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APPLICATIONS OF PAIRED SAMPLES T-TEST IN ASSESSING STUDENTS' ATTITUDES TOWARD PROBABILITY AND STATISTICS

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Abstract:

Introduction to Probability and Statistics (STA116) is a mandatory course for Diploma in Computer Science (CDCS110) students at Universiti Teknologi MARA (UiTM). However, because of their inadequate mathematical and statistical backgrounds, students typically have significant scholastic difficulties when learning probability and statistics. In general, the growth of topic understanding is positively impacted by a positive attitude toward learning probability and statistics. Therefore, it is essential to examine the students' attitude towards this course to determine whether the learning outcomes for this course have been met. Pre- and post-test designs are employed to evaluate participants' attitudes or perceptions of a particular incident or to assess how comfortable they are using the knowledge that was covered in class. A total of 30 students from one class who are taking the STA116 course have been involved in this study. The data was collected in Week 1 (pretest) and in Week 14 (posttest). Overall, the findings show that students' views about probability and statistics improved significantly after learning these subjects as opposed to before they started. Students' views regarding probability and statistics have thereby improved because of the class this semester. There were also notable differences between the pre- and post-test views on probability and statistics. This indicates that after studying this topic for the entire semester, the students' perspectives have evolved. Consequently, educators need to learn more about students' perspectives on

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probability and statistics. Thus, determining students' attitudes toward statistics and designing an instructional approach that improves their statistical literacy will improve their mathematical performance.

Keywords:

Statistics, Probability, Pre-Test, Post Test

Introduction

In Universiti Teknologi MARA (UiTM), Introduction to Probability and Statistics (STA116) is one of the required studies that must be taken by students from the Diploma in Computer Science (CDCS110). This course is made up of fundamental instruments such as drawing graphs and summary measures for characterising data, descriptive statistics and discrete and continuous random variables. Based on Lee et al. (2016), probability is a component of mathematics and cannot be quantified directly as an abstract concept. The views that students have about probability influence how they approach probability-related tasks, resulting in either a productive or a non-productive attitude. The idea of probability and statistics is used in numerous areas, including computer science, mathematics, investment, finance, accounting and most business. In a highly data-centric society, the abilities students acquire in this course will help them become more statistically literate and acquire skills in data management and analysis (Rittle-Johnson, 2017). Students who study probability and statistics will be more able to make accurate predictions, inferences, and explanations about the context of information.

However, in most cases, students have a lot of academic challenges when learning probability and statistics, and this is because their background in mathematics and statistics is not good enough (Kandeel, 2019). According to Agyapong (2014), most students struggle to comprehend fundamental probability ideas. Majority of students struggled to comprehend probability ideas, how they were unable to use tree diagrams to solve probability questions, and how they did not complete probability assignments. Most of these academic challenges are found in the permutation, combination, probability, and random variable classes. The study supported the results of Arum et al. (2017), who found that students struggled with the probabilistic problem and could be categorised into three areas: comprehending the problem, selecting and utilising the right strategies, and using computation to solve the problem.

Basically, one needs to enjoy the learning process in order to retain information and make learning easier. A good attitude towards the subjects will motivate a person to learn the subject much better. As per Adnan and Haslisa (2019) assertion that students' success in particular disciplines is dependent upon their attitude towards the subject. A good attitude towards learning probability and mathematics has a good impact on the development of topic understanding (Tan et al., 2011). Therefore, it is essential to examine the students' attitude towards this course to determine whether the learning outcomes for this course have been met. Pre and posttest are conducted to measure the mean value of students' attitudes before and after studying probability and statistics course. Two sets of pre- and post-tests were given to the students in order to test the effectiveness of the class throughout the 14 weeks.

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Literature Review

There are two sections that will be discussed in the literature review: the definition of attitudes and previous research on students' attitudes toward probability and statistics.

Definition of Attitudes

Several definitions of attitude have been proposed by earlier studies. According to Gal and Garfield (1997), a collection of all the feelings and emotions felt when studying a subject or subjects. Meanwhile, the behaviours, emotions, or thoughts that indicate a person's attitude or perspective stated by Phillip (2007). Al-Mamun et al. (2012) state that an attitude is a psychological concept that denotes a particular behaviour. An attitude is a manner of thinking, acting, and conducting oneself (Mensah et al., 2013). According to Male and Lumbanturuan (2021), one's attitude, which encompasses their perception and reaction to their environment, is crucial in educational environments. Positive attitudes can develop early in the learning process, but depending on how strong they are, they can gradually shift with time (León-Mantero et al., 2020). Ashaari et al. (2011) mentioned that affective factor, cognitive capacity, value, difficulty, interest, and student effort are the six characteristics that identify as influencing students' attitudes towards statistics courses. They continued by saying that students had a very positive attitude and made the required efforts to learn the material more thoroughly.

