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Attitudes toward statistics among business students: Do majors, mathematical background, sex, and field of secondary education matter?

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Abstract

Statistics knowledge, literacy, and skills are vital to undergraduates' academic and professional careers. Students' attitudes toward statistics play a vital role in their understanding of the importance of statistics. Therefore, it is important to examine their attitude toward statistics. This study investigated the attitude of 153 business students toward statistics and the factors that affect this attitude using the Survey Attitudes Toward Statistics (SATS-36) scale. It also investigated the relationship between attitudinal components and students' demographic and academic characteristics. Five components underlying students' attitudes toward statistics were identified using exploratory factor analysis. Further, a background in quantitative subjects and demographic characteristics was found to affect students' attitudes toward statistics. The results suggested that statistics should be taught in a more practical way to relate it to students' lives, and teachers must adopt active learning methods in which students work with data and real-life examples.

KEYWORDS

business studies, statistical literacy, students' attitudes toward statistics, teaching statistics

1 | INTRODUCTION AND LITERATURE REVIEW

Statistics is an important discipline in quantitative business courses, especially courses concerning managerial economics, business analytics, and finance. Having statistical knowledge develops not only analytical and technical skills but also transferable skills, such as problem-solving, critical thinking, and decision-making. Moreover, statistical knowledge is critical for conducting accurate analyses. In this information-driven era, one's decisions must be based on information and evidence. Students must possess analytical and information management skills to support their problem-solving and decision-making processes. They must think critically and be analytical and creative in making decisions and solving problems in a fast-moving environment. This makes statistics a core subject of higher education.

Learning statistics requires a set of different but related cognitive processes: statistical literacy, statistical reasoning, and statistical thinking.[4, 5, 16] Statistical literacy is the most basic skill. Statistical reasoning is the ability to explain the reasons for the occurrence of a particular result and the appropriateness of selecting a particular model of representation. Meanwhile, statistical thinking is the ability to understand why and how statistical investigations are conducted and the ideas underlying statistical investigations.[43]

Most undergraduate business students take an introductory course in business statistics. Such courses provide knowledge about the sources of statistical information, understanding and absorbing statistical information, and analyzing reports and readings. The business industry values graduates who possess both analytical and statistical skills. However, the subject of statistics often has a negative reputation among students. They believe that statistics classes are boring and difficult.

The attitude toward statistics has received widespread attention in statistics education. This attitude affects students' learning outcomes[13] and whether they will use what they have learned in their future careers.[44] Attitude is a central component of one's personality; it may be described as strong feelings and emotions that are developed through repeated positive or negative emotional reactions. Students' attitudes can influence their statistical thinking outside the classroom or their intention to apply for other courses and thus encourage them to take higher-level statistics courses.[14] Students' positive or negative attitudes can affect how they understand statistical concepts, theories, and methods and develop statistical thinking skills.[15, 17] Having a positive attitude toward statistics can motivate students to enroll in advanced statistics courses, whereas a negative attitude can affect their learning process and hinder effective learning.[31] Therefore, it becomes imperative to examine students' attitudes toward statistics. Assessing this attitude may provide instructors with information about the effectiveness of different curricula or didactical approaches. The results can also be used to identify students at risk of failing a statistics course.

It is also necessary to assess the different dimensions of students' attitudes toward statistics. Many studies have endeavored to find the factors influencing one's attitude toward statistics. Salazar[34] found that math self-efficacy is a factor that affects students' motivation to learn statistics. Schau[36] found that the attitude toward statistics is associated with math experience and math achievement. Those having no enthusiasm and being insure for mathematics tend to have the same attitude toward statistics. Ashaari et al.[2] found that difficulties in understanding statistical concepts and theories are not only due to non-cognitive factors, such as attitude, perception, interest, expectation, and motivation, but also due to cognitive factors, such as the student's intellectual capability to perform well in the subject. Parker et al.[28] found that students with a solid background in statistics tend to have better academic performance and careers. They suggested that students take two statistics courses: The first course should focus on building a strong theoretical foundation, and the second course should teach the practical aspect of statistics. Peters et al.[30] found that many students do not realize the importance of statistics in business courses. Einbinder,[12] Nilsson and Hauff,[23] and Slootmaeckers et al.[40] found that some students struggle with introductory business statistics courses and experience anxiety and antipathy despite knowing the importance of statistics in their learning.

