	0.609	9.265***	0.402	Yes
COGCOM -> EFF	H2 <sub>b</sub>	-0.097	1.818	0.395	Not
COGCOM -> INT	H2 <sub>c</sub>	0.09	0.977		Not
COGCOM -> STATOUT	H2 <sub>d</sub>	0.018	0.231	-	Not
DIFF -> COGCOM	H3 <sub>a</sub>	0.423	5.402***	0.207	Yes
DIFF -> INT	H3 <sub>b</sub>	-0.527	8.206***		Yes
EFF -> STATOUT	H4 <sub>a</sub>	0.278	4.598***	-	Yes
INT -> EFF	H5 <sub>a</sub>	0.621	11.942***	-	Yes
INT -> VAL	H5 <sub>b</sub>	0.157	2.032*	-	Yes
MATHACH -> AFF	H6 <sub>a</sub>	0.102	1.596	-	Not
MATHACH ->	H6 <sub>b</sub>	0.211	3.367***	-	Yes

COGCOM					
MATHACH -> STATOUT	H6 <sub>c</sub>	0.152	2.279*		Yes
SELFEFF -> STATOUT	H7 <sub>a</sub>	0.351	4.969***		Yes
VAL -> STATOUT	H8 <sub>a</sub>	0.174	2.815**		Yes

t-values > 1.96\* (p < 0.05), t-values > 2.58\*\* (p < 0.01), t-values > 3.29\*\*\* (p < 0.001)

### FIGURES

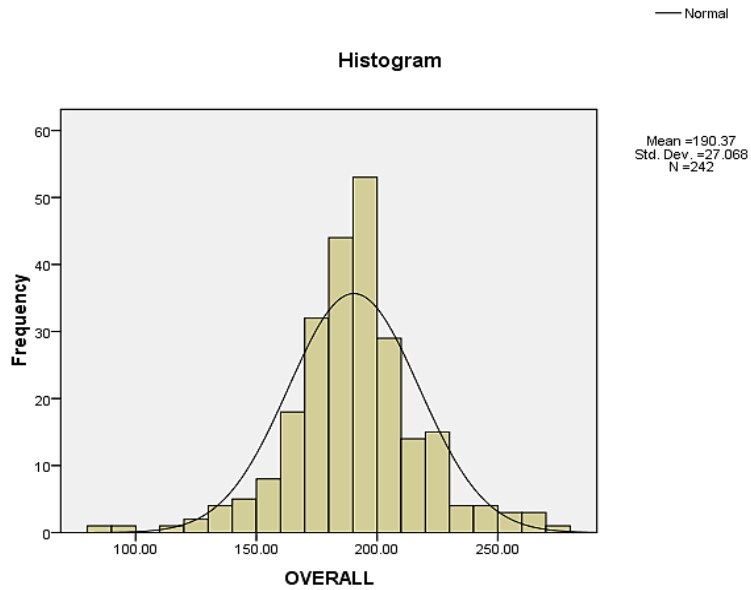


Figure 1. Overall view of skewed distribution “Statistics Attitude-Outcomes Model-41”

