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The effect of students' attitudes and concerns on statistical concepts performance: A SEM approach

Fadila Amira Razali[1]
Sharifah Norhuda Syed Wahid[2+]
Noor Izyan Mohamad Adnan[3]
Nik Muhammad Farhan Hakim Nik Badrul Alam[4]
Zulkifli Ab Ghani Hilmi[5]

[1,2,3,4,5]*College of Computing, Informatics and Media, Universiti Teknologi MARA Cawangan Pahang, Kampus Jengka, 26400 Bandar Tun Abdul Razak, Pahang, Malaysia.*
[1]*Email: fadila962@uitm.edu.my*
[2]*Email: sha_norhuda@uitm.edu.my*
[3]*Email: noorizyan@uitm.edu.my*
[4]*Email: farhanhakim@uitm.edu.my*
[5]*Email: zulghani@uitm.edu.my*


(+ Corresponding author)

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ABSTRACT

The purpose of this study was to investigate how the attitudes and concerns of higher learning students made an impact on their performance in the fundamental concepts of the statistics course. Despite being classified as one of the important areas of scientific, industrial, or social problems, students generally perceive statistics as a challenging course to understand. This negative perception leads to a set of complex emotional reactions that may cause great discomfort, resulting in negative consequences, such as anxiety. A sample of 248 UiTM Pahang Branch students, enrolled in a basic statistics course, was randomly selected using a stratified sampling technique. This study employed Structural Equation Modeling (SEM) method to assess the linear relationship model between students' attitudes and concerns, and their performance in statistics examinations. The findings indicated that both students' attitudes and concerns showed a significant negative influence on their performance in statistics examinations, resulting in poor academic performance. Hence, to foster students' academic success in statistics courses, it is essential to cultivate a positive attitude and enhance their confidence levels.

Contribution/Originality: The study emphasizes students' attitudes and concerns as significant factors on statistical concepts performance so that the findings can be used effectively to address any statistical education issue that arises related to statistical performance.

1. INTRODUCTION

Statistics has been one of the essential courses in universities (Arumugam, 2014) as most government and private sectors, including pharmacy, have increased their demand for statistical skills in their organizations and businesses (Hughes, Harris, Flack, & Cuffe, 2012). Further, a great improvement and development of technologies nowadays has caused more data to accumulate fast, making statistics to be more relevant. Besides, the skill and knowledge of statistics have been accepted as one of the prerequisites for a higher-paying profession today. However, many still think statistics is a challenging course as it has a complex statistical concept that is hard to

understand by certain people (Garfield et al., 2008). Apart from that, Saidi and Siew (2018) state that there is a difference in understanding statistical concepts and statistical mechanics that implies substituting digits into the right formula. Yotongyos, Traiwichitkhun, and Kaemkate (2015) also state that statistics is important to everyone as it is being used in scientific research and unravels some crises faced by the world. A great statistician will be able to help in improving students' statistical thinking, which is highly dependent on critical judgment and interpretation to use the correct method (Hannigan, Gill, & Leavy, 2013).

Malaysia has put up statistics as a prominent course in the education system in an effort to move forward to be a successful developed country. A solid understanding of mathematical and statistical theory is essential for academics to teach statistics successfully (Auliya, 2018) because mathematics skills are required in statistics. In addition, Batanero, Burrill, and Reading (2011) asserted that mathematics and statistics are two different disciplines where mathematics teachers still need adequate training to teach statistics courses. Therefore, students must have a good perception of mathematics for them to understand statistics well.

Many students from higher learning institutes consider statistics examination papers as very challenging, and its concept is complicated to understand (Arumugam, 2014; Emmioğlu & Capa-Aydin, 2012; Hedges & Harkness, 2017) including the introductory statistics examination paper (Hovermill, Beaudrie, & Boschmans, 2014). Although statistics courses have been exposed to students since primary school, there are still some problems that arise in achieving the objective including statistical concerns, negative perceptions and attitudes towards this course that will affect students' decisions (Garfield et al., 2008). Students' concerns and attitudes towards statistics greatly affect their academic achievement for the statistics course (Lai, Tanner, & Stevens, 2011) which is supported by Benson (1989) findings that anxiety and negative attitudes are associated with student performance. Furthermore, Marzita (2002) reported that students' attitudes toward some courses may be influenced by their anxiety, suggesting that attitudes play a mediating effect between students' anxiety and their performance in statistics courses. Rosli, Maat, and Rosli (2017) also found that students who have a positive attitude and less statistical anxiety have a better understanding of statistics.

