A TOPIC-SPECIFIC EVALUATION OF STUDENTS' ATTITUDES TOWARDS STATISTICS

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This study involves an evaluation of students' attitudes towards various topics in statistics. The purpose of the study is to determine how students' attitudes towards statistics vary across different topics and to determine possible changes in students' attitudes from the beginning to the end of a course. The target population is that of students taking a statistics course for non-majors at a university in Nigeria. The study involved a pre-test (within the first week of the course) and a post-test (applied at the end of the course) focused on specific topics in the statistics course. Results indicated that students' attitudes were moderately positive at the onset and remained the same at the end of the course for most topics. Implications for teaching statistics are discussed.

INTRODUCTION

The place of statistics for decision making across various fields of human endeavor cannot be overemphasized. Moreover, in recent times, there has been an increase in the realization of the need for statistical literacy by all. It is, however, one thing to need to take courses in statistics and another thing to have the right attitude towards it. Students' attitude towards statistics is one of the major concerns in statistics education given the large number of articles in this regard (e.g., Ashaari et al., 2011; Cashin & Elmore, 2005; Gal et al., 1997; Garfield et al., 2002; Gundlach et al., 2015; Oliveira Júnior et al., 2018; Schau & Emmioglu, 2012; Schau et al., 1995; Whitaker et al., 2022), and the fact that different scales have been developed for this purpose. The most popular attitude scale has hitherto been the Survey of Attitudes Toward Statistics (SATS) scale by Schau et al. (1995), with a later version in 2003. Some details about various scales can be found in Oliveira Júnior et al. (2018), where a study on student's attitudes towards probability and statistics was presented. One of the conclusions made by these authors was that the study of attitudes contributes to the effectiveness of the educational process in the teaching of probability and statistics. Earlier, Ashaari et al. (2011) presented a paper on attitudes of students in Information Science and Technology and contributed to knowledge on producing effective and innovative teaching and learning of statistics.

The importance of attitudes towards statistics cannot be overemphasized because it determines, to a large extent, the rate of acquisition of and, most especially, appropriate applications of statistical thinking. In a study on importance of attitudes in statistics education, Ramirez et al. (2012) presented a Model of Students' Attitudes Toward Statistics (SAT-M). The SAT-M was made up of student characteristics, previous achievement and related experiences, and statistics attitudes. The authors inferred from the study that all constructs of SAT-M should be interrelated and that they impact important course outcomes. Specifically, the review of previous studies by Ramirez et al. indicated that relationships among student characteristics and statistics attitudes were complex, having a pattern that suggests the need to consider multiple student characteristics concurrently, and suggesting a need for engagement in planned and consistent research across countries.

Researchers have assessed the attitudes of undergraduates towards statistics under various educational approaches, interventions, or demographic factors. For example, Gundlach et al. (2015) compared pre- and post-course attitude scores of students under traditional, online, and flipped classes. They discovered that students across all section types tended to have decreases in scores from pre- to post-course on value, interest, and effort scales (Gundlach et al., 2015).

Peiro-Signes et al. (2020) presented a survey on attitudes of students at the secondary education level towards statistics whereby the results indicated that self-confidence and motivation were important factors leading to low and high levels of anxiety. In another study, Opstad (2020) considered the influence of gender, mathematical skill, and personal traits on attitudes towards statistics among business students in a Norwegian business school. The results suggested the

In S. A. Peters, L. Zapata-Cardona, F. Bonafini, & A. Fan (Eds.), *Bridging the Gap: Empowering & Educating Today's Learners in Statistics. Proceedings of the 11th International Conference on Teaching Statistics (ICOTS11 2022), Rosario, Argentina.* International Association for Statistical Education. iase-web.org

existence of a substantial gender gap in attitudes toward statistics, although the gap became smaller when taking mathematical skills and personal characteristics into consideration.

These are just few of the numerous contributions on attitudes towards statistics. To the best of our knowledge, research has not been focused on attitudes towards specific topics in statistics. In this study, we examine possible variations in students' attitudes towards different topics in statistics. It was essentially aimed at emphasizing how the knowledge of students' initial attitudes towards specific topics could be used by teachers for teaching the course.

METHODOLOGY

Research Design

The study adopts the use of primary data through questionnaire administration. There were two stages. The pre-test was carried out within the first week of the course, and the post-test was carried out during the last week of the course, just before the final examination. This study was designed to focus on two main goals to evaluate students' attitudes towards specific topics in statistics and to use the information to improve instruction and improve students' attitudes towards statistics as a whole. The topics covered in the course were grouped into 10 categories for the purpose of this research and stated as follows in the questionnaire for easy identification by students:

- Mean, median, mode, variance, and standard deviation;
- Probability;
- Pie charts, bar charts, and graphical displays of data;
- Correlation and regression;
- Frequency distribution/table;
- Quartiles, deciles, and percentiles;
- Hypothesis testing;
- Chi square test of independence;
- Analysis of variance; and
- Use of statistical software.

