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# The Development of a Structural Equation Model of Graduate Students' Statistics Achievement

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The aim of this research was to test the hypothesized model of the effects of attitudes towards statistics, statistics anxiety and teaching quality on graduate students' statistics achievement. The samples were 246 Master's degree students who registered in the course of statistics for research that the researcher taught in two universities, one public university and one private university in Thailand. Multi-stage random sampling was used and data was collected through a test, a survey of the attitudes towards statistics (SATS), statistical anxiety rating scale (STARS) and a course experience questionnaire (CEQ). The structural model (SEM) was used in data analysis. The results showed that the structural equation model of graduate students' statistics achievement had a good fit with the empirical data. The statistical values were Chi-square ($\chi^2$) = 187.87, $df$ = 176, $\chi^2/df$ = 1.07, $p$-value = 0.26, $RMSEA$ = 0.02, $RMR$ = 0.02, $GFI$ = 0.93, $AGFI$ = 0.91, and $CFI$ = 0.99. From the validated model, the attitudes towards statistics and teaching quality had a significantly positive direct effect on statistics achievement. Besides this, the statistics anxiety had a significantly negative direct effect on statistics achievement. Furthermore, teaching quality had an indirect effect on statistics achievement, which was mediated by attitudes towards statistics and statistics anxiety. The attitudes towards statistics, statistics anxiety, and teaching quality accounted for the 53% variances in the graduate students' statistics achievement. As a result, these findings could be used for teaching and learning management in the subject of statistics at the graduate level.

***Keywords:*** structural equation modeling, statistics achievement**,** attitudes towards statistics, statistics anxiety, teaching quality, graduate students

The teaching and learning management at graduate level of education focuses on study, exploration, investigation, and creative research to generate a novel body of knowledge. Learners will cultivate their academic contributions, research work or thesis with scientific methods to find out the answers to resolve academic enquiries. One of the most important steps in research findings is data analysis; therefore, graduate-level students must understand statistics which is used to analyze statistical data in research methodology, especially quantitative–based research. The Thai graduate-level education management has established statistics into the curriculum to have become a compulsory subject, which has also been placed into the research methodology subject in science and technology, arts, humanities and social sciences for graduate-level students to understand and use statistics. Therefore, statistics is an important and essential course which graduate-level students must take because it is an important tool for any individual in today's world in which numerical data is increasingly presented (Ben-Zvi & Garfield, 2010).

Chiesi and Primi (2010) indicated that an important problem of management of education in statistics is the students' low levels of performance in statistics achievement because of individual differences of their knowledge background in mathematics and statistics. The low mathematical and statistical knowledge background in students has revealed negative attitudes towards statistics, based on the perception that it is a complex and

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difficult subject to understand and registering the statistics course makes them stressed which increases their high levels of anxiety. Research results by Mohamed, Ashaari, Judi, and Wook (2012) showed that in learning a statistics course, students are forced to deal with complicated formula which makes them feel under a lot of pressure and they tend to find it difficult to understand certain concepts. In support of this, Onwuegbuzie (2003) undertook research which showed that 66-80% of graduate students experienced uncomfortable levels and worry levels of statistics anxiety. Deep or intense statistics anxiety is experienced by many graduate students and it can affect their refusal to enroll onto statistics courses or delaying enrollment onto these courses as long as possible. Some delayed to take these courses until the final semester of their degree.

For the practical reasons mentioned above, the researcher was interested in studying the variables that had an effect on the graduate students' statistics achievement. Onwuegbuzie (2003) studied modeling statistics achievement among graduate students and found that statistics anxiety, teaching quality and classroom environment had a significantly direct and indirect effect on graduate students' statistics achievement. Besides that research, Watson et al. (2004) found that anxiety and attitudes in statistics had an effect on graduate students' statistics achievement. Moreover, Emmioglu and Capa-Aydin (2012) conducted research synthesis to address the effect of attitudes on statistics achievement by meta-analysis and found that attitudes towards statistics had strongly affected the overall statistics achievement. Therefore, attitudes towards statistics, statistics anxiety, and teaching quality were considered to be the variables that have an effect on graduate students' statistics achievement. As a result, the researcher chose these three predictive variables to do this specific research project.

Attitudes towards statistics, statistic anxiety, teaching quality, and statistics achievement are latent variables that correspond to abstract concepts. Therefore, the latent variables can be inferred from observable variables which can be directly measured. The four observable variables to measure attitudes towards statistics are: 1) affect; 2) cognitive competence; 3) value; and 4) difficulty in using the instrument called the Survey of Attitudes Towards Statistics (SATS) (Schau, Stevens, Dauphinee, & Del Vecchio, 1995). The three observable variables to measure statistics anxiety are: 1) interpretation anxiety; 2) a test and class anxiety; and 3) the fear of asking for help, using the instrument called the Statistical Anxiety Rating Scale (STARS) (Baloglu, 2002; Cruise, Cash, & Bolton, 1985). Teaching quality could be measured by using these six observable variables: 1) teaching; 2) skills development; 3) appropriate assessment; 4) appropriate workload; 5) clear goals and standards; and 6) the academic environment by using the Course Experience Questionnaire (CEQ) (Mclnnis, Griffin, James, & Coates, 2001; Ramsden, 1991) as an assessment instrument. Besides these approaches, statistics achievement could also be measured by the course assessment divided into the mid-term examination to assess descriptive statistics and the final examination to assess inferential statistics (Chiesi & Primi, 2010). Moreover, these three predictive variables directly and indirectly influence the statistics achievement of graduate students. Therefore, the researcher became very interested in testing the causal relationships model among all these three variables in the structural equation model of graduate students' statistics achievement.