A study of university students enrolled in a statistics course should be conducted to investigate the challenges faced and actions needed to tackle any emergent concerns. Therefore, the purpose of this study is to determine how the attitudes and concerns of higher learning students impact their performance in the fundamental concepts of the statistics course.

2. LITERATURE REVIEW

2.1. Students' Attitudes towards Basic Concept of Statistics

As suggested by a prior study through the Survey of Attitudes Toward Statistics (SATS) (Schau, 2003) it is essential for students to possess a positive attitude with affective, value, cognitive competence, interest, difficulty, and self-effort to motivate them to become engaged in the learning process (Ashaari, Judi, Mohamed, & Wook, 2011). The latest research reported by Lavldas, Barkatsas, Manesis, and Gialamas (2020) confirms that the three-component model of attitudes toward statistics, including the value, affective-cognitive, and difficulty, was approved. In addition, Lavldas et al. (2020) concluded that effective knowledge and skills are strongly related and need to be combined in applying statistics. Student behavioral involvement is seen as the main cause of the influence of attitudes on their academic performance.

According to a study reported by Emmioğlu and Capa-Aydin (2012) attitude toward statistics may be measured using a variety of categories, the most popular of which are: i) affect; ii) cognitive competency; iii) value; and iv) difficulty. Moreover, they also discovered in their meta-analysis of 17 types of research that these four categories of statistics attitudes were constantly correlated with students' performance in a statistics course. However, affect and cognitive competency were more closely associated with higher grades compared to difficulty and value. Furthermore, there are many studies conducted to examine students' experiences and perceptions of statistics

courses, which indicated that they always have a negative attitude towards this course (e.g., (Conners, McCown, & Roskos-Ewoldson, 1998; Druggeri, Dempster, Hanna, & Cleary, 2008; Hogg, 1991; Schutz, Drogosz, White, & Distefano, 1998)). The lack of research conducted on statistical attitudes among introductory level statistics students has had a major impact on the theory that students are not interested in learning statistics because they do not realize the value of statistics courses (Counsell & Cribbie, 2020).

The challenges of learning and understanding statistics are due to non-cognitive and cognitive factors. However, Ashaari et al. (2011) claimed that the non-cognitive factor was the main factor that can cause problems in understanding statistics. The non-cognitive factor is also known as an affective domain, which consists of learning habits, learning interests, learning motivation, attitudes, and self-concept (Djali, 2014). Students who have a low self-perception of the statistics course are more likely to develop a negative attitude towards the course. Precursors of statistics course performance were determined, such as interest, mathematics and statistics self-efficacy, enjoyment, value, relevance and effort (Bokang & Ntebogang, 2015). Additionally, Slootmaeckers, Kerremans, and Adriaensen (2014) revealed that first-year students who are interested in learning statistics show worse academic performance. The study also found that students' mathematics self-concept is strongly associated with the number of mathematics classes attended in high school. Their attitude towards statistical difficulty is related to a longer period of time to maintain statistical skills. This may be due to the development and change of attitude towards one's academic life.