Evaluating the attitude toward statistics and its dimensions is possible only when proper evaluation instruments are available. The most extensively used instruments to evaluate students' attitudes toward statistics are the Statistics Attitude Survey,[32] Attitudes Toward Statistics,[45] and the Survey of Attitudes Toward Statistics (SATS).[35] The SATS is the best-known among these three instruments. It was developed by C. Schau, J. Stevens, T. Dauphine, and A. Vecchio in 1995 to help understand students' attitudes toward statistics and how learning is affected by these attitudes.[35] Initially, it had 28 items (SATS-28), which measured four components (or dimensions) of one's attitude toward statistics: Value, Difficulty, Affect, and Cognitive Competence. In 2003, C. Schau revised the SATS-28[36] to have 36 items (SATS-36). These 36 items measured six components of one's attitude toward statistics. In addition to the original four components, the items measured two additional components: Interest and Effort. However, some studies have found that the SATS-28 is more reliable and valid in measuring attitudes toward statistics than the SATS-36.[9, 24, 37] Therefore, more research is necessary for applying the STAS-36 in assessing attitudes toward statistics.

Cladera et al.[8] explored the components that capture the items of the SATS-28 and identified Anxiety, Affect & Self-Confidence, and Value as the components of tourism students' attitudes toward statistics. Affect & Self-Confidence and Value positively affected students' attitude toward statistics, while Anxiety had a negative effect, in line with several studies. Persson et al.[29] found that a six-factor structure (Affect, Cognitive Competence, Difficulty, Value, Interest, and Effort) captures the relationships among the items in the SATS-36. Xu and Schau[46] performed a large-scale assessment study to examine the extent to which 13,507 students vary in their attitudes toward statistics across 160 introductory statistics instructors using multilevel confirmatory factor analysis. Their results support a correlated six-factor model at each level and provide empirical support for the use of the SATS-36. Aschenbruck[1] used cluster analyses to differentiate student groups by their interest toward statistics, self-confidence toward their own abilities, and their willingness to invest effort into learning. They argued that using their individual items instead of the SATS-36 attitudinal constructs might lead to a better separation of the clusters. Talwar and Bandar[42] performed multigroup confirmatory factor analysis (CFA) to test the psychometric properties of SATS-36 among undergraduate students. They suggested the 36 items in SATS-36 can be reduced to SATS-30 because the CFA results suggested a six-factor solution with 30 items. However, there is a need for further research on SATS-30. Most of the current studies are still relying on SATS-36. Li et al.[21] developed a Chinese version SATS-36 through translation and back-translation of the original scale. Factor analysis was employed, and a five-factor structure was loaded with good validity and reliability in their study. Most of these studies have concluded that students do not like statistics and feel that it is complicated and technical, but they realize its value in their academic and professional futures and think they can learn it.

Studies have shown that demographic factors can also affect students' attitudes toward statistics. Coetzee and Van der Merwe[10] and Oguan et al.[25] found that male students have a more positive attitude toward statistics. Opstad[27] found that sex-based differences in attitudes toward statistics are significantly reduced when sex-based differences in personality characteristics and the level of mathematics skills are considered. However, Cashin and Elmore[7] found no sex-based differences in achievement or attitude. Some studies have found that age determines one's attitude toward statistics. Coetzee and van der Merwe[10] and Baloglu[3] found that older students are likely to have more positive attitudes toward statistics than younger students. Carmona et al.[6] found that mathematical background is related to students' affective responses to statistics but not to their valuing of statistics. Cladera et al.[8] found that differences in the scores of attitudinal components are related to sex, previous achievement in mathematics, the intention to attend support classes, the field of secondary education, employment situation, and whether one has completed other statistics courses. Sharma and Srivastav[38] found that the business students have positive perception toward statistics and more positive toward the beginning of the semester. Melad[22] employed a descriptive-correlational research design to investigate the relationship between the components of the students' attitudes toward statistics and students' academic achievement in statistics. Their research findings showed that the students' academic achievement in statistics is significantly positively related to the attitude components Affective, Cognitive Competence, Value, Interest, and Effort, but not significantly related to the attitude component Difficulty. Roten and Roten[33] found that the male sports science undergraduate students have higher positive feelings (Affect) toward statistics and greater confidence about their own capabilities (Competence) than their female counterpart. However, there is no gender difference in achievement at the end of the semester. Guo et al.[19] compared the attitude toward statistics between the undergraduate and postgraduate medical students. They found the undergraduates generally exhibit a favorable attitude toward statistics except one of the extracted components Difficulty, the undergraduates express a purer interest in statistics and stronger dedication to mastering this subject than the postgraduates. Their study also found that the students' attitudes might be affected by their major (medical vs. nursing) and gender. Dushimimana et al.[11] conducted an exploratory factor analysis (EFA) on SATS-36 and led to the validation of the novel model comprising 25 items across four distinct factors. Interestingly, they observed that the female students who were pre-service primary teachers exhibited more favorable attitudes toward statistics compared with the male students.