This study will create knowledge in the field of educational statistics because it includes various important variables affecting statistics achievement in the model, including the pre- and post- attitudes towards statistics, the pre- and post- statistics anxiety, and the level of teaching quality used. Moreover, this study will also show any changes of the effects

from pre-attitudes towards statistics and anxiety to the post-attitudes towards statistics and anxiety, by using teaching quality as a mediated variable that past researchers have not studied yet. Besides those factors, this study will also use Structural Equation Modeling (SEM) in the analysis. Furthermore, the results can be used to direct the development process of teaching and learning management for graduate students in statistics as well as students' statistics achievement.

## Literature Review and Conceptual Framework

### Statistics Achievement

Statistics is the science of collecting, organizing, analyzing, interpreting, and presenting data (Zikmund, Babin, Carr, & Griffin, 2010). The content of Statistics for research at the graduate level of education has two components: 1) descriptive statistics (frequency distributions, central tendency and measure of dispersion); and 2) inferential statistics (z-test, t-test, analysis of variance, correlation, chi-square test and regression analysis). Statistics achievement was assessed by using a test.

### Factors Affecting Statistics Achievement

There are many factors affecting statistics achievement, both directly and indirectly. The researcher reviewed past research projects that had studied variables related to students' statistics achievement. Supsopha (2008) had studied factors affecting graduate students' statistics achievement in the faculty of education at Chulalongkorn University, Thailand and the results had found that student factors, instructor factors, and educational environment factors, and statistics anxiety had direct effects on graduate students' statistics achievement. Emmioglu and Capa-Aydin (2012) had synthesized the research topics about the attitude affecting statistics achievement by meta-analysis and found that attitudes towards statistics had strongly affected statistics achievement. This was consistent with Sorge and Schau (2002), who had found that the engineering students' attitudes had affected their achievement in statistics. Also, research by Chiesi and Primi (2010) had studied about the cognitive and non-cognitive factors related to students' statistics achievement and found that attitudes towards statistics and statistics anxiety had affected the statistics achievement. Besides this, the research results from Bandalos, Finney, and Geske (2003) found that statistics anxiety had also affected undergraduate students' statistics achievement. Furthermore, teaching and learning strategies, teaching quality, and the classroom environment had an effect on statistics achievement. This was supported by Budé, Imbos, Van De Wiel, Broers, and Berger (2009) who had studied the effect of directive tutor guidance in problem-based learning of statistics on the students' perceptions and achievement. Also, Collins and Mittag (2005) had studied the effect of calculator technology on student achievement in an introductory statistics course. Moreover, Schroeder, Scott, Tolson, Huang, and Lee (2007) had synthesized the research area about the effects of teaching strategies on student achievement in science in the United States by meta-analysis and had found that high teaching quality affected high learning achievement. However, in studies with graduate students (Onwuegbuzie, 2003; Watson et al., 2004), the results found that attitudes towards statistics, statistics anxiety and teaching quality had an effect on graduate students' statistics achievement. Therefore, the researcher selected these three variables as the predictive variables in this specific research study.

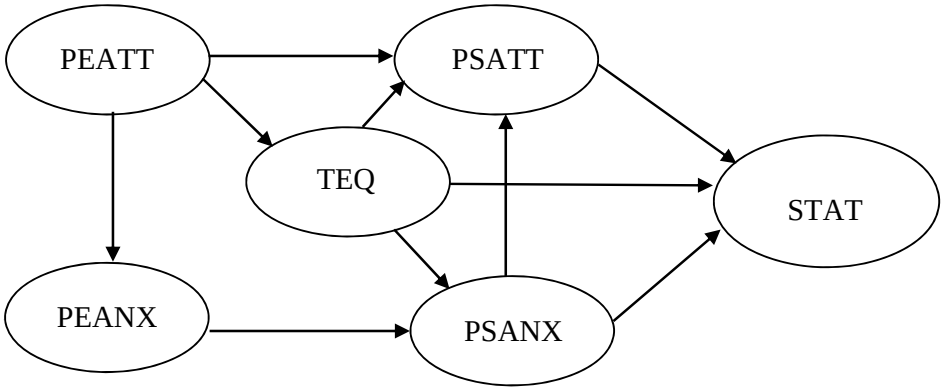
Onwuegbuzie (2003) found that pre-course attitudes towards statistics affected the post-course attitudes towards statistics and statistics anxiety. Besides that, the pre-course statistics anxiety affected post-course attitudes towards statistics and post-course statistics anxiety. The attitudes and anxiety associated with statistics have also led to the development and implementation of programs designed to address the problem. Added to that, Hattie (2009) had synthesized the research about the factors that relate to the achievement and the results found that qualified learning management could affect better achievement, positive attitude, and reduced anxiety in studying. Therefore, teachers should develop teaching quality, promote motivation, and enhance their efforts to make students understand statistics and create an exciting academic environment in the classroom.

