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RESEARCH ARTICLE

Grasping the STARS: A comprehensive study on statistics—Anxiety levels among engineering students

Nurul Shida[1,*], Sharifah Osman[2], Achmad Buchori[3]

[1] *Department of Mathematics, Science and Computer, Polytechnic Ibrahim Sultan, Pasir Gudang 81700, Malaysia*

[2] *Faculty of Social Sciences and Humanities, Universiti Technologi Malaysia, Skudai 81300, Malaysia*

[3] *Mathematic Education Program, Universitas PGRI Semarang, Semarang 50614, Indonesia*

*** Corresponding author:** Nurul Shida, nurulshida@pis.edu.my

ABSTRACT

Engineering students often face the challenge of comprehending and applying statistical concepts to evaluate and assess research. This research seeks to investigate the factor structure of Statistics Anxiety Rating Scale (STARs), which comprises six domains with 51 items. The questionnaire was administered to engineering students currently enrolled in a statistics class, and the data were analyzed using Statistical Package for the Social Sciences. The study sheds light on the factors that contribute to students' statistics anxiety when taking a statistics course. The findings highlight the elements that influence statistics anxiety, educators and institutions can develop targeted interventions and support mechanisms to enhance students' statistical competence and overall learning experience. This research not only addresses the unique challenges faced by engineering students but also holds implications for fostering statistical literacy across various disciplines.

Keywords: statistics anxiety; STARS

1. Introduction

Research has identified statistics anxiety as a significant issue among students taking statistics courses, and it can have a detrimental impact on their academic performance[1,2]. In some other work of research, Kaufmann et al.[3,4], statistics anxiety is a multidimensional construct that includes worry, tension, and stress, and it can vary based on gender differences. They discovered female students were seen to be more anxious about statistics than male students. Recognizing the complex nature of statistics anxiety and the role of gender variations in resolving the issue is critical.

Several studies have discovered by Welch et al.[5,6] that statistical anxiety has a bad impact on education and academic ability. The researchers reported that statistics anxiety was connected with lower grades and performance in research methodology courses. In another study, MacArthur and Santo[7,8] investigated the fear of seeking assistance and bad views toward statistics teachers have been identified as predictors of poor academic performance in statistics courses. They emphasized the importance of addressing students' negative attitudes towards statistics teachers and creating a supportive learning environment to reduce statistics anxiety.

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Several factors have been found as contributing to statistical anxiety in the literature, including personality traits, self-efficacy, learning strategies, prior experience, and teaching methods[9]. For instance, research has indicates by Schau et al.[10] shown students who lack self-efficacy have higher degrees of statistical anxiety. Hsu and Wang[11] investigated that effective teaching methods, such as providing clear explanations, using examples, and promoting active learning, have been identified as potential interventions to reduce statistics anxiety Overall, understanding the factors that cause statistics anxiety can help educators develop effective interventions to support students and enhance their academic performance.

1.1. The goal of the research

The participants were enrolled in a statistics course at a polytechnic in Johor. As part of their graduation requirements, most engineering students must pass a statistics course. It is critical to research to assess these students' attitudes and views about statistics. The purpose of this study was to learn about the experiences and viewpoints of engineering students on statistics anxiety.

1.2. Research questions

The information gathered was analysed to address the following issues:

i. What are the levels of anxiety in statistics among engineering students?
ii. Is there a statistically significant difference in statistics anxiety between gender among engineering students?
iii. What are the factors contributing to statistics anxiety among engineering students?

1.3. Hypothesis

In this study, the researchers hypothesized that:

(H1): There is a significant difference in statistics anxiety between gender among engineering students.

2. Literature review

Several studies have proposed interventions to alleviate statistics anxiety among students. Marshall et al.[12] reported that online learning environments may exacerbate statistics anxiety, leading to even higher levels of anxiety, and suggest that interventions should focus on fostering self-efficacy, motivation, and persistence among students. Huang[13] found that taking an introductory statistics course reduced graduate students' statistics anxiety, and identified several activities that could help reduce anxiety, such as emphasizing basic ideas to assure mastery, allocating additional time for statistics study, focusing on fewer topics each time to improve learning, and connecting statistics learning to students' academic performance study fields.

