# INVESTIGATING THE ATTITUDINAL DIFFERENCES OF STUDENTS IN SERVICE AND MAINSTREAM COURSES TOWARDS STATISTICS

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**ABSTRACT**–In this paper, we report on the attitudinal differences of students in service and mainstream courses towards statistics. Knowledge regarding descriptive and inferential statistics are required in a variety of courses over many faculties at tertiary level. An overview of the literature confirms, especially in developing countries, the under-preparedness (not only on first-year level), inadequate performance and somehow daunting attitude of students in statistics courses. Data collected from an international recognised instrument (SATS-36) revealed students' perceived attitudes towards statistics concerning six components; affect, cognitive competence, value, difficulty, interest and effort. Significant differences between students' attitudes in mainstream and service courses were detected, and furthermore between gender groups. These results could inform lecturers of statistics courses whether changes (major or minor) in curriculum and teaching methods are required to improve students' attitude, and ultimately their competencies.

**Keywords:** Statistics education; Student attitudes in mainstream statistics courses; Student attitudes in service module statistics courses; Learning statistics.

## 1. INTRODUCTION

Over the last two decades statistics education emerged worldwide as a discipline in its own right (Garfield & Ben-Zvi, 2007; Jose, 2017), although it is closely connected to mathematics education. Within the South African education system, the topics statistics and probability are initially introduced to students as a component of the mathematics school curriculum (CAPS, 2011). Furthermore, fundamental and progressive statistical knowledge that requires competencies such as representing data, calculating probability, notion of distribution, variability, sampling and statistical inference, is required in a variety of courses over many faculties (science, engineering, business, humanities, education and others) at tertiary level. The students enrolled for these courses do not necessarily have a strong mathematical background. The unsatisfactory performance of students (particularly in developing countries) in mathematics at school is well documented and confirmed by international tests of educational achievement, such as TIMSS (Trends in International Mathematics and Science Study) (Juan & Visser, 2017; Spaull, 2013), and similar trends are experienced at tertiary level (Rylands & Coady, 2009). Rylands and Coady (2009) highlight the importance of students' strong mathematical secondary school background on their performance in science subjects at first-year tertiary level. Furthermore, research findings from Yousef (2017) emphasize, apart from mathematical knowledge, additional aspects playing a role in students' understanding of quantitative course material at tertiary level (not only on first-year level). These aspects are the teaching style of the lecturer in relation to how the lecturer speaks, the pace and structure of presenting the content, the communication between lecturer and student and language of instruction, and the availability of course content via an electronic learning environment.

In addition, positive attitudes of students towards statistics could influence students' enrolment, achievement and motivation towards quantitative courses (Coetzee & van der Merwe, 2010). Research results from Coetzee and van der Merwe (2010, p. 1) reveal, "the degree to which students perceived themselves to be competent in mathematics was related to the degree to which they felt confident in their own ability to master statistics". The authors are of the opinion that students from different faculties view and experience the learning of statistics courses (mainstream courses versus service module courses) differently, and findings from Sulieman (2015), comparing student attitudinal differences across different majors, strengthen this opinion. In this inquiry, the authors compare the attitudes of students at a public university in South Africa, in the Faculty of Science (students enrolling

for statistics as a mainstream course) with the attitudes of students in the Faculties of Management and Engineering (students enrolling for statistics as a service module course). The two research questions are: (1) what are the differences between the attitudes of students in service and mainstream courses towards statistics, and (2) are there differences between the attitudes of gender groups in statistics courses? In answering these research questions, the authors attempt to broaden their knowledge about how students experience statistics courses over disciplines. These results could contribute towards major or minor changes in curriculum and teaching methods, at public universities in developing countries, to enhance students' learning in statistics.