From reviewing the previous work by Cashin and Elmore (2005), Chiesi and Primi (2009), Sorge and Schau (2002), Watson et al. (2004), the researcher of this project found that the Survey of Attitudes Toward Statistics (SATS) developed by Schau et al. (1995) was used as an instrument to assess the attitudes towards statistics and assessed the four components of: 1) affect; 2) cognitive competence; 3) value; and 4) the potential difficulty. Affect measured the positive and negative feelings concerning statistics. Cognitive competence measured the students' attitudes about their intellectual knowledge and skills when applied to statistics. Value measured the attitudes about the usefulness, relevance, and worthiness of statistics in personal and professional life. Potential difficulty measured the students' attitudes concerning the difficulty of statistics as a subject. From reviewing the work of Baloglu (2002), Chiesi and Primi (2010), Mohamed et al. (2012), Onwuegbuzie (2000), Onwuegbuzie, Slate, Paterson, Watson, and Schwartz (2000), Watson et al. (2004), the researcher found that the Statistics Anxiety Rating Scale (STARS) developed by Cruise et al. (1985) was used as an instrument to assess statistics anxiety and assessed three components: 1) interpretation anxiety; 2) test and class anxiety; and 3) fear of asking for help. Interpretation anxiety is concerned with any anxiety experienced when students are faced with making a decision about, or interpreting, statistical data. Test and class anxiety referred to the anxiety involved when taking a statistical class or test. Fear of asking for help measured the anxiety experienced when asking a fellow student or a teacher for help in understanding specific course content.

From the work undertaken by Byrne and Flood (2003) and Downie and Moller (2002), the researcher found that the Course Experience Questionnaire (CEQ), developed by Mclnnis et al. (2001) and Ramsden (1991), was used as an instrument to assess teaching quality and assessed six components: 1) teaching; 2) skills development; 3) appropriate assessment; 4) appropriate workload; 5) clear goals and standards; and 6) the academic environment. The CEQ measurements provided helpful feedbacks, motivation, efforts to make students understand the subject easier, work hard to make the subject interesting, put a lot of time to be concerned with students individually, using appropriate assessment and appropriate workload, set clear goals and standards, and create an academic environment in the classroom.

From reviewing a comprehensive range of literature about the different factors affecting graduate students' statistics achievement, the researcher found that the attitudes towards statistics and statistics anxiety that both directly and indirectly affected statistics achievement and attitudes towards statistics, had an effect on statistics anxiety (Bandalos et al., 2003; Mohamed et al., 2012). It was also noted that the pre–course attitudes affected anxiety and post–course attitudes and pre–course attitudes had an indirect effect on statistics achievement which was mediated by anxiety and post–course attitudes (Chiesi & Primi,

2010; Watson et al., 2004). Teaching quality (teaching and learning strategies, learning management, and classroom environment) affected the statistics achievement (Budé et al., 2009; Collins & Mittag, 2005; Schroeder et al., 2007). Furthermore, teaching quality had an indirect effect on statistics achievement which was mediated by the attitudes towards statistics and the statistical anxiety (Onwuegbuzie, 2003). Therefore, all causal relationships among the variables were a structural equation model of graduate students' statistics achievement (conceptual framework in this study). In the model, the exogenous latent variable was the pre–course attitudes towards statistics and the endogenous latent variable was the post–course attitudes towards statistics, the pre- and post–course statistics anxiety, teaching quality and graduate students' statistics achievement, as shown in Figure 1 below.




*Note.* PEATT=Pre–course attitudes towards statistics; PSATT=Post–course attitudes towards statistics; PEANX=Pre–course statistics anxiety; PSANX=Post–course statistics anxiety; TEQ=Teaching quality; STAT=Statistics achievement.

*Figure 1.* Conceptual Framework.

**Research Hypothesis**

In order to remain consistent with related literature in this field, this research project tested the following hypotheses:

$H_1$: Attitudes towards statistics, statistics anxiety, and teaching quality have an effect on graduate students' statistics achievement.

$H_2$: The pre-course attitudes towards statistics, statistics anxiety, and teaching quality have an effect on graduate students' post-course attitudes towards statistics.

$H_3$: The pre-course attitudes towards statistics, pre-course statistics anxiety, and teaching quality have an effect on graduate students' post-course statistics anxiety.

$H_4$: The pre-course attitudes towards statistics have an effect on graduate students' post-course statistics anxiety and teaching quality.

## Methodology

**Target Population and Sample**

The target population considered in this study was the total number of graduate students in a Master's degree program who had registered on the course of statistics for research that the researcher taught in semester 1 and 2 of the year 2014 (August, 2014–May, 2015) in two universities in Thailand (one public university and one private university).

Cross-sectional survey with multi-stage random sampling design method was used in this study. At the first stage, a stratified random sampling technique by type of university was used. At the second stage, cluster random sampling technique by classroom section was used in selecting students from each university. Therefore, 5 from 7 class groups were selected in the public university and 2 from 3 class groups were selected in the public university. The overall sample included 246 graduate students studying in a Master's degree program from two universities. The sample size had been determined based on the criteria established by Hair, Black, Babin, and Anderson (2010) who had suggested that the size of the sample should be 10 times the number of the observed variables. In this study, there were 22 observed variables.

**Research Instruments and Data Collection**

The Research Instruments used in this study consisted of the Statistics test and three questionnaires – 1) the Survey of Attitudes Towards Statistics (SATS); 2) the Statistics Anxiety Rating Scale (STARS); and 3) the Course Experience Questionnaire (CEQ). SATS, STARS, and CEQ were translated from the English version into a Thai language version by using the process of translation and adaptation of instruments. First, the forward translation (from English to Thai) was conducted and then a back-translation (from Thai to English) was performed by an English expert. Following that, a pre-testing pilot session with three graduate students was undertaken in order to check the accurate language understanding was used, and to make any improvement for the instrument into the final version.