Target Population

The study was focused on students taking an applied statistics course: Statistics for Agricultural and Biological Sciences, a 200-level course housed in the Department of Mathematical Sciences at the Redeemer's University, Ede, Osun State, Nigeria. The course is introductory. There were five departments, Anatomy, Biochemistry, Microbiology, Physiology, and Physiotherapy in Redeemer's University, Ede, whose students studied in this 200-level applied course.

Instrument

The instrument used was the Survey of Attitudes Towards Statistics (SATS-36) by Schau (2003) that uses a 7-point Likert scale (1 = Strongly Disagree, 4 = Neither Disagree nor Agree, 7 = Strongly Agree). The instrument measures the six attitude components of affect, cognitive ability, value, difficulty, interest, and efforts of students. The questionnaire was adapted for attitudes towards specific topics. However, for the specific topics, to avoid having a questionnaire that was too lengthy and that might lead to unreliable responses, only 12 questions (items) from the general attitude items across five out of the six components of the attitude scales in SATS were selected for administration. The distribution of items across components was as follows: two questions on "Affect," four questions on "Cognitive Competence," three questions on "Value," two questions on "Difficulty," and one question on "Interest." This was not regarded as a setback because the complete SATS-36 was used to evaluate students' overall attitudes towards statistics. Knowledge of variations in attitudes across different topics from the pre-test was considered in the course delivery to guide a more focused delivery. Students' attitudes towards specific topics were also measured by the post-test survey alongside students' attitude towards the entire statistics course.

The Cronbach alpha for reliability test on general attitude items was 0.901 for all items and 0.787 for Affect; 0.772 for Cognitive Competence; 0.802 for Value; 0.559 for Difficulty; 0.918 for Interest, and 0.882 for Efforts. In the case of specific topics, the reliability ranged between 0.789 and 0.871, which indicates sufficient internal consistency of the questions.

RESULTS AND DISCUSSION

Hypotheses

There are two hypotheses for this study. They are:

1. H_1: On average, there is a significant difference in individual respondents' attitudes between the pre-test and post-test for different statistics topics and for statistics as a whole.
2. H_2: On average, there is a significant difference in paired item scores between pre-test and post-test for different statistics topics and for statistics as a whole.

Data Description

There were five major courses of study for students who enrolled in the statistics course. They are Anatomy, Biochemistry, Microbiology, Physiology, and Physiotherapy. The distribution of respondents across these five major courses of study is displayed in Table 1 for both the pre-test and the post-test surveys. Most of the students were from the physiotherapy programme, and the remaining students were spread across the other departments. A test of association suggested that students' attitudes towards statistics as a whole did not vary between physiotherapy students and others (when other courses were combined) in the pre-test ($p = 0.244$) but varied significantly in the post-test ($p = 0.016$).

Table 1. Distribution of respondents by major course of study

Major Course of Study	Pre-test		Post-test	
	Number	Percent	Number	Percent
Anatomy	6	7.1	7	8.4
Biochemistry	10	11.8	7	8.4
Microbiology	13	15.3	20	24.1
Physiology	5	5.9	12	14.5
Physiotherapy	51	60.0	37	44.6
Total	85		83	

Respondents were asked to create a unique identification in the pre-test survey and to use the same identification in the post-test survey in order to have comparisons paired by respondents. However, at the end of the survey, there were only 29 paired responses out of the 85 pre-test and 83 post-test responses. Table 2 contains the results of the paired *t*-test (using the 29 available matched pairs) for assessing possible changes in students' attitudes at the end of the course. We also analyzed unmatched data on all 85 pre-test responses and 83 post-test responses to assess overall changes in attitude for each of the specific topics.

Results and Discussion

Respondents' matched pairs tests to determine significant changes in average individual score differences between the pre-test and post-test. These tests concern the first hypothesis (H_1). Results from the matched pairs *t*-test for individual respondents (see Table 2) suggest that there is no significant change in the average score difference between pre-test and post-test for all topics presented in the course as well as for statistics overall. It implies that the first hypothesis is not supported. This is probably due to the small size of available matched pairs; a more elaborate study with a larger sample size might reflect variations across the topics as suggested in the next paragraph, although responses were matched item by item.