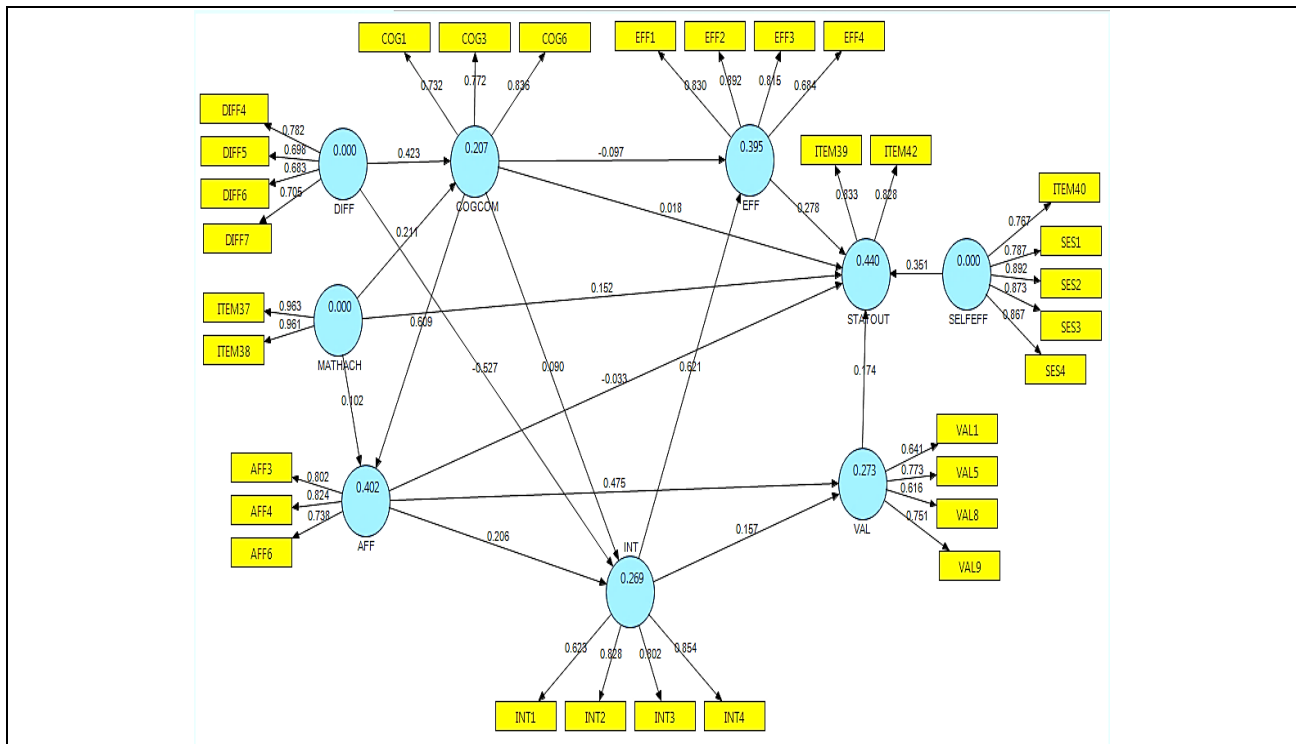


Figure 2 Evaluation of the measurement model SAT-41 (Outer loadings for each item)

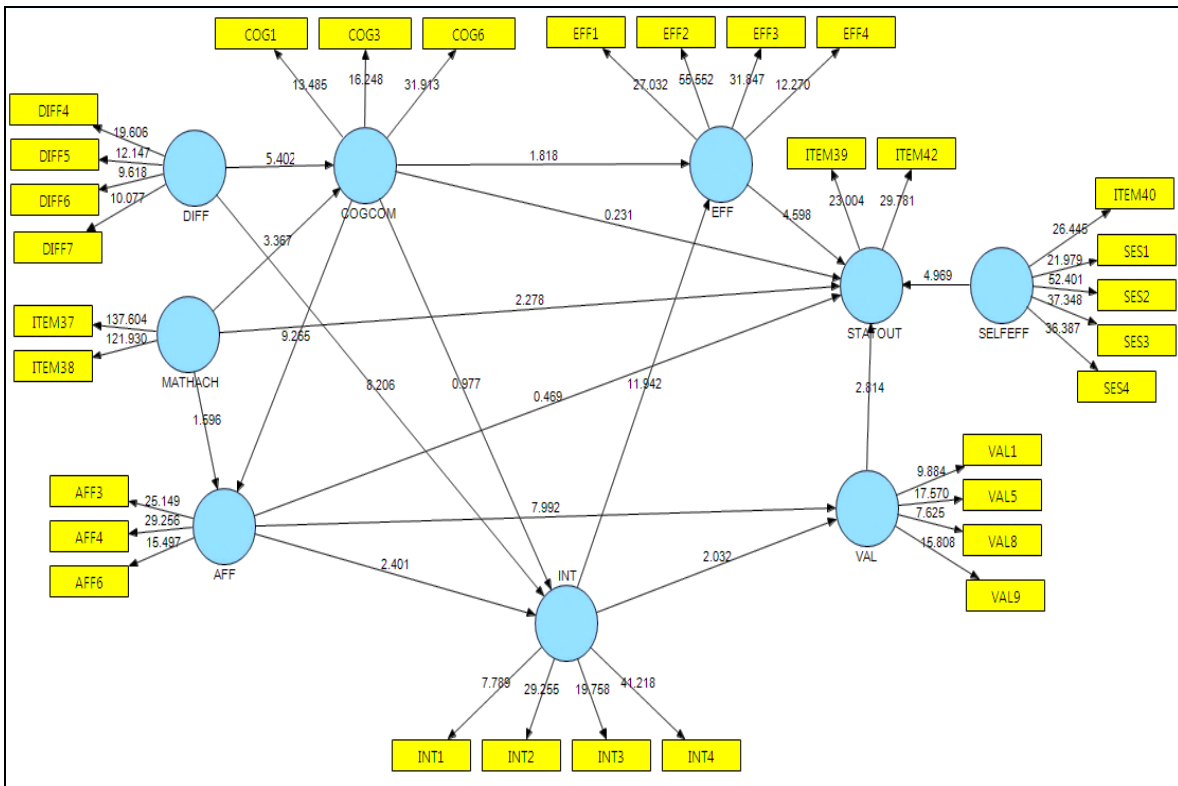


Figure 3. Bootstrapping model evaluation