The remainder of this paper is structured as follows. Section 2 describes the methodology. Section 3 presents and discusses the results. Section 4 provides recommendations for statistics educators and concludes the study.

2 | METHODOLOGY

2.1 | Data collection

Data were collected from all sophomores enrolled in the business school of the author affiliation. Half of the sophomores (those majoring in Accounting, Finance, and Business Intelligence & Data Analytics) were scheduled to take a statistics course in the first semester, and the remaining half (those majoring in Business Administration and International Integrated Resorts Management) were scheduled to take the same course in the second semester. The instructors, topics covered, and assessment methods were identical across the semesters. To prevent instructor bias, only those students were included in our sample who were enrolled in the sections taught by a selected instructor. A self-administered questionnaire consisting of three sections was distributed to the students on a particular day in the last week of each semester. A total of 153 responses were collected. Less than 5% of the students were absent on the day of the survey, and the probability of bias in the data was low. Because there were a few missing values in the dataset, imputation was unnecessary.

2.2 | Instrument

As stated earlier, the self-administered questionnaire comprised three sections. Section A contained three questions. The first question asked whether the student had studied statistics in secondary school. The second question asked whether they were repeating the statistics course. The third question asked the student to rate their achievement in Mathematics or Quantitative Analysis. Section B consisted of the items of the SATS-36. Section C comprised questions on students' demographic and academic characteristics, such as their major, sex, and field of secondary education.

The SATS-36 and related information are available on Schau's website: www.evaluationandstatistics.com. The Affect component measures students' feelings concerning statistics. The related items measure whether students like and enjoy statistics, feel stressed and scared in solving statistical problems, and feel frustrated in following course material. The Cognitive Competence component measures students' perceptions of their intellectual knowledge and skills when applying them to statistics. The related items measure students' beliefs about whether they can understand statistical concepts based on how they think, can learn statistics, make many mistakes in computation, and can understand formulae and statistical concepts. The Value component measures students' perceptions of the usefulness and relevance of statistics in their studies and personal and professional lives. The Difficulty component measures students' perceptions of the difficulty of statistics as a subject. The related items measure whether formulae, techniques, and calculations are easy to understand and execute. They also measure whether the subject is easily understandable and requires discipline and a new way of thinking. The Interest component measures students' level of individual interest in statistics. The related items measure whether students are interested in learning, using statistics, and understanding and discussing statistical information. Finally, the Effort component measures the amount of labor students employ to learn statistics. It assumes that students who have employed tremendous effort, such as completing all assignments, studying hard, and attending all lectures, will likely have a positive attitude toward statistics.

The 36 items are rated on a seven-point Likert scale, with 1 denoting "strongly disagree," 4 denoting "neutral," and 7 denoting "strongly agree." Some items are negatively worded, and their scores must be reversed before analyzing data. Furthermore, there are two versions of the SATS: a pre-test that is administered at the beginning of a statistics course and a post-test that is administered after a statistics course. The items in both versions are identical except for some wording changes related to the timing of the assessment; most of these changes are related to translation (the questionnaire is written in both English and traditional Chinese). The evaluation of students' attitudes toward statistics depends on the appropriate instrument. The SATS-36 has proven to be reliable and valid[29, 41] and thus was used in this study (the post-test version).