The researcher checked content validity of the instruments by analyzing the index of item-objective congruence (IOC) derived from three experts in statistics and two experts in measurement and evaluation. Any difficulty, discrimination, and reliability was analyzed from 32 graduate students who had registered on the course of statistics for research that the researcher taught in semester 2 of the academic year 2013 (November, 2013–March, 2014).

1) The Survey of Attitudes Towards Statistics (SATS) was used as an instrument to assess the student's attitudes towards statistics. The researcher adapted the SATS developed by Schau et al. (1995). The revised scale of SATS contained 28 items using 5-point scales ranging from 'Strongly disagree' to 'Strongly agree.' The SATS assessed four specific components: 1) affect (positive and negative feelings concerning statistics); 2) cognitive competence (students' attitudes about their intellectual knowledge and skills when applied to statistics); 3) value (attitudes about the usefulness, relevance, and worthiness of statistics in personal and professional life); and 4) difficulty (students' attitudes about the difficulty of statistics as a subject). The SATS had an IOC between 0.80–1.00 and Cronbach's alpha was estimated to be 0.87 (details of the Cronbach's alpha in each component is shown in Table 1). The SATS had solid sections to guarantee the content validity and reliability. The SATS was used at the beginning of the course (to assess pre-course attitudes) and again at the end of the course (to assess post- course attitudes).

2) The Statistics Anxiety Rating Scale (STARS) was used as an instrument to assess any statistics anxiety. The researcher adapted the STARS developed by Baloglu (2002) and Cruise et al. (1985). The revised scale of STARS contained 23 items using a 5-point scale ranging from 'No anxiety' to 'Very much anxiety.' The STARS assessed three components: 1) interpretation anxiety (anxiety experienced when students were faced with making a decision about, or interpreting, statistical data); 2) test and class anxiety (anxiety involved when taking a statistics class or test); and 3) the fear of asking for help (anxiety experienced

when asking a fellow student or a teacher for help in understanding specific course content). The STARS had an IOC between 0.80–1.00 and the Cronbach's alpha was estimated to be 0.82 (details of the Cronbach's alpha in each component is shown in Table 1). The STARS had solid sections to guarantee the content validity and reliability. The STARS was used at the beginning of the course (to assess pre-course anxiety) and again at the end of the course (to assess post-course anxiety).

Table 1

*Reliability in Observed Variables in this Study*

| Observed variables | Cronbach's alpha |
|---|---|
| Attitudes towards statistics | |
| Affect | 0.70 |
| Cognitive competence | 0.72 |
| Value | 0.79 |
| Difficulty | 0.77 |
| Statistics anxiety | |
| Interpretation anxiety | 0.77 |
| Test and class anxiety | 0.71 |
| Fear of asking for help | 0.72 |
| Teaching quality | |
| Teaching | 0.74 |
| Skills development | 0.73 |
| Appropriate assessment | 0.70 |
| Appropriate workload | 0.71 |
| Clear goals and standards | 0.72 |
| Academic environment | 0.76 |

3) The Course Experience Questionnaire (CEQ) was used as an instrument to assess the teaching quality. The researcher adapted the CEQ developed by Mclnnis et al. (2001) and Ramsden (1991). The revised scale of CEQ contained 30 items using a 5-point scale ranging from 'Strongly disagree' to 'Strongly agree'. The CEQ assessed six components: 1) teaching (students' perception of the lecturer in giving helpful feedback, motivation to do the best work, making an effort to understand difficulties, making the topics interesting, and putting a lot of time into commenting on the assignments); 2) skills development (students' perception of the course in developing the ability to study, sharpening analytical skills, tackling unfamiliar problems, developing problem-solving skills, and improving skills in written communication); 3) appropriate assessment (students' perception of the lecturer in testing what students understood more than what the student memorized); 4) appropriate workload (students' perception of the workload in giving enough time to understand the things students have to learn); 5) clear goals and standards (students' perception of the lecturer in explaining a clear objective of learning in the statistics course); and 6) the academic environment (students' perception of the course in providing intellectual stimulation, supporting students in their learning, using information technology to help students to learn). The CEQ had an IOC between 0.80 - 1.00 and the Cronbach's alpha was estimated to be 0.84 (details of the Cronbach's alpha in each component is shown in Table 1). The CEQ had solid sections to guarantee the content validity and reliability. The CEQ was used at the end of the course.

4) Examinations to assess statistics achievement in Statistics for a research course were used on two occasions: In the mid-term assessment test to assess the descriptive statistics and at the final assessment test to assess inferential statistics. Both examinations were a test consisting of 30 multiple-choice questions (one correct out of five alternatives). Each task scored either 1 (correct) or 0 (incorrect). The mid-term test had an IOC between 0.80–1.00; difficulty was between 0.34–0.72; discrimination was between 0.26–0.58; and Kuder Richardson-20 was estimated to be 0.83. The final test had an IOC between 0.80–1.00; difficulty between 0.28–0.64; discrimination between 0.34–0.68; and Kuder Richardson-20 was estimated to be 0.76. Therefore, both the mid-term and final examinations had solid sections to guarantee the content validity, difficulty, discrimination and reliability. The researcher used the same midterm and final exam with graduate students in both universities**.**

### Data Analysis

The first step in the analysis used descriptive statistics for the attitudes towards statistics, statistics anxiety, teaching quality and statistics achievement. Thereafter, the correlation was used to analyze the relationship between the attitudes towards statistics, statistics anxiety, teaching quality and statistics achievement and check for any multicollinearity problem. The structural equation model by the AMOS program was used in testing the validity of the structural equation model of the graduate students' statistics achievement and to identify any factors that either directly or indirectly affected the graduate students' statistics achievement and to distinguish the variations in that achievement.