Research by Shultz and Koshino (1998) indicated positive attitudes toward statistics because both specialty and field courses were more common among postgraduates than undergraduates psychology students. Their study revealed that positive attitudes such as students' thoughts of enrolling in a statistics course did not make them nervous and students felt that statistics would be useful in their profession, making students' attitudes towards statistics more positive. Regarding their field of study, both postgraduates and undergraduates had a more positive attitude towards statistics. A theory is made by Gal and Garfield (1997) where the causes of statistics anxiety among students are due to lack of interest, enthusiasm, and motivation. Moreover, Cahyawati, Wahyudin, and Prabawanto (2018) mentioned that the change in students' attitudes between the beginning and end of studying statistics is significant, which involves the dimensions of value, effort, and effectiveness. Differences in attitudes that involve the only dimension of value are found in students who are from different disciplines, that is from science students. Based on student feedback received in the study regarding each attitude dimension, students gave positive responses to all items in the dimension where the highest percentage was the effort dimension. This shows that they possessed a positive attitude to study statistics courses. Furthermore, the interest dimension was the only one that received neutral responses across all items, which can be assumed that statistics is not yet an interesting course among students. Note that the effort dimension received the highest percentage for positive attitudes. In addition, Ashaari et al. (2011) found that the neutral attitude had the highest percentage in the difficulty dimension and categorized the difficulty dimension as a positive attitude. Their study also mentioned that the affective dimension received the highest percentage of negative attitudes.

2.2. Students' Concern towards Basic Concept of Statistics

When learning statistics and students feel discomfort when performing statistics tasks, they are said to have statistics anxiety to be concerned about (Onwuegbuzie, Da Ros, & Ryan, 1997). According to Onwuegbuzie and Wilson (2003) statistics anxiety can be classed into three categories: situational, dispositional and environmental. The situational category refers to the factor that is stimulated by surroundings, whereas dispositional refers to the factor that is caused by the individual itself, while the environmental category refers to events that occurred in the past. The popular scales among researchers has been widely used to assess the level of statistical anxiety which are Statistics Anxiety Rating Scale (STARS) (Cruise, Cash, & Bolton, 1985) and the Statistics Anxiety Inventory (SAI)

(Zeidner, 1991). Therefore, students' concern on statistical concept performance will me tested using STAR and SAI.

Test anxiety and content anxiety are two underlying factors that lead to statistics anxiety. Zeidner (1991) described statistics anxiety in students who feel anxious about their performance in which they feel worried extensively and disrupted by intrusive thoughts. Using the SAI, Zeidner (1991) also concluded a negative correlation between statistics anxiety and mathematics scores in high school. Furthermore, the statistics anxiety was also found to correlate negatively with the self-perception of mathematical abilities. Hence, the obtained results showed that statistics anxiety could be caused by students' prior poor achievement in mathematics and low self-efficacy in mathematics.

Lane, Hall, and Lane (2002) suggested that students' behavior during lectures, usage of information technology, motivated behavior and time management are highly related to do better in statistics courses. The lecturers will also face serious challenges to teach students who have a low level of self-efficacy towards statistics. From their findings, it is revealed that positive attitudes among sports students in terms of focus in class, and being good in technology usage and efficient in time management, tend to have a high level of confidence in learning the first statistics module. Onwuegbuzie (2004) investigated the relationship between academic procrastination and statistics anxiety. It was found that students who have high anxiety levels procrastinate on their assignments. The result obtained is in line with previous findings on the relationship between academic procrastination and anxiety (Ferrari, 1991; Rothblum, Solomon, & Murakami, 1986; Solomon & Rothblum, 1984).

DeVaney (2010) conducted a study to compare the levels of statistics anxiety in on-campus and online statistics classes. STARS was used for this purpose, and it was found that students who attended online statistics classes tended to have higher levels of anxiety about statistics. Using STARS, Kawsar, Zahan, and Islam (2019) investigated the relationship between statistics anxiety, performance and depression among university students in Bangladesh. From their findings, students with high levels of statistics anxiety experienced depression and scored low on examinations. Their study also found that that social science students have a higher level of statistics anxiety than science students. In another study conducted by Levpušček and Cukon (2020) using the STARS, it was found that students who perceive mathematics and statistics as a threat have the highest levels of statistics anxiety. They also found out that students who did not enjoy learning mathematics had a lower computational self-concept during high school. In fact, they also consider statistics as a less worthy course.

Lee (2021) investigated how university students in a statistics class benefited from teaching their peers to reduce mathematics anxiety because mathematics anxiety and statistics anxiety were highly correlated (Paechter, Macher, Martskvishvili, Wimmer, & Papousek, 2017). From the findings, students who carry out group tutoring tasks can reduce their level of mathematics anxiety because the strategy is proven to be very helpful in learning mathematics compared to those who do not tutor others. Furthermore, the mathematics anxiety and students' attitudes towards learning statistics were moderated by teaching their friends. This finding is consistent with the previous studies, which found that active learning and self-directed learning are helpful in improving students' achievement (Freeman et al., 2014; Yoder & Hochevar, 2005).