2.3 | Statistical analysis

While computing the scores on the SATS-36, we reversed the responses to negatively worded items. Higher item scores were considered to contribute to a favorable attitude toward statistics. To obtain the underlying dimensions of students' attitudes toward statistics, we performed an exploratory factor analysis (EFA) and derived the factor scores of the attitudinal components. The EFA was conducted using principal component analysis with the varimax rotation method to extract the factors underlying students' attitudes and minimize the number of variables with high loadings on each other. The reliability of the attitudinal components was tested using Cronbach's alpha. The Cronbach's alpha is found to be 0.746 which is greater than the benchmark value 0.70. Finally, we examined whether the scores of attitudinal components differ based on students' demographic and academic characteristics. The students were grouped based on whether they had studied statistics in secondary school (yes/no), whether they were repeating the subject (yes/no), their rating of their achievement in Mathematics or Quantitative Analysis (poor/fair/good/very good/excellent), their majors (Accounting/Finance/Business Intelligence & Data Analytics/International Integrated Resort Management/Business Administration), their sex (male/female), and their field of secondary education (sciences/arts/commerce/hybrid). Using a parametric t test or analysis of variance (ANOVA), we examined whether the scores of attitudinal components differ among these groups. Parametric tests were employed because the Kolmogorov–Smirnov test accepts the normality assumption (all p values are greater than 0.05).

3 | RESULTS AND DISCUSSIONS

3.1 | Sample description

More than half the respondents had studied statistics-related subjects in secondary school (57.5%), and 5.9% of the respondents were repeating the course. Most students stated that they had relatively better achievements in mathematics or quantitative analysis (69.2%), and only 6.5% of the respondents believed they had poor achievements. More than half the respondents were female (53.6%). Regarding students' majors, 20.2% were majoring in Accounting, 13.1% in Finance, 19.0% in International Integrated Resort Management, 12.4% in Business Intelligence & Data Analytics, and 35.3% in Business Administration. Further, nearly half of the respondents (49.7%) were in the field of science in secondary education, and the remainder were either in the fields of arts or commerce.

3.2 | Students' attitude toward statistics

Table 1 presents the percentage of variance explained by the different numbers of components extracted using EFA. It shows that the first five components were extracted, and this five-factor structure accounted for a high percentage of variance. It accounted for 62.87% of the total variance.

Table 2 shows the rotated factor matrix, which presents the components obtained for the dataset along with factor loadings and communality of each item of the SATS-36. The EFA suggested that five components should be extracted. The communalities of all items were above 0.40, except for Item 18 (0.395). However, because the figure was slightly below 0.40, none of the items were removed from our analysis because of low communality. It is generally considered acceptable when this value is between 0.20 and 0.40, and a good way to measure factor analysis is to have a communality of at least 0.40.[18] The appropriateness of the EFA for this study was proven using two statistical methods. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.882, which was considered adequate. Bartlett's test of sphericity rejected the null hypothesis that the variables are unrelated and unsuitable for factor analysis.

Among the 36 items, the first component extracted was Anxiety. It covered the items concerning students' belief that statistics makes them anxious and is a difficult subject. The second component, Technique, covered items related to the perceived difficulty of the subject and the effort required to complete the subject. The third component, Life & Professional Relevance, included items related to the relevance and value of statistics in students' personal and professional lives. The fourth component, Interest & Usefulness, captured the items concerning students' belief that learning and using statistics is interesting and their perception of the usefulness of statistics in personal and professional life. Asian students often show no interest in the subjects they consider irrelevant. The last component, Effort & Self-Confidence, covered items concerning the efforts students employ in learning statistics and their confidence in their capability to learn the subject.