Gender differences have also been observed in statistics anxiety. Eduljee and LeBourdais[14] reported that females reported higher levels of test and class anxiety in statistics courses than males. Edirisooriya and Lipscomb[15] highlighted that age and gender significantly influenced statistics anxiety among graduate students, with older students reporting higher levels of anxiety and males experiencing higher anxiety when seeking help from professors or fellow students. Najmi et al.[16] found that Statistical anxiety has a detrimental impact on student's academic achievement and attitudes toward statistics, particularly among females who tend to exhibit higher levels of anxiety.

Research has discovered numerous factors that contribute to statistics anxiety among students. Bourne's[17] study suggests that trait anxiety is the clearest predictor among first-year undergraduate psychology students, while better mathematical ability, enjoyment, and confidence are linked to more positive attitudes toward statistics. De Vink[18] reported that self-efficacy and certain personality traits were found to be related to statistics anxiety but did not affect statistical performance or mediate the relationship between other variables

and statistical performance. According to Trassi et al.[19], statistics anxiety was significantly predicted by self-efficacy, learning strategies, procrastination, and self-perception among university students

Kiss et al.[20] suggest that instructors should aim to foster a positive classroom climate through community building, utilize interactive instruction methods, provide flexible office hours and anonymous question options, and offer feedback on student writing to alleviate statistics anxiety in students. Tutkun[21] indicates that an understanding the sources of anxiety, such as math and exam stress, computer skills, and foreign language abilities, is also important for more effective teaching In conclusion, statistics anxiety is a prevalent issue among students, and effective interventions are needed to mitigate its negative impact on academic and personal development.

3. Methodology

The study utilized the STARS questionnaire, a 51-item survey accessible online through the link http://www.psych.qub.ac.uk/surveys/STARS/. Participants, consisting of students enrolled in engineering mathematics 3 courses, were informed about the study and invited to complete the questionnaire during a three-week period in March 2023. A total of 47 participants responded to the survey. The questionnaire included demographic inquiries and assessed anxiety levels using a 5-point Likert scale across six scales. The first 23 items required participants to indicate their anxiety levels, ranging from no anxiety to strong anxiety, while the subsequent 28 items focused on agreement levels, varying from strongly agree to strongly disagree. The questionnaire's reliability was established through 5-week test-retest assessments, showing reliability scores between 0.67 and 0.83. Concurrent validity was affirmed by strong positive correlations observed with the Mathematics Anxiety Scale developed by Cruise et al.[22] whose devised the Statistical Anxiety Rating Scale (STARS). It is made up of 51 items divided into two divisions, each is assessed on a Likert scale with five points. Participants are asked to score their level of anxiety in certain scenarios in the first section, and their attitudes toward statistics will be evaluated in the second. The STARS are constructed up of six domains: test and class anxiety (TCA), statistics fear of teachers (SFA), fear of asking for help (FAH), interpretation anxiety (IA), worth of statistics (WOS), and computation self-concept (CSC).

The first three domains (TCA, IA, and FAH) assess statistical anxiety by asking participants were asked to rate their level of anxiety in various scenarios on a scale of "not at all anxious" to "extremely anxious." There are eight indicators for test and class anxiety, eleven for interpretation anxiety, and four for fear of asking for help.

The STARS component assesses attitudes toward statistics on three domains: WOS, FST and CSC. Participants rate their level of agreement from 1 to 5 on a 5-point Likert scale from "strongly disagree" to "strongly agree". WOS worth 16 points, CSC is worth seven items, and FST is worth five items. Polytechnic Ibrahim Sultan was used to recruit a convenience sample of engineering students who had signed up for a statistics course at the time.

4. Analysis data

According to the pie chart (**Figure 1**), out of the total number of students enrolled in the statistics course, 47 students (67.1%) were male, while 23 students (32.9%) were female.

Table 1 shows the descriptive measurements for the STARS domain. The students were the most anxious in the WOS domain (64.55%), followed by TCA (59.46%), FST (57.21%), CSC (56.75%), FAH (53.41%) and IA (52.47%).