Previous studies have found that students' attitudes and concerns have a significant impact on their statistics performance, which is an ongoing issue in statistics education. Basically, the studies focus on overall statistics that includes concepts, methods and interpretation of statistical results. Therefore, this study was interested in focusing on statistical concepts only because the positive journey and interest in statistics starts with basic concepts. The following hypotheses were tested in this study.

H1: Students' attitude towards statistics has a significant effect on their performance in statistics examinations.

H2: Students' concern level towards statistics has a significant effect on their performance in statistics examinations.

3. METHODOLOGY

3.1. Data Collection

A cross-sectional study was used in the study to analyze the data gathered from the selected samples to represent the population at a specified time point. Students enrolled in basic statistics courses from four diploma programs; accounting (AC110), wood technology (AS117), applied science (AS120) and plantation (AT110) at UiTM Pahang Branch were selected as samples, using stratified sampling technique (AC110 = 38, AS117 = 18, AS120 = 138 and AT110 = 54), totaling 248 participants. All the selected students answered the online questionnaire voluntarily. The instrument used was divided into four parts; A, B, C and D. Part A consisted of demographics, Part B consisted of respondents' concern towards statistics questions (25 items), Part C examined respondents' attitude towards statistics questions (24 items) and Part D inquired about students' performance in statistics concept examination. The questions of Part B and Part C were adapted from previous studies (Vanhoof, Kuppens, Sotos, Verschaffel, & Onghena, 2011). The Likert Scale used in this study was in interval form ranging from 1 (strongly disagree) to 10 (strongly agree).

Exploratory Factor Analysis (EFA) was applied for pilot study data to assess the consistency of all items and the related components of each construct. IBM-SPSS AMOS (Analysis of Moment Structures) software 24.0 was used to develop Structural Equation Modelling (SEM), which started with the Confirmatory Factor Analysis (CFA) as constructs confirmation (Awang, 2015; Awang, Afthanorhan, Mohamad, & Asri, 2015; Awang, Lim, & Zainudin, 2018). The CFA evaluated every construct measurement model based on four criteria; Construct Validity, Convergent Validity, Discriminant Validity, and Composite Reliability (CR).

3.2. Reliability and Validity of the Study

The Construct Validity, Convergent Validity, Discriminant Validity and CR were used to ascertain the fitness of the measurement models. The Average Variance Extracted (AVE) has to be used to check a construct's Convergent Validity, which should be at least 0.5 to attain Convergent Validity. However, if AVE is less than 0.5, but CR is higher than 0.6, the Convergent Validity of the construct is still adequate (Fornell & Larcker, 1981). In terms of the reliability requirement, a construct's measurement model must meet the CR standard. Note that the recommended value of CR is a minimum of 0.60 (Aimran, Ahmad, Afthanorhan, & Awang, 2017). The modification index indicated the measurement model of a construct, which was found free from redundant items. Discriminant Validity was attained when the measurement model was free of redundant elements. The Construct Validity was verified using a set of Fitness Indexes computed that includes Absolute Fit, Incremental Fit and Parsimonious Fit. Construct Validity was achieved when at least one fitness index from each category reached the desired level (Awang, 2015).

4. RESULTS

In total, 248 students aged between 18 to 21 years old were involved in the study, with an equal proportion of each program using a stratified sampling technique. Majority of them were females (186, 75%), and the rest were males (62, 25%) with the mean score of grade B (M = 61.04, SD = 13.48) in the statistics concept's examination. As shown in Table 1 results found that, on average, the students' attitude towards statistics was at low level (M = 3.83, SD = 1.225) and affect component recorded the highest attitude level (M = 4.61, SD = 1.770). Meanwhile, the student's concern was at a moderate level (M = 5.39, SD = 1.601), with the highest concern level being from the test or assessment component (M = 6.73, SD = 2.108).

Table 1. The level of students' statistical anxiety and attitudes towards statistics.