## Results

### Characteristics of the Research Sample

The sample included 246 graduate students who came from a public university (64.6%) and a private university (35.4%) in Thailand. For the public university, most of the students were female (57.2%), aged between 30-40 years old (43.4%) and worked as government officers (57.9%). For the private university, most of the students were female (63.2%), aged less than 30 years old (43.7%) and worked as business employees (49.4%), as shown in Table 2.

### Mean, Standard Deviation, and Correlation among the Observed Variables

The statistics achievement had two observed variables: the mid-term test about descriptive statistics and the final test about inferential statistics. The results found that the mean of the mid-term test score was 18.62, *SD*=2.93 and the mean of the final test was 18.48, *SD*=3.83. For the attitudes towards statistics, the results found that the mean of the pre-course attitudes towards statistics in four observed variables was between 3.11 and 3.28, and the mean of the post-course attitudes towards statistics in four observed variables was between 3.75 and 4.09. Concerning the statistics anxiety, the results found that the mean of the pre-course statistics anxiety in three observed variables was between 3.78 and 3.98, and the mean of the post-course statistics anxiety in three observed variables was between 2.55 and 2.76. For the teaching quality, the results found that the mean of the teaching quality in six observed variables was between 3.59 and 4.30. The mean scores and standard deviation of each observed variable are shown in Table 3.

The results of the correlation among 22 observed variables (253 pairs) found that every correlation coefficient was significant at the .05 level. The highest correlation coefficient was 0.65 (i.e. the correlation between skills development and appropriate assessment) and the lowest correlation coefficient was -0.15 (i.e. the correlation between the post–test and class anxiety and pre–value)**.** Before any analysis, checking the problem of multicollinearity was performed by considering all correlations among the independent variables. The results found that all correlations in this study were less than 0.80. This range of correlation coefficients was considered to be at an acceptable level without the problem of multicollinearity (Doane & Seward, 2011; Hair et al., 2010). The results of the Chi-square of Bartlett's Test of Sphericity was 2,149.32 (*df*=231) and the *p*–value was 0.00 that showed significantly at the .05 level. Furthermore, the Kaiser-Meyer-Olkin (KMO) analysis was performed. It found that the KMO value was more than 0.50 (KMO=0.92). This showed that the correlation matrix among observed variables in this study did not identity as a matrix and correlations among the observed variables were sufficient for factor analysis to test the validity of the structural equation model, as shown in Table 3.

Table 2

*Characteristics of the Research Sample*

| Variable | University | | |
|---|---|---|---|
| | Public university | Private university | Total |
| | 159 (64.6%) | 87 (35.4%) | 246 (100%) |
| Gender | | | |
| Male | 68 (42.8%) | 32 (36.8%) | 100 (40.7%) |
| Female | 91 (57.2%) | 55 (63.2%) | 146 (59.3%) |
| Total | 159 (100%) | 87 (100%) | 246 (100%) |
| Age (years) | | | |
| Less than 30 | 58 (36.5%) | 38 (43.7%) | 96 (39.0%) |
| 30–40 | 69 (43.4%) | 29 (33.3%) | 98 (39.8%) |
| More than 40 | 32 (20.1%) | 20 (23.0%) | 52 (21.2%) |
| Total | 159 (100%) | 87 (100%) | 246 (100%) |
| Occupation | | | |
| Government officer | 92 (57.9%) | 11 (12.6%) | 103 (41.9%) |
| Business employee | 26 (16.4%) | 43 (49.4%) | 69 (28.0%) |
| Owner's business | 14 (8.8%) | 19 (21.8%) | 33 (13.4%) |
| Unemployed | 27 (16.9%) | 14 (16.2%) | 41 (16.7%) |
| Total | 159 (100%) | 87 (100%) | 246 (100%) |

**The Validity of Structural Equation Model of Graduate Students' Statistics Achievement**

The results from analyzing the goodness of a fit test of the Structural Equation Model of graduate students' statistics achievement, showed the following statistical values: the Chi-square ($\chi^2$) = 187.87; *df* = 176; $\chi^2/df$ = 1.07; *p*-value = 0.26; *RMSEA* = 0.02; *RMR* = 0.02, *GFI* = 0.93; *AGFI* = 0.91; and *CFI* = 0.99. These indicators were under the criteria for consideration whether the model will fit with empirical data or not:

1) Test Chi square-test goodness of fit must have a p–value more than 0.05.

2) Test Chi square/*df* should be below 3.

3) Test Goodness of Fit Index (*GFI*), Adjusted Goodness of Fit Index (*AGFI*) and Comparative Fit Index (*CFI*) should be more than 0.90.

4) Test Root Mean Square Residual (*RMR*) and Root Mean Square Error of Approximation (*RMSEA*) should be less than 0.08 (Hair et al., 2010; Jackson, Gillaspy, & Purc-Stepehenson, 2009; McDonald & Ho, 2002; Schumaker & Lomax, 1996).

Therefore, this result indicated that the Structural Equation Model had a good fit to the empirical data.