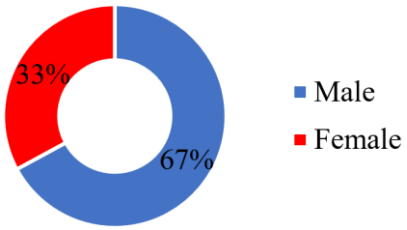

Figure 1. Gender distribution of students enrolled in statistics course.

Table 1. Overall statistics anxiety scores.

Domain	Mean	Std. deviation
TCA (max = 40)	23.7857	7.51982
IA (max = 55)	28.8571	10.08699
FAH (max = 20)	10.6812	4.09265
WOS (max = 65)	41.9571	11.24875
CSC (max = 33)	18.7286	5.48759
FST (max = 20)	11.4429	4.23456

Table 2. Gender differences in statistics anxiety.

Domain	**Males (*n* = 46)**	**Females (*n* = 23)**	**F**
Dependant variables	**Mean (SD)**	**Mean (SD)**	
TCA	22.80 (7.17)	25.44 (8.06)	1.899
IA	28.13 (10.25)	30.13 (10.04)	0.592
FAH	10.59 (3.91)	10.87 (4.53)	0.072
WOS	43.22 (10.81)	39.22 (12.06)	1.943
CSC	19.15 (5.14)	17.78 (6.24)	0.943
FST	12.04 (4.58)	10.09 (3.19)	3.373*

As shown by the mean scores (**Table 2**), males (M = 12.04, SD = 4.58) were more afraid of statistics teachers than females (M = 10.09, SD = 3.19).

Table 3. Correlations between all six STARS domain.

Domain	Cronbach's alpha	IA	FAH	WOS	CSC	FST
TCA	0.74	0.769**	0.663**	0.379**	0.407**	0.275**
IA	0.74		0.808**	0.370**	0.326**	0.343**
FAH	0.77			0.338**	0.391**	0.351**
WOS	0.80				0.522**	0.589**
CSC	0.77					0.630**
FST	0.78					

Table 3 presents the correlations between all six STARS domains. The findings indicate a high positive correlation of 0.808 between interpretation anxiety and fear of asking for help, indicating that these two variables are strongly related. Moreover, interpretation anxiety appears to be strongly associated with fear of asking for help. In contrast, the correlation between test and class anxiety and fear of statistics teachers indicates the lowest score of 0.275, indicating a weak correlation between these two variables. Cronbach's alpha analysis demonstrated that the internal consistency of the worth of statistics domain was quite strong,

while the remaining domains also demonstrated strong internal consistency. This indicates that the measures used in these domains are reliable and consistent.

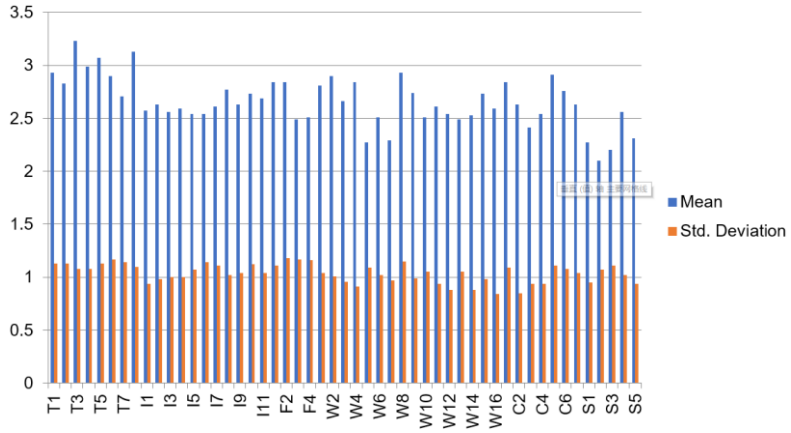

Figure 2. Mean and standard deviation for the domain of the STARS.