Construct/ Components	Mean (M)	Standard deviation (SD)
Attitude	3.83	1.225
Affect	4.61	1.770
Interest	3.33	1.559
Value	3.84	1.469
Effort	2.67	1.503
Concern	5.39	1.601
Interpretation	5.46	1.878
Test/Assessment	6.73	2.108
Fear to ask	5.32	2.097
Lecturers	3.91	2.398

4.1. Assessment for Construct Validity

Three categories of Fitness Indexes, namely Absolute Fit, Incremental Fit, and Parsimonious Fit, assessed the Construct Validity. The Absolute Fit category, namely Root Mean Square of Error Approximation (RMSEA), was 0.061 (achieved the threshold of < 0.08), the Incremental Fit category, namely Comparative Fit Index (CFI), was 0.895 (achieved the threshold of > 0.85), and the Parsimonious Fit category, namely the ratio of Chi-square/df was 1.927 (achieved the threshold of < 3.0). Therefore, the measurement models for students' anxiety and student's attitude towards statistics constructs achieved the minimum requirement for Construct Validity, as shown in Figure 1 (Yusof, Awang, Jusoff, & Ibrahim, 2017).

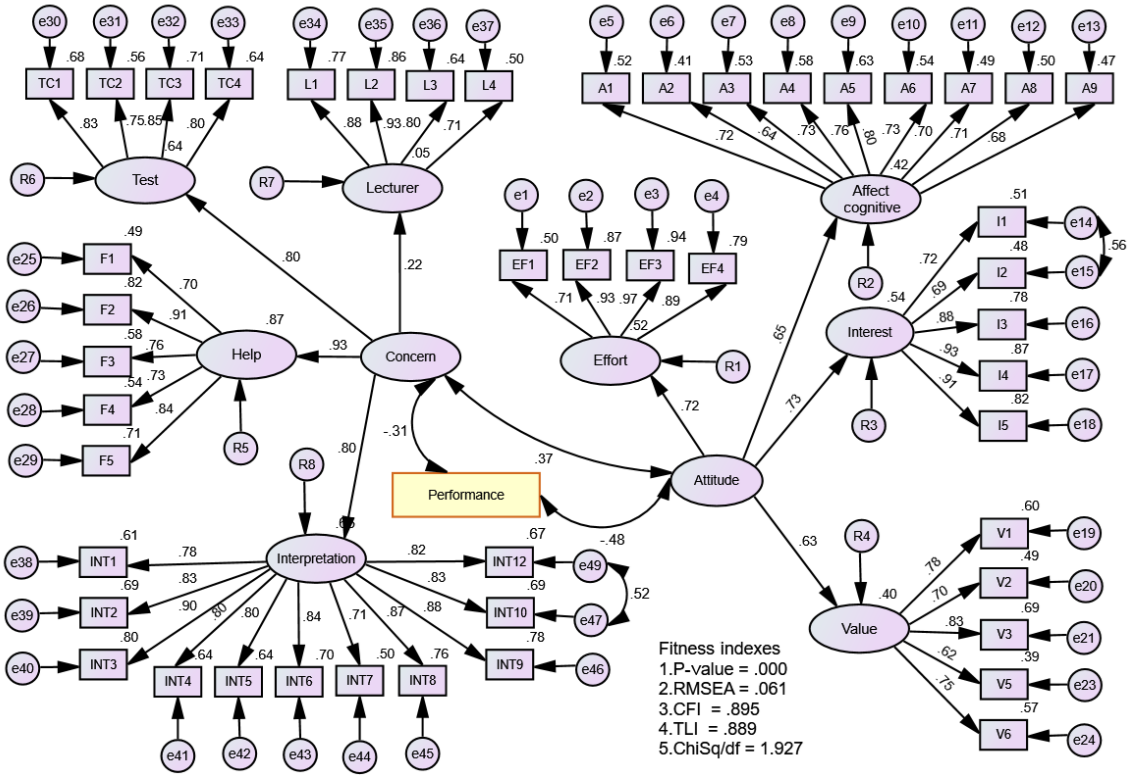

Figure 1. The pooled CFA results and the output showed all fitness indexes achieve.