All the hypotheses were examined by confirming the presence of a statistically significant relationship in the predicted direction. When the direct effect of predictive variables on graduate students' statistics achievement was considered at the .05 level of significance, it found that post–course attitudes towards statistics and the teaching quality had a positive effect and the post–course statistics anxiety had a negative effect on the statistics achievement. That is to say, teaching quality had the highest effect (DE = 0.63), followed by the post–course statistics anxiety (DE = -0.42) and the post–course attitudes towards statistics (DE = 0.37) respectively. Besides these results, the pre–course attitudes towards statistics had a positive effect on the post–course attitudes towards statistics (DE = 0.36) and teaching quality (DE = 0.28) but had a negative effect on pre–course statistics anxiety (DE = -0.36). The pre–course statistics anxiety had a negative effect on the post–course statistics anxiety (DE = -0.18). Teaching quality had a positive effect on the post–course attitudes towards statistics (DE = 0.47) but also had a rather negative effect on the post–course statistics anxiety (DE = -0.42). The post–course statistics anxiety had a negative effect on the post–course attitudes towards statistics (DE = -0.40), as is shown in Table 3 and Figure 2 below.

When the indirect effect on graduate students' statistics achievement was considered, the results found that the pre–course attitudes towards statistics had an indirect effect on the graduate students' statistics achievement by mediating teaching quality, post–course attitudes towards statistics, and both pre- and post–course statistics anxiety. The effect size coefficient (IE) was 0.39. Teaching quality had an indirect effect on the graduate students' statistics achievement by mediating post–course attitudes towards statistics and post–course statistics anxiety. The effect size coefficient (IE) was 0.41. Pre–course statistics anxiety had an indirect effect on the graduate students' statistics achievement by mediating post–course statistics anxiety and post–course attitudes towards statistics. The effect size coefficient (IE) was -0.10. Post–course statistics anxiety had an indirect effect on the graduate students' statistics achievement by mediating post–course attitudes towards statistics. The effect size coefficient (IE) was -0.15, as shown in Table 3.

When the total effect of predictive variables on the graduate students' statistics achievement was considered, the results found that teaching quality had the highest total effect (TE = 1.04), followed by post–course statistics anxiety (TE = -0.57), pre–course attitudes towards statistics (TE = 0.39)**,** post–course attitudes towards statistics (TE = 0.37), and pre–course statistics anxiety (TE = -0.10) respectively. In conclusion, all the variables in the model can be used to explain the reasons for the variance of the graduate students' statistics achievement for 53%, as shown in Table 3.

Table 3

*Direct and Indirect Effect in the Structural Equation Model*

| Dependent variables | $R^2$ | Effect | Independent variables | | | | |
|---|---|---|---|---|---|---|---|
| | | | PEATT | PSATT | PEANX | PSANX | TEQ |
| PSATT | 0.44 | DE | 0.36 | - | - | -0.40 | 0.47 |
| | | IE | 0.15 | - | -0.07 | - | 0.17 |
| | | TE | 0.51 | - | -0.07 | -0.40 | 0.64 |
| PEANX | 0.35 | DE | -0.36 | - | - | - | - |
| | | IE | - | - | - | - | - |
| | | TE | -0.36 | - | - | - | - |
| PSANX | 0.39 | DE | - | - | -0.18 | - | -0.42 |
| | | IE | -0.05 | - | - | - | - |
| | | TE | -0.05 | - | -0.18 | - | -0.42 |
| TEQ | 0.26 | DE | 0.28 | - | - | - | - |
| | | IE | - | - | - | - | - |
| | | TE | 0.28 | - | - | - | - |
| STAT | 0.53 | DE | - | 0.37 | - | -0.42 | 0.63 |
| | | IE | 0.39 | - | -0.10 | -0.15 | 0.41 |
| | | TE | 0.39 | 0.37 | -0.10 | -0.57 | 1.04 |

*Note.* DE = Direct Effect, IE = Indirect Effect, TE = Total Effect.

## Discussion and Implications

The aim of this research project was to test the hypothesized model of the effect of attitudes towards statistics, assess the statistics anxiety and the teaching quality on graduate students' statistics achievement. The results found that the structural equation model of graduate students' statistics achievement had a good fit to the empirical data, which was consistent with the research hypotheses. Pre–course attitudes towards statistics (i.e. attitudes at the beginning of the course) had a positive and significant effect on the post–course attitudes towards statistics (i.e., attitudes at the end of the course). That, in turn, influenced statistics achievement, which was consistent with the research results of Chiesi and Primi (2010) and Sorge and Schau (2002), indicating that the graduate students' statistics achievement will be improved if both the teaching and learning management enables students to have far more positive attitudes towards studying statistics.