Students Attitudes towards Probability and Statistics

Basically, the students need to enjoy the learning process to retain information and make learning easier. Therefore, students will study a subject much more effectively if they approach it with positivity. Students' attitudes towards a subject have an impact on how well they succeed in it. According to de Oliveira Junior et al. (2018), students' attitudes and beliefs can help or hinder their ability to study statistics. They can also impact how much they are able to apply what they learn and develop practical statistical thinking abilities. Based on previous research, the students had a positive attitude towards statistics. Their analysis indicated that attitudes towards statistics had a more significant influence on statistics engagement than did self-efficacy (Gopal et al., 2018). According to the findings, during the applied statistics course, students demonstrated greater confidence, more positive attitudes, and fewer negative attitudes. It was agreed by Zin et al. (2023), which stated that the conceptual grasp of statistics among students is significantly related to their attitudes and perceptions. The conceptual comprehension of statistical ideas is moderate among students with positive attitudes and perceptions. Conversely, students who have previously encountered statistics find it to be a challenging and anxiety-inducing topic. Ghulami et al. (2015) proved that students demonstrated greater confidence, more positive attitudes, and fewer negative attitudes during the applied statistics course. Conversely, students who have previously encountered statistics find it to be a challenging and anxiety-inducing topic.

Affective factor, cognitive capacity, value, difficulty, interest, and student effort are the six characteristics that Ashaari et al. (2011) identify as influencing students' attitudes towards statistics courses. They continued by saying that the pupils had a very positive attitude and made the required efforts to learn the material more thoroughly. Positive attitudes towards statistics courses, especially the basic statistics courses, were more common than negative attitudes in a study on students' attitudes towards statistics (Mills & Raju, 2011). A good attitude towards the subjects will motivate someone to learn the subject much better. As per Adnan and Haslisa (2019), the students' success in some subjects is dependent on their attitude

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towards the subject. Additionally, they added that a student's positive attitude towards learning encourages active engagement, critical thinking, enhanced interaction, and communication skills. A study by Calma et al. (2022) found that students see probability and statistics positively. Students were shown to be attracted and interested in probability and statistics, but they also experience anxiety when studying these subjects. On the other hand, students' negative perspectives towards statistics and their lack of confidence in their own statistical ability were shown by the affective and value components. According to both students and teachers, some students have negative attitudes, fears, and expectations when it comes to learning research and statistics (Wisecup, 2017). As stated by Gonda et al. (2022), many students hold the misconception that statistics is just for exceptionally talented individuals.

Methodology

This study is a quasi-experimental design. In order to determine whether any changes can be related to the treatment, a pretest-posttest research design has been employed, where respondents have the identical evaluation measures before and after treatment. Pre- and post-test designs are also employed to evaluate participants' attitudes or perceptions of a particular incident or to assess how comfortable they are using the knowledge that was covered in class. A total of 30 students from one class who are taking STA116 course has been involved in this study. The technique for gathering data has been an online survey. To gather information from respondents for this study, a Google Form was created. The data was collected in Week 1 (Pretest) and on Week 14 (Posttest). The students need to answer the same questionnaires but at the different points in time. The questionnaire has been adopted from de Oliveira Júnior et al. (2018).

In this study, several statistical methods have been used to analyze the data such as descriptive statistics, normality test and dependent samples t-test. Descriptive statistics refers to the transformation of raw data into a form that will make them easy to understand and interpret including frequency table and pie chart. A normality test is used to investigate whether the dependent variables are normally distributed or not. This is because all parametric tests require the variables analyzed to be normally distributed. Alternatively, if the variables are not normal, non-parametric analysis should be used in the analysis. A data normality can also be assessed based on skewness and kurtosis. Even though skewness and kurtosis are frequently employed in practice, there is no set rule that specifies the values that signify normalcy. There have been reports in certain papers suggesting skewness and Kurtosis may be interpreted as normality, while some findings indicated significantly higher values of using skewness and kurtosis to determine whether the data are normal (Şirin et al, 2018). According to Hair et al. (2010), the data is normally distributed if the absolute value of skewness and kurtosis is 2.0 or lower. Meanwhile, the dependent samples t-test is used to compare the sample means from two similar groups. This indicates that the scores for the two groups under comparison are provided by the same individuals. This test aims to identify any differences between one measurement (group) and another. The formula used is:

$$t = \frac{\bar{d} - d_0}{s_d / \sqrt{n}}$$

Where,

Mean pair difference, $\bar{d} = \frac{\sum d}{n}$,

Standard deviation of differences, $s_d = \sqrt{\frac{1}{n-1}\left(\sum d^2 - \frac{(\sum d)^2}{n}\right)}$

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The hypotheses have been created in this study is:

Null hypothesis H_0: There is no difference in mean for pre and post of students' attitudes towards probability and statistics.

Alternative hypothesis H_1: There is a difference in mean for pre and post of students' attitudes towards probability and statistics.

Results

Descriptive Statistics

Table 1 shows the demographic profile of 30 students in one class who are taking Introduction to Probability and Statistics (STA116). It shows that 66.7% of the respondents were from the female group, while 33.3% were from the male group. Then, a high percentage of the respondents were from the age group of 30-49 years old (38.1%), and another 3.3% of the respondents were from the age group of 21 to 23 years old.

Table 1: Demographic Profile Of Students

Variables	Frequency	Percentage (%)
Gender		
Male	10	33.3
Female	20	66.7
Age		
18 to 20 years old	29	96.7
21 to 23 years old	1	3.3

Figure 1 shows the percentage of students who are taking any probability or statistics subject. According to the findings, 83.3% of students took statistics or probability subjects before this, whereas another 16.7% did not.

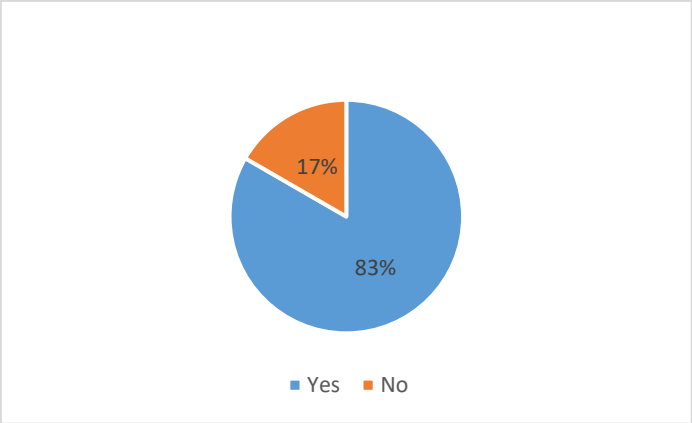

Figure 1: The Percentage of Students Who Are Taking Probability or Statistics as A Previous Subject

Test of Normality Assumption

Table 2 shows the normality test for mean score students' attitude variable.

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Table 2: Test of Normality

Variables	Mean Score	Skewness	Kurtosis
Mean Score Attitudes (Pre-Test)	3.01	0.349	-0.271
Mean Score Attitudes (Post Test)	3.20	0.148	- 0.281

Based on Table 2, the skewness and kurtosis statistics for both variables are within ±1 away from zero. Therefore, these indicate that the distribution of mean scores attitudes towards probability and statistics among students (pre- and post-test) is approximately normally distributed.

Level of Students' Attitudes towards Probability and Statistics (Pre-Test)

The mean score interpretation is displayed in Table 3. Mahamod and Nor (2012) state that there are three categories into which the mean value can be made: low, moderate, and high.

Table 3: Mean Score Interpretation

Mean Score	Interpretation
0.00 – 2.33	Low
2.34 – 3.66	Moderate
3.67 – 5.00	High

Table 4 indicates that the mean range for all items is between 2.50 to 4.00 and the standard deviation (SD) range is between 0.629 to 1.031. Overall, before studying this subject, students' attitudes towards probability and statistics are moderate, with a mean value of 3.11 and a standard deviation value of 0.790.