The components we obtained using EFA differ from the original six attitudinal components suggested by Schau.[36] Some studies have also found different structures of attitudinal components. Vanhoof et al.[44] found weak loadings with three Difficulty items, indicating that this component is difficult to capture using the originally suggested items. Their results suggested that the SATS-36 can be improved by removing some insignificant items, and some of the original components (Affect, Cognitive Competence, and Difficulty) can be combined into one. Persson et al.[29] also found that some difficulty items have weak loadings. Khavenson et al.[20] extracted seven factors using principal component analysis. Two of the original six components (Affect and Cognitive Competence) were restructured as negative expectations toward statistics. The original component Value was divided into separate components: Value of Statistics in Professional Life and Value of Statistics in Everyday Life. Slootmaeckers et al.[40] could not distinguish the Affect component from other components such as Interest, Cognitive Competence, Value, and Difficulty.

Table 3 summarizes the descriptive statistics of the five components extracted by EFA and items of the SATS-36 classified based on the five components. Most of the items and components had a mean score greater than 4.0, the value representing neutrality on the seven-point Likert scale. This result indicates that Macanese and Chinese students' attitude toward statistics was not very negative (all the students enrolled in the business school of author affiliation were Macao-born Chinese or Portuguese individuals or Chinese individuals from Mainland China, Hong Kong, Taiwan, or Malaysia. Due to the outbreak of COVID-19 and border restrictions, exchange students from other countries have not been allowed since the academic year 2020/2021). Only six items had a mean score of less than 4.0, four of which were covered by the dimension Technique. This dimension was the only dimension with a mean score of less than 4.0. This result suggests that the items related to the

TABLE 1 Percentage of variance explained by exploratory factor analysis of the SATS-36 items.

Number of components	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.488	34.690	34.690	5.836	16.212	16.212
2	3.966	11.017	45.707	4.848	13.468	29.680
3	2.620	7.277	52.984	4.650	12.916	42.596
4	1.949	5.413	58.398	4.385	12.181	54.777
5	1.610	4.472	62.869	2.153	5.982	60.759

TABLE 2 Results of rotated factor matrix of exploratory factor analysis on the SATS-36 items.

	Factor loading	Communality
Anxiety		
2. I feel insecure when I have to do statistics problems	0.816	0.745
14. I am under stress during statistics class	0.733	0.668
3. I have trouble understanding statistics	0.720	0.736
21. I am scared by statistics	0.652	0.759
11. I get frustrated going over statistics quizzes in class	0.648	0.560
6. Statistics is a complicated subject	0.589	0.557
27. I find it difficult to understand statistical concepts	0.507	0.727
20. I made a lot of math errors in statistics	0.501	0.547
Technique		
26. Statistics is highly technical	0.739	0.739
22. Statistics involves massive computations	0.739	0.610
28. Most people have to learn a new way of thinking to do statistics	0.719	0.599
18. Learning statistics requires a great deal of discipline	0.492	0.395
4. Statistics formulas are easy to understand	0.447	0.551
Life & professional relevance		
25. Statistics is irrelevant in my life	0.808	0.757
19. I have no application for statistics in my profession	0.713	0.655
12. Statistical thinking is not applicable in my life outside my job	0.688	0.630
16. Statistics conclusions are rarely presented in everyday life	0.687	0.608
10. Statistics is not useful to the typical professional	0.619	0.593
5. Statistics is worthless	0.270	0.622
9. I have no idea of what is going on in this statistics course	0.123	0.605
Interest and Usefulness		
30. I am interested in using statistics	0.906	0.882
31. I am interested in understanding statistical information	0.899	0.865
32. I am interested in learning statistics	0.897	0.865
29. I am interested in being able to communicate statistical information to others	0.765	0.713
1. I like statistics	0.720	0.702
15. I enjoy taking statistics courses	0.666	0.694
13. I use statistics in my everyday life	0.501	0.444
7. Statistics should be a required part of my professional training	0.414	0.566
Effort and self-confidence		
34. I plan to work hard in my statistics course	0.869	0.838
35. I plan to study hard for every statistics test	0.849	0.796
36. I plan to attend every statistics class session	0.749	0.674
33. I plan to complete all of my statistics assignments	0.698	0.563
23. I can learn statistics	0.619	0.676
8. Statistical skills will make me more employable	0.493	0.665
24. I understand statistics equations	0.476	0.689
17. Statistics is a subject quickly learned by most people	0.466	0.488

TABLE 3 Descriptive statistics for the SATS-36 items and EFA components.