Items' matched pairs test to determine significant changes in average item score differences between the pre-test and post-test. These tests address the second hypothesis, and the results are presented in Table 3. The results indicated that for probability, charts, quantiles, and analysis of variance, there was a significant decrease in the average score difference. These results support the second hypothesis for some of the topics. Average attitude scores on the pre-test and the post-test reflect the decreases. In the pre-test using all 85 responses, the average attitudes scores were greater than 4.5 for all the topics and are thus considered to be positive attitudes on this 7-point Likert scale.

On the other hand, the average attitudes scores from the post-test (using all 83 responses) for some topics (chi-square test of independence; analysis of variance; use of statistical software) were lower than 4.5.

Table 2. Respondents matched pairs *t*-tests

Topics	Paired Differences		*t*	*df*	*p*-value
	Mean	Std Error			
Measures of average and dispersion	0.1686	0.1600	1.05	28	0.30
Probability	0.1907	0.1609	1.19	28	0.25
Charts	0.2221	0.1650	1.35	28	0.19
Correlation and regression	0.0393	0.1706	0.23	28	0.82
Frequency distribution	0.0821	0.1553	0.53	28	0.60
Quantiles	0.0962	0.1680	0.57	28	0.57
Hypothesis testing	0.0617	0.1878	0.33	28	0.75
Chi-square test of independence	0.0993	0.1755	0.57	28	0.58
Analysis of variance	0.1810	0.1782	1.02	28	0.32
Use of statistical software	0.3041	0.1782	1.63	28	0.11
Overall attitude towards statistics	0.1527	0.1316	1.16		0.26

Table 3. Items' matched pairs tests

Topics	Pre-test Mean	Post-test Mean	Paired Differences		*t*	*df*	*p*-value
			Mean	Std Error			
Measures of average and dispersion	5.38	5.10	0.213	0.102	2.10	11	0.06
Probability	5.24	4.68	0.489	0.099	4.93	11	0.00
Charts	5.37	4.96	0.353	0.102	3.47	11	0.01
Correlation and regression	4.77	4.68	0.056	0.136	0.41	11	0.70
Frequency distribution	5.20	4.82	0.317	0.254	1.25	11	0.24
Quantiles	4.87	4.52	0.308	0.096	3.20	11	0.01
Hypothesis testing	4.68	4.56	0.097	0.141	0.69	11	0.51
Chi-square test of independence	4.63	4.36	0.253	0.211	1.20	11	0.26
Analysis of variance	4.70	4.36	0.326	0.114	2.87	11	0.02
Use of statistical software	4.67	4.22	0.424	0.215	1.97	11	0.07
Overall attitude towards statistics	4.78	4.48	-0.308	0.127	-2.43		0.02

Although the mean attitude scores for all topics were positive on the pre-test, we noticed that they were smaller for hypothesis testing, chi-square test of independence, and use of statistical software. This informed the need for course instructors to intensify efforts on these topics as well as others, by employing useful tactics for developing optimum knowledge in the course. Regardless of the fact that there were no positive changes at the end of the course as judged by the post-test results, the usefulness of inferences drawn from this study still stands for subsequent sessions. Many other factors might have contributed to the lack of positive changes in attitudes which could be investigated in other to further consider explanations for the results.

The results also showed students' positive attitudes towards all six components of the attitude scales in the pre-test and post-test except for Difficulty for both pre-test and pre-test and Interest for the post-test (Table 4). There was a negative change in the overall attitude towards statistics for all components except Effort, which did not have significant change in the post-test relative to the pre-

test with mean scores 6.12 and 6.29, respectively. Some results in literature (e.g., Bateiha et al., 2020) also showed negative changes or no changes among the Attitude component as measured by the SATS-36. Throughout all the statistics topics as well as the overall attitude, the variation was higher for the post-test than the pre-test. This can be explained from the fact that by the post-test period, the students had already been taught statistics, and their attitudes could vary based on their reception of the teachings.

Table 4. Mean scores for components of the attitudes scale

Attitude Component	Affective	Cognitive ability	Value	Difficulty	Interest	Efforts
Pre-Test	5.12	5.44	4.81	4.07	5.16	6.29
Post-Test	4.51	4.83	4.62	3.95	4.38	6.12

CONCLUSION

Results from this study suggest that attitudes towards statistics may vary among topics covered in an introductory/elementary statistics course. The teachers in the particular course on which this study was based are concerned with negative changes in students' attitudes towards some statistics topics. This concern will inform updating instructional methods, aids, and materials for the course in subsequent sessions. The significance of this study is to encourage statistics teachers to take a survey of attitudes towards different topics in a statistics course, both at the beginning and end of the course. Information gathered from such a survey could then be used within the same session as well as subsequent sessions for improved instruction and consequently, better statistical literacy.

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