## 2. THEORETICAL FRAMEWORK

The authors grounded their view on learning statistics, such that students develop a conceptual understanding of the content, on the "Statistical Reasoning, Thinking, and Literacy" framework from Garfield and Ben-Zvi (2007, p. 380). According to this framework, there is a clear distinction between statistical literacy, reasoning and thinking. Although all three components are interconnected and a type of hierarchy does exist, statistical literacy forms the foundation for reasoning and thinking. Garfield and Ben-Zvi (2007, pp. 380-381) explain, *Statistical Literacy* (which is often the expected outcome of introductory courses in statistics) is an "understanding and using the basic language and tools of statistics: knowing what basic statistical terms mean, understanding the use of simple statistical symbols, and recognising and being able to interpret different representations of data", whereas *Statistical Reasoning* is "the way people reason with statistical ideas and make sense of statistical information", and *Statistical Thinking* "involves a higher order of thinking than statistical reasoning … the way professional statisticians think". Hence, the authors are of the opinion all three components are important for students to develop a proficiency in statistics. Garfield and Ben-Zvi (2007), supported by other literature sources (Bakker & Gravemeijer, 2004; Chick & Watson, 2002; Garfield & Chance, 2000; Pfannkuch, 2005) in the field of statistics education and based on original work from Garfield (1995), introduced a list of eight principles about how students learn statistics. These research-based principles (Garfield & Ben-Zvi, 2007, pp. 387-389), which provide insight to lecturers, are: (1) "students learn by constructing knowledge" (they enter the learning environment with prior knowledge and tend to accept new ideas only if their previous ideas do not work), (2) "students learn by active involvement in learning activities" (they tend to learn cooperatively when solving problems), (3) "students learn to do well only what they practice doing" (they tend to learn more efficiently when they experience applying new ideas), (4) "difficulty students have in understanding basic concepts of probability and statistics" can easily be underestimated, as well as an overestimation of (5) "how well students understand basic concepts", (6) "learning is enhanced by having students become aware of and confront their errors in reasoning" (they are often slow to change misconceptions), (7) "technological tools should be used to help students visualize and explore data, not just to follow algorithms to pre-determined ends" (these tools provide students opportunities to explore), and (8) "students learn better if they receive consistent and helpful feedback on their performance" (they require time to reflect on the feedback, make changes and attempt problems again).

An overview of the literature suggests a relation between learning statistics and a positive attitude towards the discipline. Coetzee and van der Merwe (2010) confirms the latter and explain attitudes towards statistics is a multidimensional concept, focusing first on an affective domain such as emotions and motivation, second on a cognitive domain such as beliefs and knowledge about the discipline and third on a behavioural domain with regards to tendencies in studying the content. The authors considered the theory on learning statistics and fostering a confident attitude towards statistics as equally important components.

## 3. RESEARCH DESIGN

This inquiry relates to an attempt to measure the attitudes of students in mainstream and service courses towards statistics, conducted from a *post-positivist* worldview (Creswell, 2013), where quantitative data was collected by using an internationally recognised instrument, namely the Survey of Attitude Toward Statistics (SATS-36). Schau et al. (1995) first introduced the SATS-28 questionnaire, which consisted of 28 questions divided into four factors, namely, affect (describing students' feelings concerning statistics), cognitive competence (relating students' attitudes about their intellectual knowledge and skills when applied to statistics), value (unfolding students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life) and difficulty (telling students' state of mind about the difficulty of statistics as a subject). Later, Schau (2003) extended the original 28-item version to a 36-item version (SATS-36) to include two additional factors; interest (describing students' level of individual interest in statistics) and effort (clarifying the amount of work the student expends to learn statistics). The responses for the SATS-36 survey were measured on a 7-point Likert scale (1 = strongly disagree, 4 = neither disagree nor agree, 7 = strongly agree), where higher scores correspond to a more positive attitude.

Six hundred (600) undergraduate students, studying on a full time basis at the University of Johannesburg (UJ), took part in this investigation. A convenient sampling method was utilized and participants completed the survey online via the UJ student portal during the first term of the academic year in 2017. The participants consisted of 130 first year students (39 female, 91 male) from the Faculty of Science, 196 third year students (42 female, 154 male) from the Faculty of Engineering and 274 first year students (155 female, 119 male) from the Faculty of Management. A summary of descriptive statistics is displayed in Table 1. Approximately 26% of participants were not at all likely to choose statistics to be part of their degree if the choice had been theirs and only 19% of participants' indicated English (the medium of instruction at UJ) as their home language.

**Table 1. Characteristics of the participants**

| Item | Category | Frequency | Percent |
|---|---|---|---|
| Gender | Female | 236 | 39.3 |
| | Male | 364 | 60.7 |
| Race | Black | 481 | 80.2 |
| | White | 65 | 10.8 |
| | Other (Asian Coloured, Indian, etc.) | 53 | 8.9 |
| If the choice had been yours, | Not at all likely | 155 | 25.8 |
| how likely is it that you would | Somewhat likely | 260 | 43.3 |
| have chosen to take statistics? | Very likely | 178 | 29.7 |
| What is your home language? | Afrikaans | 18 | 3.0 |
| | English | 115 | 19.2 |
| | Indigenous South African or African language | 442 | 73.7 |
| | Other (Chinese, French, Portuguese, etc.) | 24 | 4.1 |