After analyzing the data presented in **Figure 2**, several noteworthy findings have emerged. The highest-scoring item in the TCA domain was, "Doing the final examination in a statistics course," with an average score of 3.23. This suggests that students may feel particularly anxious about this particular aspect of their statistics education. In the IA domain, the item that scored the highest was "Figuring out whether to reject or retain the null hypothesis," with an average score of 2.77. This indicates that students may struggle with this aspect of statistical analysis and interpretation, which could have implications for their overall understanding of statistics.

Interestingly, two items tied for the highest mean score in the fear of asking for help domain, "Going to ask my statistics teacher for individual help with material I am having difficulty understanding" and "Asking one of your lecturers for help in understanding a printout," both scored 2.84. This suggests that students may feel hesitant or anxious about seeking help with statistics, which could hinder their ability to learn effectively. In the WOS domain, the item that scored significantly higher than others were, "Statistics is for people who have a natural leaning toward math." This may indicate that students perceive statistics as a subject that is only accessible to those with a particular aptitude or affinity for mathematics.

In the CSC domain, the item "I could enjoy statistics if it weren't so mathematical" scored the highest mean (2.91), suggesting that students may feel more positive about statistics if it were less focused on computation and more on other aspects of the subject. Finally, in the FST domain, the item "Statisticians are more number oriented than they are people oriented" scored the highest mean (2.56). This may suggest that students perceive statistics teachers as being less approachable or less interested in building relationships with their students compared to teachers in other subjects.

Table 4. Descriptive and t-test results on gender and statistics anxiety.

Gender	***N***	**Mean**	**Std. Deviation**	***t*-value**	***p*-value**
Male	46	135.9348	30.79784	0.289	0.236
Female	23	133.5217	36.29033	-	-

The t-test was implemented to compare the statistics anxiety levels of male and female respondents. According to the means in **Table 4**, male students (mean = 135.9348) showed slightly more statistics anxiety than female students (mean = 133.5217). Nevertheless, the *t*-value (t = 0.289) with *p*-value (0.236) is greater

than the yardstick significance of 0.05. Thus, the null hypothesis (H1): that there is a substantial difference in statistics anxiety between male and female respondents is rejected by a 5% margin.

5. Discussions

Summary statistics (means and standard deviations), the t-test, and correlation were used to analyse the data. According to **Table 1**, the vast majority of responses were male (67.0%). The given statement presents a pie chart indicating that 67% of the students enrolled in a statistics course were male, while 33% were female. This gender disparity in enrollment may reflect broader societal trends in STEM fields, cultural and societal expectations about gender roles, and the teaching and learning environment. Addressing these issues and creating a more inclusive and supportive learning environment for all students, regardless of their gender, is crucial to promote gender balance in STEM fields.

Table 2 indicates that the students experience the highest level of anxiety in the worth of statistics domain, followed by test and class anxiety, fear of statistics teachers, computational self-concept, fear of asking for help, and interpretation anxiety. The high anxiety levels suggest that students may have negative attitudes toward statistics and lack confidence in their statistical abilities. This emphasises the need for educators to create a friendly and encouraging learning environment to reduce students' anxiety and build a positive attitude toward statistics. Furthermore, incorporating good teaching methods, enabling personalised support, and encouraging students to active learning could boost their confidence and enthusiasm when learning statistics.

The mean scores demonstrate that males are more afraid of statistics teachers than females. Furthermore, the null hypothesis of equality of variance-covariance matrices is not rejected, showing that the data satisfy the assumption of homogeneity of variance-covariance matrices. Overall, these findings suggest that gender may have a role in influencing fear of statistics teachers among students.

According to the correlation data in **Table 3**, interpretation anxiety and fear of asking for help are highly positively connected. This implies students who have high levels of interpretation anxiety are also likely to have high levels of fear of asking for help. Additionally, the correlation analysis indicates that test and class anxiety and fear of statistics teachers are weakly correlated, suggesting that these two variables may be independent of one another. The high internal consistency of the measures used in all six STARS domains suggests that they are reliable and consistent. Overall, these findings provide valuable insights into the relationships between the different domains of statistics anxiety and highlight the importance of considering multiple factors when assessing and addressing statistics anxiety among students.