	Mean	Standard deviation
Anxiety	4.33	0.975
2. I feel insecure when I have to do statistics problems[a]	4.08	1.600
14. I am under stress during statistics class[a]	4.50	1.461
3. I have trouble understanding statistics[a]	4.64	1.445
21. I am scared by statistics[a]	4.91	1.775
11. I get frustrated going over statistics quizzes in class[a]	4.79	1.609
6. Statistics is a complicated subject[a]	3.50	1.501
27. I find it difficult to understand statistical concepts[a]	4.37	1.499
20. I made a lot of math errors in statistics	3.81	1.468
Technique	3.65	0.748
26. Statistics is highly technical[a]	3.45	1.323
22. Statistics involves massive computations[a]	3.06	1.415
28. Most people have to learn a new way of thinking to do statistics[a]	3.92	1.192
18. Learning statistics requires a great deal of discipline[a]	3.52	1.181
4. Statistics formulas are easy to understand	4.33	1.316
Life & professional relevance	4.86	0.784
25. Statistics is irrelevant in my life	2.81	1.380
19. I have no application for statistics in my profession[a]	5.20	1.428
12. Statistical thinking is not applicable in my life outside my job[a]	5.20	1.480
16. Statistics conclusions are rarely presented in everyday life[a]	4.54	1.408
10. Statistics is not useful to the typical professional[a]	5.16	1.507
5. Statistics is worthless[a]	5.77	1.320
9. I have no idea of what is going on in this statistics course[a]	5.32	1.403
Interest and usefulness	4.50	1.093
30. I am interested in using statistics	4.41	1.350
31. I am interested in understanding statistical information	4.48	1.328
32. I am interested in learning statistics	4.49	1.308
29. I am interested in being able to communicate statistical information to others	4.01	1.328
1. I like statistics	4.70	1.391
15. I enjoy taking statistics courses	4.42	1.403
13. I use statistics in my everyday life	4.27	1.504
7. Statistics should be a required part of my professional training	5.24	1.328
Effort and self-confidence	5.36	0.899
34. I plan to work hard in my statistics course	5.69	1.150
35. I plan to study hard for every statistics test	5.88	1.108
36. I plan to attend every statistics class session	6.05	1.108
33. I plan to complete all of my statistics assignments	5.37	1.380
23. I can learn statistics	5.37	1.219
8. Statistical skills will make me more employable	5.37	1.223
24. I understand statistics equations	4.86	1.293
17. Statistics is a subject quickly learned by most people	4.30	1.095

[a]Responses to these items are reversed.

difficulty of the subject and the computational ability required in the subject generated anxiety and stress among the students, causing them to have negative attitudes toward the subject. It aligns with the findings of previous studies that found that students may not have a negative attitude toward statistics, at least not toward all attitudinal components. The item with the lowest score was Item 25 "Statistics is irrelevant in my life." This result indicates that students cannot find a relationship between statistics and their lives.

3.3 | Differences in attitudinal component scores based on students' demographic and academic characteristics

Because the Kolmogorov–Smirnov test supported the normality assumption and the Levine test indicated homogeneity of population variances across groups, the parametric *t* test and ANOVA were employed to check whether the mean EFA component scores differ based on students' demographic and academic characteristics. Table 4 presents the *p* values for the tests.

The score for all attitudinal components, except Technique, differed significantly based on whether the student had studied statistics in secondary school. Students who had studied statistics had significantly higher scores for Anxiety and Effort and Self-Confidence than those who had not studied statistics previously. Because the responses to negatively worded questions were reversed, higher scores indicated less anxiety concerning statistics. Moreover, it is generally agreed that an important determinant of a positive attitude toward statistics is previous experience.[6, 14] This result suggests that having studied statistics in upper secondary school makes students feel less anxious about the subject and thus motivated to put effort into it. At a 5% significance level, no significant differences were found in the score of any of the attitudinal components based on whether the student was repeating the course.