4.2. Assessment for Convergent Validity and Composite Reliability

Table 2 shows that the AVE values of students' attitude and concern towards statistics were 0.468 and 0.548, respectively (achieved the minimum value of at least 0.45) (Awang et al., 2018) to be concluded that the Convergent Validity was assessed successfully.

Meanwhile, the CR values of students' attitude and concern towards statistics were 0.778 and 0.807, respectively (achieved the minimum value of at least 0.6) (Awang et al., 2015; Awang et al., 2018). The CR values indicate that the CR was achieved.

Table 2. The average variance extracted (AVE) and composite reliability (CR).

Constructs	Components	Factor loading	CR (Minimum 0.6)	AVE (Minimum 0.45)
Attitude	Affect	0.65	0.778	0.468
	Interest	0.73		
	Value	0.63		
	Effort	0.72		
Concern	Interpretation	0.80	0.807	0.548
	Test	0.80		
	Help	0.93		
	Lecturer	0.22		

4.3. Assessment of Discriminant Validity among Constructs and Normality

Table 3 presents the Discriminant Validity for the respective construct achieved since the diagonal value (0.684 and 0.74) was more than 0.37 (Asnawi, Awang, Afthanorhan, Mohamad, & Karim, 2019; Awang et al., 2015; Awang et al., 2018; Mohamad, Awang, & Ali, 2017; Mohamad, Mohammad, Ali, & Awang, 2016; Mohamad, Mohammad, Mat Ali, & Awang, 2018).

Table 3. The discriminant validity index summary for all constructs.

Constructs	Attitude	Concern
Attitude	0.684	0.37
Concern	0.37	0.74

The skewness values were found between -0.970 to 1.150, revealing that the data was approximately normally distributed. According to Awang (2015) Structural Equation Modelling (SEM) using the Maximum Likelihood Estimator (MLE) like AMOS was fairly robust to skewness greater than 1.0 in absolute value if the sample size was large than 200 or more. This is considered large enough in MLE even though the data distribution is slightly non-normal.

4.4. Structural Model and Structural Equation Modeling (SEM)

Figure 2 shows the standardized regression path coefficients between constructs. The coefficient of multiple determination of the model indicates that about 25% of the students' performance in statistics concept examination was explained by their attitude (affect, interest, value and effort) and concern (interpretation, test, help and lecturer) level towards statistics, while the other 75% was influenced by others.

4.5. Testing Hypotheses

Figure 3 illustrates the regression path coefficients between the constructs and the results stated in Table 4 and Table 5. Results show that the students' attitude towards statistics has a significant effect on their performance in statistics concept examination ($P < 0.05$). Thus, the student's attitude towards statistics which consists of effect, interest, value and effort sub-construct, become an important construct towards students' performance in statistics concept examination. Furthermore, the result also shows that the students' concern towards statistics, which consists of interpretation, test, help, and lecturer, significantly affects their performance in statistics concept examination ($P < 0.05$). Therefore, both hypotheses are significantly supported at the 5% significance level.