## 4. STATISTICAL ANALYSIS AND DISCUSSION

During analysis, the authors compared the general attitude of participants towards statistics in service and mainstream courses. Each of the statistics courses (in the respective faculties) is tailored (in terms of content and level of difficulty) to meet the specific requirements. Therefore, the authors expected difference in attitude towards statistics to some extent. The validity and reliability of the SATS-36 survey have been confirmed in former studies (Coetzee & van der Merwe, 2010; Mills, 2004). More specifically, Coetzee and van der Merwe (2010) confirmed the instruments' reliability for a South African sample of

industrial psychology students. We reconfirmed these results, based on the sample in this inquiry, by conducting a confirmatory factor analysis (not displayed in this paper) and calculated Cronbach's alpha levels (see Table 2), which demonstrated internal consistency. All six factors (affect, cognitive competence, value, difficulty, interest and effort) had acceptable Cronbach alpha levels that were consistent with former studies. The authors suspect the lower Cronbach alpha for the factor *difficulty*, is largely due to the variation in difficulty levels between mainstream and service courses. The modal, median and mean scores (out of 7) for each factor are shown in Table 2. First results from the analysis (conducted via SPSS, version 24), indicated participants perceived attitudes towards statistics are mostly positive in nature. From Table 2, most scores were above 4, indicating a more positive attitude. The factor *difficulty* seemed to be the most negative prevailing attitude towards statistics in service courses, with a modal score of 3.3 for engineering students and 3 for management students, compared to the modal score of 6.3 for science students. Statistics lecturers for service module students could considered these finding when spreading out curriculum topics (the sequence of activities) and related teaching methods.

**Table 2. Descriptive statistics of students perceived attitude towards statistics**

| Factor | Faculty | Mode | Median | Mean | Std. Dev | Skewness | Kurtosis | Cronbach Alpha |
|---|---|---|---|---|---|---|---|---|
| Affect | Science | 5.3 | 5.3 | 5.2 | 1.1 | -1.2 | 2.7 | 0.79 |
| | Engineering | 5.2 | 4.7 | 4.7 | 1.1 | -0.4 | 0.4 | |
| | Management | 4.0 | 4.7 | 4.6 | 1.2 | -0.3 | -0.3 | |
| Cognitive Competence | Science | 5.0 | 5.2 | 5.2 | 1.0 | -1.4 | 6.0 | 0.77 |
| | Engineering | 5.2 | 5.2 | 5.2 | 1.0 | -0.9 | 2.9 | |
| | Management | 5.2 | 5.2 | 5.1 | 1.1 | -0.7 | 1.3 | |
| Value | Science | 4.8 | 4.8 | 4.8 | 0.9 | -1.3 | 5.5 | 0.68 |
| | Engineering | 5.3 | 5.1 | 5.0 | 0.8 | -1.6 | 7.3 | |
| | Management | 4.9 | 4.8 | 4.7 | 0.8 | -0.9 | 1.4 | |
| Difficulty | Science | 6.1 | 4.3 | 4.2 | 1.5 | -0.3 | -0.9 | 0.57 |
| | Engineering | 3.3 | 3.4 | 3.4 | 0.8 | -0.3 | 1.2 | |
| | Management | 3.0 | 3.1 | 3.1 | 0.7 | 0.0 | 0.3 | |
| Interest | Science | 7.0 | 6.0 | 5.9 | 1.1 | -1.9 | 6.2 | 0.86 |
| | Engineering | 5.8 | 5.8 | 5.6 | 1.1 | -1.6 | 4.7 | |
| | Management | 6.0 | 5.8 | 5.4 | 1.3 | -1.2 | 1.6 | |
| Effort | Science | 7.0 | 5.5 | 5.4 | 1.5 | -0.7 | -0.3 | 0.66 |
| | Engineering | 7.0 | 6.5 | 6.3 | 0.8 | -3.4 | 19.9 | |
| | Management | 7.0 | 6.5 | 6.4 | 0.7 | -2.1 | 6.4 | |