Table 4: Level of Students' Attitudes (Pre-Test)

No	Items	Mean	SD
B1	I regard Statistics and Probability as much-needed matters in my career.	3.40	0.770
B2	Statistics and Probability issues leave me feeling bad.	2.50	0.682
B3	Studying or working with Statistics and Probability does not scare me.	3.17	0.791
B4	Using elements of Statistics and Probability is fun for me.	3.27	0.691
B5	Statistics and Probability are too theoretical to be used in my professional practice.	3.03	0.809
B6	I want to have a deeper knowledge of Statistics and Probability.	3.93	0.691
B7	Statistics and Probability are topics that I am afraid of the most.	2.97	0.890
B8	I have confidence in myself when I face statistical and probabilistic problems.	3.03	0.809
B9	I have fun talking to others about Statistics and Probability.	3.93	0.691
B10	Statistics and Probability may be useful to those involved in research but not to other professionals.	2.97	0.890
B11	Knowing how to use Statistics and Probability would increase my chances of working.	2.87	0.629
B12	When I come across a statistical or probabilistic problem, I cannot think clearly.	2.83	0.747
B13	I calm down when I am solving a statistical or probabilistic problem.	2.83	1.020

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B14	The statistics and odds are nice and stimulating for me.	4.00	0.788
B15	I hope to use little statistical or probability in my professional life.	2.70	0.702
B16	For the professional development of my career, I believe there are other issues that are more important than Statistics and Probability.	2.87	0.819
B17	Working with Statistics and Probability makes me very nervous.	3.00	0.743
B18	I do not change my behaviour when I have to work with statistics and probability problems.	3.27	0.785
B19	I would like to have a profession in which I would have to use Statistics and Probability.	3.33	0.711
B20	I have great satisfaction in solving statistical and probabilistic problems.	3.03	0.999
B21	For the professional development of my career, one of the most important subjects to be studied is Statistics and Probability.	2.80	0.664
B22	Carrying statistics makes me uncomfortable and nervous.	2.73	0.828
B23	If I worked, I think I would dominate the statistical and probabilistic contents.	3.20	1.031
B24	If I had the opportunity, I would enroll in other courses in Statistics and Probability.	3.13	0.860
B25	The subject that is taught in the Statistics and Probability class is very uninteresting.	2.87	0.681
	Attitudes (Pre-Test)	**3.11**	**0.79**

Level of Students' Attitudes towards Probability and Statistics (Post-Test)

Table 5 indicates that the mean range for all items is between 2.40 to 4.03 and the standard deviation range is between 0.691 to 1.163. Overall, after studying this subject, students' attitudes towards probability and statistics are moderate, with a mean value of 3.26 and a standard deviation value of 0.865. However, the mean value has increased compared to the pre-test before studying probability and statistics.

Table 5: Level of Students' Attitudes (Post-Test)

No	Items	Mean	SD
B1	I regard Statistics and Probability as much-needed matters in my career.	3.77	0.774
B2	Statistics and Probability issues leave me feeling bad.	2.40	0.814
B3	Studying or working with Statistics and Probability does not scare me.	3.63	0.809
B4	Using elements of Statistics and Probability is fun for me.	3.73	0.980
B5	Statistics and Probability are too theoretical to be used in my professional practice.	2.80	0.761
B6	I want to have a deeper knowledge of Statistics and Probability.	3.83	0.834
B7	Statistics and Probability are topics that I am afraid of the most.	2.60	1.163
B8	I have confidence in myself when I face statistical and probabilistic problems.	3.67	0.711
B9	I have fun talking to others about Statistics and Probability.	3.33	0.802
B10	Statistics and Probability may be useful to those involved in research but not to other professionals.	3.07	0.691

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B11	Knowing how to use Statistics and Probability would increase my chances of working.	3.93	0.907
B12	When I come across a statistical or probabilistic problem, I cannot think clearly.	2.53	0.730
B13	I calm down when I am solving a statistical or probabilistic problem.	3.40	0.932
B14	The statistics and odds are nice and stimulating for me.	3.30	0.837
B15	I hope to use little statistical or probability in my professional life.	3.53	0.973
B16	For the professional development of my career, I believe there are other issues that are more important than Statistics and Probability.	3.13	0.900
B17	Working with Statistics and Probability makes me very nervous.	3.00	1.050
B18	I do not change my behaviour when I have to work with statistics and probability problems.	3.33	0.884
B19	I would like to have a profession in which I would have to use Statistics and Probability.	3.07	0.828
B20	I have great satisfaction in solving statistical and probabilistic problems.	4.03	0.890
B21	For the professional development of my career, one of the most important subjects to be studied is Statistics and Probability.	3.43	0.858
B22	Carrying statistics makes me uncomfortable and nervous.	2.60	1.070
B23	If I worked, I think I would dominate the statistical and probabilistic contents.	3.20	0.847
B24	If I had the opportunity, I would enroll in other courses in Statistics and Probability.	3.77	0.774
B25	The subject that is taught in the Statistics and Probability class is very uninteresting.	2.40	0.814
	Attitudes (Post-Test)	**3.26**	**0.865**