The results presented in **Table 4** provide insight into specific aspects of statistics education that students may find particularly challenging or anxiety-provoking. For instance, students seem to experience high levels of anxiety related to final examinations in statistics courses, interpretation of statistical analysis results, and asking for help with statistics-related problems. Moreover, the findings suggest that students may perceive statistics as a subject that requires a natural affinity for mathematics, which could lead to feelings of exclusion or inadequacy among students who do not feel they have this aptitude. Interestingly, students seem to view statistics teachers as less approachable and less people-oriented compared to teachers in other subjects. These findings can inform efforts to design statistics education programs that cater to students' needs, alleviate their anxiety, and build a positive attitude toward the subject.

The findings of the t-test used to compare male and female respondents' statistics anxiety indicate that there is no significant difference between the two groups. Although the mean ratings indicate that male students may be significantly more anxious about statistics anxiety than female students, the *t*-value and *p*-value indicate that this difference is not statistically significant. Therefore, it can be concluded that gender does not

play a significant role in predicting statistics anxiety among students. It is important to note, however, that other factors, such as prior knowledge, teaching methods, and individual learning styles, may influence statistics anxiety and should be considered into account in future research.

Another important factor in minimizing statistical anxiety is the instructor's teaching style. Teachers must keep in mind the different abilities of their students and effectively adjust the pace and method of teaching. It is critical to give students enough time to learn statistical fundamentals before moving on to more difficult topics. Teachers can also use diverse teaching approaches, such as online materials and interactive exercises, to better engage students and accommodate varied learning styles. Creating a supportive and encouraging classroom climate in which students feel comfortable asking questions and seeking assistance can also help to alleviate statistics anxiety.

Perchtold-Stefan et al.[23] examined the findings delineate a promising expandable approach for helping students' cope with statistics anxiety in a healthier way. Findings from Fairlamb[24] suggest that self-esteem concerns are intimately connected with statistics learning, particularly when one's self-worth is staked in an academic domain. Finally, students must practise and reinforce statistical principles through exercises and assignments to learn the subject. Teachers can provide students with a regular opportunity to practise and apply statistical ideas both in and out of the classroom. These exercises can take the shape of group projects, class activities, or individual tasks. Students can improve their problem-solving skills and gain confidence in their ability to use statistical principles in real-world situations by getting enough practise. Finally, minimising statistics anxiety entails providing a supportive environment, good teaching methods, and lots of chances for statistical concept practise and reinforcement.

6. Conclusion

In conclusion, this study has provided valuable insights into the factors contributing to statistics anxiety among students enrolled in statistics courses. The findings underscore the significance of establishing a friendly and encouraging learning atmosphere, incorporating effective teaching practices, and promoting active learning to mitigate anxiety and foster a positive attitude towards statistics. Additionally, the research has highlighted the role of gender differences in influencing students' fear of statistics teachers. It is evident from this research that addressing statistics anxiety requires a multifaceted approach that considers various factors. Educators and institutions should be mindful of the diverse elements impacting students' anxiety levels and tailor interventions accordingly. By creating a supportive environment, employing innovative teaching methods, and offering ample opportunities for practice and reinforcement of statistical concepts, educators can significantly reduce statistics anxiety and enhance students' statistical competence. Moreover, recognizing the potential influence of gender differences on statistics anxiety calls for further exploration and targeted support for affected students. Addressing these disparities will contribute to a more inclusive and equitable learning environment.

In summary, this study contributes valuable knowledge to the field of statistics education, highlighting the importance of a holistic approach to reduce statistics anxiety. By embracing these insights, educators and institutions can empower students to overcome apprehensions, build confidence in statistical analysis, and thrive in their academic pursuits. Continued research and application of evidence-based strategies will pave the way for a future where statistics education is accessible and enjoyable for all students, irrespective of their backgrounds or fields of study.

Author contributions

Conceptualization, NS and SO; methodology, NS; software, NS; validation, NS and SO; formal analysis, NS; investigation, NS; resources, NS; data curation, NS; writing—original draft preparation, NS; writing—review and editing, NS; visualization, NS; supervision, SO and AB; project administration, SO; funding acquisition, SO. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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