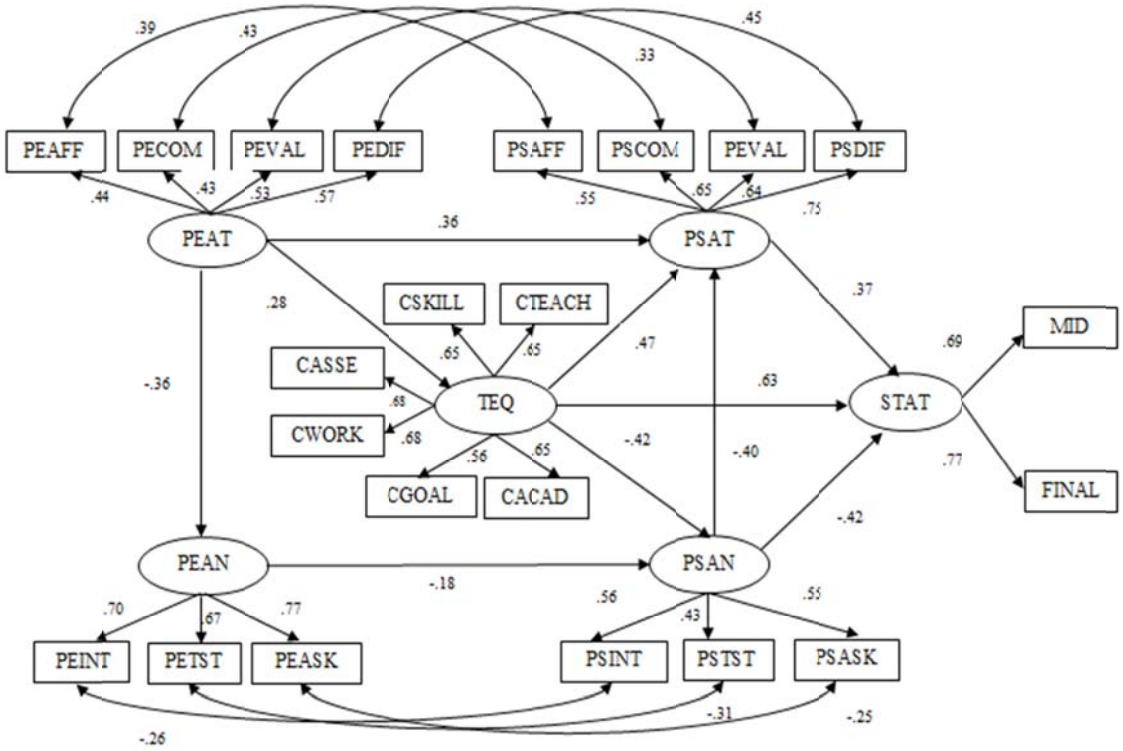



Figure 2. Structural Equation Model of Graduate Students' Statistics Achievement.

The pre-course attitudes had a negative and significantly direct effect on pre–course statistics anxiety (i.e., anxiety at the beginning of the course) and the pre–course statistics anxiety had a negative and significant effect on the pre–course statistics anxiety (i.e. anxiety at the end of the course). That, in turn, affected the post-course attitudes. Because of this, statistics is often the subject which most students are most likely to become anxious about very easily. Therefore, if lecturers created a positive learning environment, then this would increase far more positive student attitudes towards statistics and reduce the existing level of students' anxiety on statistics. This would be consistent with the research undertaken by Onwuegbuzie (2003), who found that lecturers who had good teaching strategies and gave appropriate homework assignments to students, then this helped to reduce the overall students' anxiety.

The research results showed that teaching quality had a positive and significant effect on the attitudes towards statistics and a negatively significant effect on statistical anxiety. Furthermore, teaching quality had a positive and significantly direct and indirect effect on statistics achievement through the graduate students' attitudes towards statistics and the statistical anxiety. This was consistent with research results by Schroeder et al. (2007). Moreover, these results support the notion proposed by Chiesi and Primi (2010). They noted that good teaching quality will affect the attitudes towards statistics, statistical anxiety, and statistics achievement. Lecturers can increase the teaching quality in many ways. Giving assignments is a way to help students enhance their confidence in learning statistics and it also allows students to experience their mastery of the topics and will also provide a more direct feedback about their results, in order to allow them to monitor their progress.

Table 4

*Mean, Standard Deviation and Correlation among Observed Variables in the Structural Equation Model (n=246)*