The Paired (Dependent) Samples T-Test

Table 6 presents the results of paired t-tests for the pre- and post-tests. At the 5% significance level, the null hypothesis is rejected because the p-value is less than the significant level ($p = 0.013 < \alpha = 0.05$). Thus, it can be concluded that there is a statistically significant difference between the mean values of the pre- and post-tests. Therefore, it is evident that the students' attitudes towards probability and statistics have significantly improved since they began studying this subject and continued to do so throughout the semester.

Table 6: Paired T- tests

		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**	**t**	**df**	**Sig. (2-tailed)**
Pair 1	**Before - After**	-0.189	0.394	.0719	(-0.336, -0.042)	-2.635	29	.013

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Discussion

The statement "The statistics and odds are nice and stimulating for me" obtained the highest mean score before studying probability and statistics (pre-test), with a mean of 4.00. The results of this study were consistent with those of Calma et al. (2022), who stated that probability and statistics are attractive and fun to learn. Meanwhile, the highest mean score after studying probability and statistics was obtained by the statement "I have great satisfaction in solving statistical and probabilistic problems," with a mean score of 4.03. Salifu and Dokurugu (2022) also proved that most students feel confident when faced with statistical challenges. In addition, the statement "Statistics and Probability Issues Leave Me Feeling Bad" has the lowest mean score for both the pre- and post-test. Most students liked to study probability and statistics. The students' attitudes after studying probability and statistics have a positive impact on increasing their knowledge of this subject. Initially, the average student attitude towards probability and statistics was 3.11. However, after studying this subject, the mean value increased, and the post-test revealed that 3.26 was at a moderate level. Consequently, the course has improved students' views towards probability and statistics over the course of the semester.

Overall results show that there is a difference between mean score of attitudes before and after studying probability and statistics course. The study results indicate that the students' attitude towards probability and statistics has significantly improved after studying this subject for 14 weeks. The usefulness and numerous activities conducted in class during the 14-week probability and statistics course have fundamentally transformed the students' attitudes. As a result, the students' views regarding probability and statistics have significantly changed since they started taking this course and throughout the semester. Gerald and Allan (2018) agreed with this observation. Their study showed that students' academic performance in probability distributions in statistics was enhanced through sharing knowledge. The findings imply that when statistics classes use a cooperative learning approach, students' attitudes about statistics are greatly improved and typically take a positive turn. These outcomes are in line with what other studies have found about students' reactions to sharing knowledge. According to Koparan and Guven (2014), there is a statistically significant difference between the mean values of the pre- and post-tests after implementing project-based learning in class. The study's findings showed that the intervention group's students' attitudes towards statistics improved because of project-based learning. As a result, it is advised that project-based learning be included in statistics courses. They promoted the idea that project-based learning might provide a wonderful setting for learning. Projects allow students to engage in activities that align with their personal interests. These results suggest that students' attitudes towards probability and statistics will fundamentally shift once they study and actively participate in class. Incorporating a lot of activities, works, and projects in the classroom would improve university students' understanding of probability and statistics.

Conclusion

Overall, the results indicate a significant increase in the mean score of students' attitudes towards probability and statistics after studying these subjects compared to before they began. As a result, the class throughout the semester has had a positive effect on students' attitudes towards probability and statistics. Additionally, attitudes in probability and statistics were found to be significantly different between the pre- and post-test. This means that the students' attitudes have changed throughout the semester after studying this subject. Therefore, instructors need to know more about the attitudes and ideas that students have regarding probability and statistics. Students' success in mathematics will be enhanced if their attitudes

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towards statistics are defined and the instruction method is planned to increase their statistical literacy. Instructors make students aware of the real-world uses of statistical research. Instructors can therefore aid in changing students' perspectives.

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