Significant differences were found in the score for all components based on students' rating of their achievement in Mathematics and Quantitative Analysis. Students who rated themselves better in Mathematics and Quantitative Analysis were more interested in learning and using statistics, less anxious about it, did not regard it as a highly technical subject, considered it more relevant to their personal and professional lives, paid more effort in learning it, and had greater confidence in it. This result confirms that positive attitudes are associated with improved performance, consistent with the results of.[35] While we found that students with better achievement consider statistics relevant to their lives, other studies have found that a similar component Value is not related to course achievement.[6]

Significant differences were found in the scores for four components based on students' majors. Students majoring in Finance and Business Intelligence & Data Analytics had better quantitative skills and knowledge of computer operations, leading them to have less anxiety about statistics, have greater confidence in it, consider it more relevant to their careers, and pay more effort in learning it. Meanwhile, students majoring in International Integrated Resorts Management had relatively lower attitude scores, indicating that most tourism students do not have any inclination toward quantitative methods or statistics subjects. This result aligns with the findings of previous studies.[8]

Regarding sex-based differences, female students scored significantly higher in the components of Life & Professional Relevance and Effort & Self-Confidence. They also had higher, but insignificant, mean scores for

TABLE 4 Tests for differences in EFA components on academic characteristics and demographic profiles.

	Anxiety	Technique	Life & professional relevance	Interest & usefulness	Effort & self-confidence
Previous statistics courses[a]	0.000**	0.686	0.025*	0.054*	0.014*
Repeater[a]	0.082	0.393	0.060	0.058	0.096
Achievement in mathematics and quantitative analysis[b]	0.000**	0.007**	0.000**	0.000**	0.000**
Major[b]	0.001**	0.078	0.021*	0.008**	0.002**
Gender[a]	0.236	0.869	0.015*	0.735	0.044*
Field of secondary education[b]	0.000**	0.014*	0.000**	0.000**	0.000**

[a]Test for the difference in population mean component scores by pooled-variance *t* test because the normality assumption and homogeneity of variances hold.
[b]Test for the difference in population mean component scores by ANOVA because the normality assumption and homogeneity of variances hold.
*Significant at 5%.
**Significant at 1%.

other components. These results differ from those of previous studies.[10, 25] However, findings concerning sex-based differences in attitudes toward statistics have been inconsistent in the literature. Finally, students with secondary education in sciences had the highest scores for all components.

4 | IMPLICATIONS IN RESEARCH AND SUGGESTED TEACHING STRATEGIES

These findings reveal the factors that affect students' attitudes toward statistics. Full attention must be paid to the factors that generate anxiety concerning statistics and poor statistical learning among business students. Academics can use the results of this study in adopting teaching approaches that improve students' attitudes toward statistics because a favorable attitude toward statistics positively affects the learning of statistics. Teachers should focus on the most negative items and components and make appropriate curriculum adjustments or introduce interventions for students. Among the 36 items, the item "Statistics is irrelevant in my life" had the lowest score (the scores of negatively-worded items were reversed). Teachers should endeavor to relate statistics to students' lives by showing real-life applications of statistics and use the local statistical figures in their examples. The other two items that had a low score were "Statistics involves massive computations" and "Statistics is highly technical" (the scores of these negatively worded items were also reversed). It is true that calculating descriptive and test statistics requires several steps, and even one minor error may give an incorrect answer and frustrate students. In today's digital era, teachers should rely more on statistical software and spreadsheets to teach statistics. Using quantitative materials in nonmethodological courses can be a double-edged sword, but it requires the fine-tuned use of such materials. To reach these requirements, using modern technologies such as databases, online or offline analytical and visualization tools is crucial. Keeping the curriculum up with new technologies is suggested.

Regarding the five extracted components, the component that induced the most negative attitude was Technique. Teachers should adjust the curriculum of Business Statistics courses to include more information on how to use statistical software so that students do not obtain answers solely through complicated calculations and formulas. They must also adopt teaching strategies in which students work with data and real-life examples so that they learn theoretical concepts more easily. It is important to develop an interesting plan to make statistics enjoyable and more effective for students and improve their feelings and attitudes toward statistics. Some studies show that the use of real problems, technology, and engaging the students involved in the class actively are more effective than the traditional lecture-based teaching. Our students also prefer the active teaching methods over traditional lectures and seminars. They can learn not only from us but also from the group activities and cooperation with peers. The role of educators using active teaching methods are more of a facilitator and moderator rather than a lecturer role, who rely on lecture-based teaching. The teachers using active teaching methods assess the students' performance based on the group or individual works, thus may require more planning in advance. We also recommend conducting statistics courses that allow longer statistical activities to be carried out, including more sophisticated data analyses.