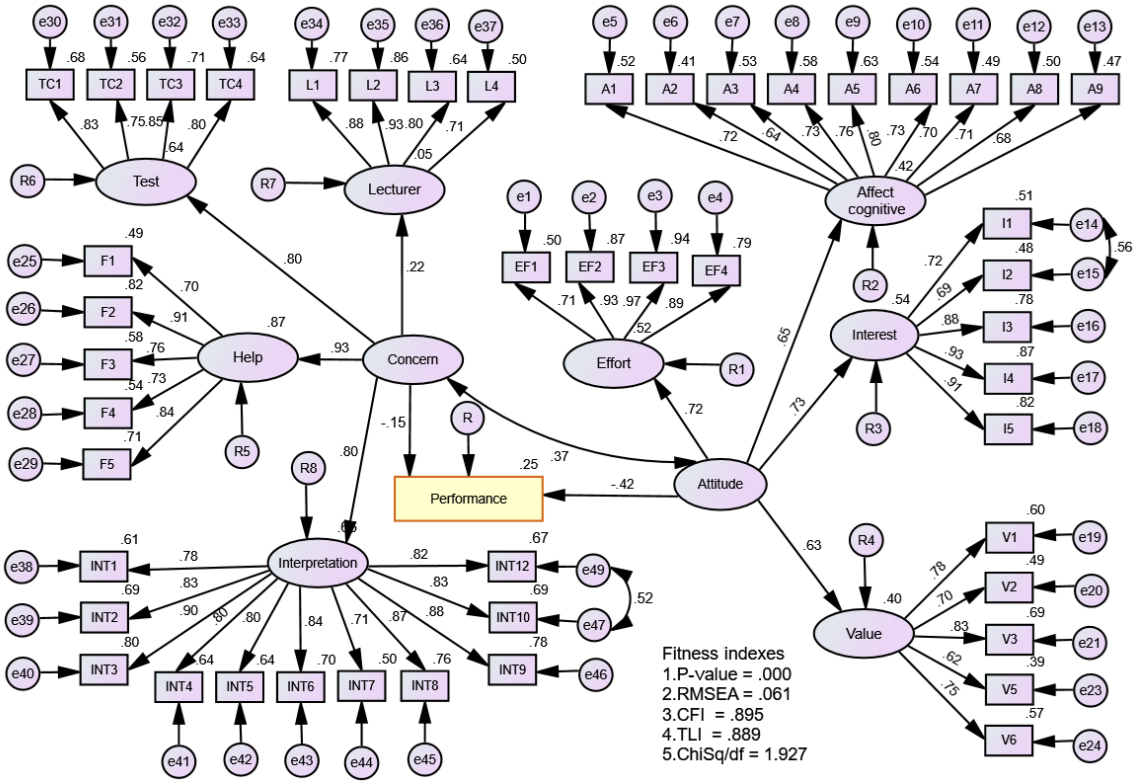

Figure 2. The standardized regression path coefficients between constructs in the study.

Table 4. The regression path coefficient between construct and its significance.

Regression path	Estimate	S.E.	C.R.	P	Result
Performance <--- Attitude (H_1)	-6.028	1.185	-5.088	0.000	Significant
Performance <--- Concern (H_2)	-1.304	0.587	-2.222	0.026	Significant

Note: S.E. = Standard error, C.R. = Critical ratio.