Next, the authors carried out multiple two-sample independent Mann-Whitney U tests (displayed in Table 3) to identify firstly whether there are attitudinal differences between statistics students in service courses and students in mainstream courses, and secondly whether gender contributes towards attitudinal differences. The following results share some light on how tertiary students experience statistics and could be incorporated through a differentiation of teaching methods between the different modules. Significant differences (*P-value* < 0.05) were found between science students and service module students' attitudes in terms of the factors *affect*, *difficulty*, *interest* and *effort*, at a 95% confidence level. More specifically, the mean rank scores indicate students in service courses did not enjoy statistics as much as students in mainstream courses, they found statistics more difficult, they had a lower interest in learning statistics, and needed to put in more effort to learn statistics. Similarly, significant differences were detected between male and female students regarding their attitude

towards statistics in three of the six factors (affect, difficulty, and effort). The mean rank scores indicated female students enjoyed statistics less, found the subject more difficult, and needed to put in more effort than their male counterparts. No attitudinal differences in *cognitive competence* and *value* of statistics could be detected. The latter confirmed students in service courses did recognize the value and need for statistics in their professional development.

**Table 3. Differences between attitudes of courses**

| Factor | Test Variables | Mean Rank | Mann-Whitney U | P-value (2-tailed) |
|---|---|---|---|---|
| Mainstream vs service module: | | | | |
| Affect | Faculty of Science | 242.42 | 12620 | 0.000 |
| | Faculty of Management | 183.56 | | |
| Cognitive Competence | Faculty of Science | 210.60 | 16757 | 0.336 |
| | Faculty of Management | 198.66 | | |
| Value | Faculty of Science | 210.55 | 16763 | 0.339 |
| | Faculty of Management | 198.68 | | |
| Difficulty | Faculty of Science | 264.92 | 9695 | 0.000 |
| | Faculty of Management | 172.88 | | |
| Interest | Faculty of Science | 233.24 | 13814 | 0.000 |
| | Faculty of Management | 187.92 | | |
| Effort | Faculty of Science | 152.81 | 11350 | 0.000 |
| | Faculty of Management | 226.08 | | |
| Mainstream vs service module: | | | | |
| Affect | Faculty of Science | 190.45 | 9237 | 0.000 |
| | Faculty of Engineering | 145.63 | | |
| Cognitive Competence | Faculty of Science | 160.90 | 12402 | 0.684 |
| | Faculty of Engineering | 165.23 | | |
| Value | Faculty of Science | 151.07 | 11125 | 0.052 |
| | Faculty of Engineering | 171.74 | | |
| Difficulty | Faculty of Science | 194.65 | 8691 | 0.000 |
| | Faculty of Engineering | 142.84 | | |
| Interest | Faculty of Science | 179.19 | 10700 | 0.014 |
| | Faculty of Engineering | 153.09 | | |
| Effort | Faculty of Science | 131.56 | 8588 | 0.000 |
| | Faculty of Engineering | 184.69 | | |
| Gender: | | | | |
| Affect | Female | 281.42 | 38449 | 0.030 |
| | Male | 312.87 | | |
| Cognitive Competence | Female | 289.82 | 40431 | 0.224 |
| | Male | 307.43 | | |
| Value | Female | 291.02 | 40714 | 0.280 |
| | Male | 306.65 | | |
| Difficulty | Female | 269.51 | 35639 | 0.000 |
| | Male | 320.59 | | |
| Interest | Female | 287.58 | 39904 | 0.140 |
| | Male | 308.87 | | |
| Effort | Female | 340.97 | 33400 | 0.000 |
| | Male | 274.26 | | |

## 5. CONCLUSION

In this inquiry, the authors compared the attitudes of students at a public university in South Africa, in the Faculty of Science (students enrolling for statistics as a mainstream course) with the attitudes of students in the Faculties of Management and Engineering (students enrolling for statistics as a service module course). Aligned with the theoretical framework on "Statistical Reasoning, Thinking, and Literacy" from Garfield and Ben-Zvi (2007, p. 380) and the strong relation between learning statistics and fostering a positive attitude toward the discipline, the researchers conducted this investigation. Quantitative data were collected via the reliable SATS-36 survey. Significant differences in attitude of students in serves and mainstream courses towards statistics, and between genders were detected. Four factors, contributing towards the attitudinal differences, were identified as affect, difficulty, interest and effort. Furthermore, based on the sample, female students found statistics more difficult and they had to put in more effort than their male counterparts. Lecturers of statistics courses at tertiary institutions could incorporate the results of the study when considering curriculum schedules and teaching methods to accommodate students from different faculties. Further research initiatives could include how students' attitudes towards statistics change over time, for example by repeating the survey at the beginning and at the end of a course. Additionally, data could be collected per topic to identify problematic areas in the curriculum. All attempts to improve students' competencies in statistics and nurturing a confident attitude towards the subject will benefit the professional development of students.

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