According to our students' reflections, teaching strategies such as instructional videos, instructor's notes, mini projects, and discussion forums in any social network are effective teaching strategies. The case studies can help students connect their learning in statistics classes, build their own knowledge on all aspects of business research, and help create a framework from scaffolding learning. The instructional videos allow students to preview the lecture materials before coming to the classroom and review them after class anywhere and anytime and can overcome learning difficulties for students with low English proficiency. Although there are many videos readily available online, we still create our own videos which stick to the concepts and materials discussed for specific courses from time to time. Based on our students' feedback, lecture notes that cover key terms, concepts, theories, applications/cases, assignment instructions, and hints of what parts of the textbook can be skimmed are another effective teaching strategy. Finally, the mini projects allow students to master particular concepts and skills, such as finding and handling raw data and forming a research question. The mini projects provide a real-world application for the course. Conclusively, some activity-based teaching and learning methods, such as problem-based learning, project-based learning, thinking-based learning, gamification, and flipped classroom, can be used in a part of a lesson, in a whole lesson or during the whole course. These methods can build not only analytical skills but also the way of thinking and other soft skills such as teamwork, communication skills, creativity.

It is also noteworthy that the choice of field of secondary education and having studied Introductory Statistics in upper secondary school matters. Thus, high school teachers must ensure that secondary students are well-informed about the consequences of the choices they make concerning higher education.

The success of statistics subject teaching and learning depends on both the educators' and the students' time expenditure and attitude.

5 | CONCLUSIONS

This study aimed to determine how to help business students in their ability to learn and retain statistical knowledge, literacy, and skills, which are essential for business undergraduates' careers. Some majors in business schools may require students to be proficient in quantitative subjects or statistics, whereas others may require students to have good communication skills rather than quantitative skills. For business students to understand the importance of statistical knowledge, literacy, and skills in decision-making and problem-solving, their attitude toward statistics plays a vital role. Different statistics courses have to focus not only on the expected outcomes of the mechanical calculations but also on developing the students' statistical literacies, statistical thinking, and the correct use of statistical tools. Therefore, teachers must know students' attitudes toward statistics and the factors that affect these attitudes.

To our knowledge, this study is the first to analyze students' attitudes toward statistics among business students studying in the same grade but majoring in different subjects. Moreover, our findings provide salient insight into students' attitudes toward statistics. We found that only six out of 36 items have scores less than 4, and Chinese and Macanese students' attitude toward statistics is not significantly worse, as expected. We also identified five components underlying students' attitudes toward statistics, which differed from the original six components. The components identified were Anxiety, Technique, Life & Professional Relevance, Interest & Usefulness, and Effort & Self-Confidence. Among these five components, only Technique induced a negative attitude among students. We also found that the score for four out of five attitudinal components differs based on whether the student has studied statistics previously and their major. Sex-based differences were found in the score for two of the five components. Scores for all components differed based on the student's achievement in Mathematics and Quantitative Analysis and their field of secondary education. No significant differences were found in component scores based on whether the student was repeating the course.

Further research may be conducted to explore an appropriate approach for teachers to balance students' attitudes and perceptions toward statistics. This study was limited to undergraduate students, and previous studies have documented that undergraduate and graduate students have different attitudes toward statistics.[26, 39] Therefore, future studies can monitor changes in students' attitudes at different stages of the study. Further, a follow-up study can be carried out to determine whether the changes in curriculum and teaching approaches improve students' attitudes, improve their perception of the value of statistics, and decrease their anxiety toward statistics.

AUTHOR CONTRIBUTIONS

The submitted work is original and the author's own work, and the work is not currently under review by any other journal.

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CONFLICT OF INTEREST STATEMENT

All authors declare that they have no conflicts of interest.

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