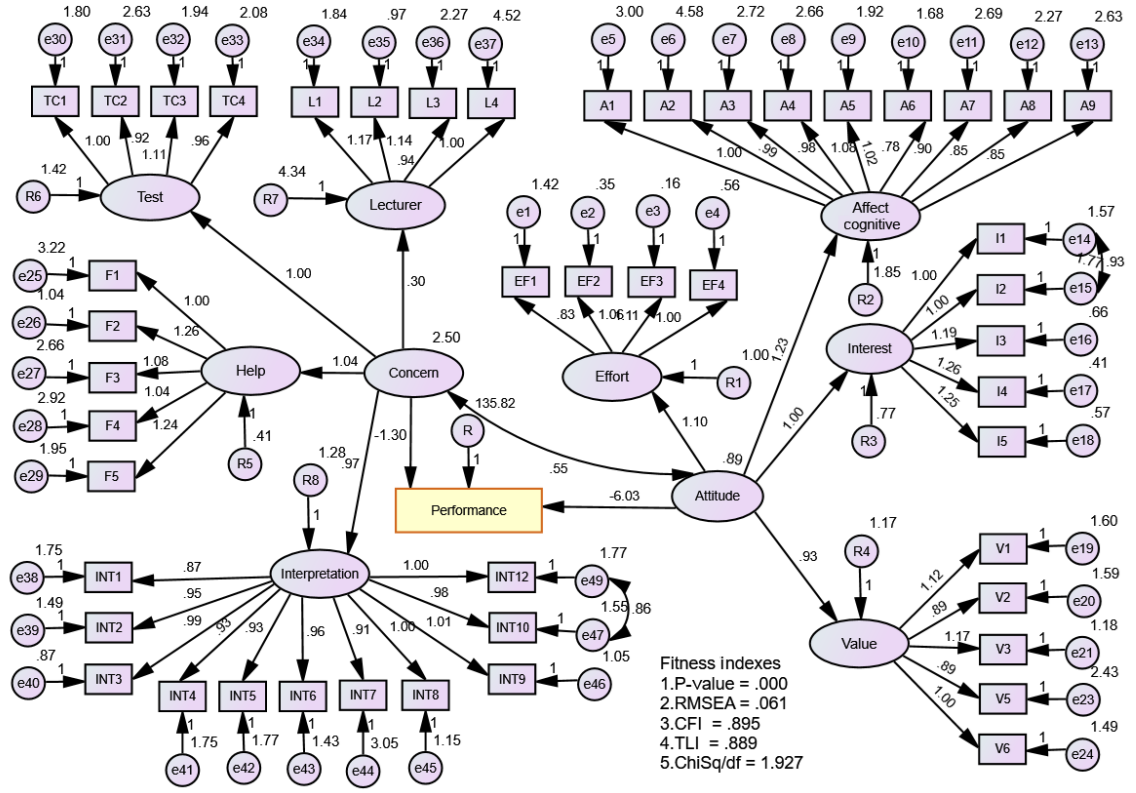

Figure 3. The regression path coefficients between constructs in the study.

Table 5. The hypotheses testing.

Hypothesis statement	Result on hypothesis
H1: Students' attitude towards statistics has a significant effect on their performance in statistics examinations.	Supported
H2: Students' concern level towards statistics has a significant effect on their performance in statistics examinations.	Supported

5. DISCUSSION

The result of the study shows that the majority of the respondents were female aged between 18 to 21 years, with the average performance in statistics concepts examination of 61.04 marks, which were categorized as a B grade. In addition, the average of respondents' attitude and concern level towards statistics are weak and moderate level respectively. Through this study, to develop Structural Equation Modelling (SEM), the research's validity and reliability were confirmed. Furthermore, Construct Validity, Convergent Validity and Discriminant Validity were confirmed with the procedure in both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The result of the first hypothesis (H_1) shows that students' attitude towards statistics has a significant negative effect on their performance in statistics examination in line with the previous study conducted by Emmioğlu and Capa-Aydin (2012) which reported that the attitude has a relationship with student's performance in a statistics course. Furthermore, previous studies (Galli, Chiesi, & Primi, 2008; Lai et al., 2011) also mentioned that negative attitudes towards statistics influenced students' performance in the statistics course, which means that a positive attitude will promise better performance in statistics (Rosli et al., 2017).

The result based on the second hypothesis (H_2) reveals that the student's concern level towards statistics has a significant negative effect on their performance in statistics examination. The result is consistent with (Lai et al., 2011) who stated the students' concern towards statistics strongly affects their performance in statistics. The result is also supported by a previous study conducted among university students of Bangladesh, which reveals that there existed a negative relationship between statistics anxiety and examination marks (Kawsar et al., 2019). As statistics concern levels get higher, the examination marks become worse. Many studies have shown the negative effect of a higher level of statistics concern on student performance. The statistics suggested that active learning and self-directed learning strategies are very recommended to be applied in improving students' performance (Lee, 2021).

6. CONCLUSION

Statistics has become a more important course since data are accumulating rapidly due to positive technological change, even though many considered statistics as a difficult course to learn due to the complexity of statistical concepts. However, negative perception towards statistics leads directly to existing anxiety feelings and negative attitudes that affect students' performance negatively, as highlighted by Galli et al. (2008) and Lai et al. (2011) although the course has been introduced to the students since primary school. As posited, the result reports that the average respondents' attitude and concern level towards statistics are weak and moderate, respectively. Meanwhile, the average students' performance in the course is 61.04 marks, which implies a moderate performance. Furthermore, the study also found that both students' attitudes and concern levels towards statistics have a significant negative effect on their performance in statistics examinations. This indicates that the negative attitude level and high level of anxiety in their study could result in poor performance. However, based on the coefficient of multiple determination of the model indicates that about 25% of the students' performance in the statistics concept examination was explained by their attitude and concern level towards statistics, while the other 75% were influenced by others. Therefore, the percentage indicates there are other factors that are influential to the statistics examination performance. Thus, it is highly recommended for further investigation regarding this issue with more factors included.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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