| OV | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. FINAL | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| 2. MID | .62* | 1.00 | | | | | | | | | | | | | | | | | | | | |
| 3. CTECH | .42* | .35* | 1.00 | | | | | | | | | | | | | | | | | | | |
| 4. CSKILL | .43* | .36* | .58* | 1.00 | | | | | | | | | | | | | | | | | | |
| 5. CASSE | .43* | .34* | .54* | .65* | 1.00 | | | | | | | | | | | | | | | | | |
| 6. CWORK | .34* | .27* | .55* | .51* | .57* | 1.00 | | | | | | | | | | | | | | | | |
| 7. CGOAL | .53* | .30* | .44* | .42* | .44* | .56* | 1.00 | | | | | | | | | | | | | | | |
| 8. CACAD | .30* | .26* | .48* | .48* | .53* | .61* | .54* | 1.00 | | | | | | | | | | | | | | |
| 9. PSINT | -.41* | -.23* | -.51* | -.57* | -.58* | -.50* | -.43* | -.57* | 1.00 | | | | | | | | | | | | | |
| 10. PSTST | -.43* | -.25* | -.44* | -.46* | -.46* | -.39* | -.34* | -.39* | .48* | 1.00 | | | | | | | | | | | | |
| 11. PSASK | -.37* | -.35* | -.57* | -.48* | -.51* | -.50* | -.45* | -.47* | .50* | .64* | 1.00 | | | | | | | | | | | |
| 12. PEINT | -.20* | -.27* | -.21* | -.25* | -.26* | -.27* | -.22* | -.29* | -.22* | -.31* | -.24* | 1.00 | | | | | | | | | | |
| 13. PETST | -.24* | -.18* | -.25* | -.23* | -.15* | -.27* | -.22* | -.25* | -.21* | -.27* | -.26* | .59* | 1.00 | | | | | | | | | |
| 14. PEASK | -.28* | -.17* | -.24* | -.24* | -.28* | -.21* | -.24* | -.26* | -.21* | -.27* | -.22* | .42* | .60* | 1.00 | | | | | | | | |
| 15. PSDIF | .30* | .31* | .54* | .55* | .59* | .57* | .46* | .52* | -.52* | -.51* | -.58* | -.25* | -.29* | -.30* | 1.00 | | | | | | | |
| 16. PSVAL | .35* | .40* | .47* | .49* | .43* | .56* | .50* | .44* | -.36* | -.41* | -.47* | -.27* | -.19* | -.28* | .58* | 1.00 | | | | | | |
| 17. PSCOM | .45* | .30* | .47* | .51* | .45* | .49* | .40* | .49* | -.52* | -.36* | -.43* | -.29* | -.22* | -.26* | .56* | .56* | 1.00 | | | | | |
| 18.PSAFF | .45* | .28* | .40* | .37* | .47* | .42* | .38* | .46* | -.42* | -.34* | -.40* | -.21* | -.18* | -.25* | .48* | .44* | .48* | 1.00 | | | | |
| 19.PEDIF | .22* | .20* | .49* | .38* | .44* | .54* | .44* | .43* | -.22* | -.19* | -.29* | -.44* | -.47* | -.53* | .52* | .48* | .45* | .45* | 1.00 | | | |
| 20.PEVAL | .16* | .17* | .41* | .42* | .49* | .41* | .36* | .47* | -.30* | -.15* | -.18* | -.47* | -.49* | -.50* | .43* | .36* | .51* | .57* | .47* | 1.00 | | |
| 21.PECOM | .34* | .19* | .37* | .35* | .42* | .33* | .35* | .49* | -.16* | -.20* | -.20* | -.32* | -.41* | -.42* | .31* | .32* | .45* | .44* | .50* | .55* | 1.00 | |
| 22.PEAFF | .24* | .16* | .39* | .42* | .46* | .39* | .31* | .42* | -.21* | -.26* | -.26* | -.36* | -.37* | -.42* | .38* | .33* | .38* | .40* | .41* | .55* | .61* | 1.00 |
| Mean | 18.48 | 18.62 | 4.30 | 3.71 | 3.96 | 3.59 | 3.85 | 3.64 | 2.66 | 2.55 | 2.76 | 3.78 | 3.89 | 3.98 | 3.94 | 4.09 | 3.75 | 3.97 | 3.19 | 3.23 | 3.11 | 3.28 |
| *SD* | 3.83 | 2.93 | 0.78 | 0.74 | 0.76 | 0.77 | 0.79 | 0.76 | 0.79 | 0.74 | 0.74 | 0.75 | 0.76 | 0.73 | 0.76 | 0.81 | 0.75 | 0.73 | 0.77 | 0.70 | 0.67 | 0.72 |

KMO: Measure of Sampling Adequacy = 0.92

Bartlett's Test of Sphericity: Chi-square = 2149.31 , *df*= 231 , *p*= 0.00

*Notes.* *$p<0.05$; OV=Observed variables; FINAL=Final exam; MID=Mid-term exam; CTECH=Teaching; CSKILL=Skills development; CASSE=Appropriate assessment; CWORK=Appropriate workload; CGOAL=Clear goals and standards; CACAD=Academic environment; PSINT=Post-interpretation anxiety; PSTST=Post-test and class anxiety; PASK=Post-fear of asking for help; PEINT=Pre- interpretation anxiety; PETST=Pre-test and class anxiety; PESK=Pre- fear of asking for help; PSAFF=Post-affect; PSCOM=Post-cognitive competence; PSVAL=Post-value; PSDIF=Post-difficulty; PEAFF=Pre-affect; PECOM=Pre-cognitive competence; PEVAL=Pre-value; PEDIF=Pre-difficulty

Therefore, the attitudes towards statistics and teaching quality had a positive and significant effect on the graduate students' statistics achievement. The statistics anxiety had a negative and significant effect on graduate students' statistics achievement. Teaching quality had the most effective impact on statistics achievement, followed by statistics anxiety and attitudes towards statistics, respectively. Furthermore, teaching quality had a significantly indirect effect on statistics achievement through the attitudes towards statistics and the statistical anxiety. Teaching quality had a positive and significant effect on the attitudes towards statistics, plus a negative and significant effect on statistical anxiety. This is consistent with past studies that was undertaken by scholars including Chiesi and Primi (2010), Mohamed et al. (2012), Onwuegbuzie (2003), Onwuegbuzie et al. (2000), Sorge and Schau (2002) and Watson et al. (2004). This is because most graduate students will have a negative attitude towards statistics, a high level of anxiety, and some high tension on studying statistics. Therefore, lecturers should provide some helpful feedbacks, promote motivation to succeed, and enhance their own efforts to make students understand statistics more easily. Besides this, lecturers should also work hard to make the subject appear more interesting, put a lot of time to be concerned with students individually, develop the abilities, and advance the problem-solving, and analytical skills among the students; have appropriate assessment methods and provide an appropriate workload; set clear goals and standards, and create a positive academic environment within the classroom (Mclnnis et al., 2001). These factors will help adjust the attitude towards statistics in the aspect of feeling concerned about statistics, help to increase their intellectual knowledge and skills, expand the usefulness and worthiness of statistics in both their personal and professional life, and strive to overcome the perceived difficulty of statistics (Schau et al., 1995). Besides these factors, this will help reduce any statistics anxiety in the aspect of interpretation anxiety, test and class anxiety and the fear of asking for help from either course colleagues or the lecturer (Baloglu, 2002; Cruise et al., 1985).

In the future, in other research projects that relate to this topic, the researcher could suggest that more variables, including gender, education level, and the specific field of study, should be studied as moderator variables to test the invariance of this model. Moreover, variables in this model can be studied in a multi-level analysis, such as involving both the undergraduate and postgraduate student level, classroom level, and university level.

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