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Research Article

Assessing Students' Attitudes and Perceptions towards Statistical Literacy in a University System in a Developing African Country

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Beaven Utete[1], Maria Tsvere[2], Jacob C. Mapara[3], Constantino M. Pedzisai[3], Silas. T. Bvekerwa[4]

1. Department of Freshwater and Fishery Sciences, Chinhoyi University of Technology, Zimbabwe; 2. Academy of Teaching and Learning, Chinhoyi University of Technology, Zimbabwe; 3. Institute of Lifelong Learning and Development Studies, Chinhoyi University of Technology, Zimbabwe; 4. Chinhoyi University of Technology, Zimbabwe

Statistical literacy is important in the curriculum of every higher education institution and the sustainable development of countries. Nonetheless, low performances and student enrolment recorded in statistical education warrant investigation into plausible factors. This case study used the Students' Attitude towards Statistics (SATS) 36-item instrument to investigate the attitudes and perceptions of 185 students, enrolled in different disciplines, towards statistics education at Chinhoyi University of Technology in Zimbabwe. Descriptive, factor reduction, and multiple regression techniques were used to summarise and extract critical covariates, and relate variables in each construct in order to explain the attitudes of students towards statistics. Thematic analysis was done for an in-depth qualitative explanation of the drivers and barriers to the teaching and learning of statistics education. The main factors which induce fear, stress, anxiety, and antipathy towards statistics include: the perceived difficulty and numerical complexity of statistics, a natural low statistics self-efficacy and self-perception, and the extremely varying statistics cognitive capabilities of students. Inadequate supporting and facilitating conditions such as modern Information Communication Technology infrastructure, and a conducive teaching and learning environment lead to low performances. Regardless, students still perceive statistics as imperative for future professions and are willing to exert enough effort provided they are motivated in statistics education. It entails a diametric paradigm repositioning of the teaching and learning of statistics, emphasising collaborative learning, the intense use of electronic learning and the assessment of statistics, and smaller-sized classes giving individualised attention to benefit weaker students. Future research needs to explore statistics curriculum development, which is lagging and may be silently responsible for the low development rate in poor African countries.

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Corresponding author: Beaven Utete, beavenu@gmail.com

1. Introduction

Statistics education, the practice of teaching and learning of statistics, along with the associated scholarly research commonly called research methods, is a core component of most programs in higher education (Onwuegbzie et al. 2017; Lynch and Gerber 2018). Statistical education is an important global concern in the information age, more so because much of the information is derived mathematically using statistics and research methods (Creswell 2012, 2014). The application of statistics and research methods varies widely across fields such as mathematics, biometrics, medicine, and epidemiology, as well as in business, economics, industry, and the natural sciences (Nahm 2016). Of late, statistics education is widely found in the humanities, arts, cultural studies, sociology, and psychology (Cresswell 2014). Correct statistical usage provides a powerful predicting tool for historical, contemporary, and future phenomena (Greenland et al. 2016). Thus, statistics courses tend to be compulsory for undergraduate and postgraduate students and even in staff development courses as they equip students and faculty with technical, logical, and problem-solving skills in higher education institutions (HEIs).

For many students, the study of research methods and statistics provokes anxiety, frustration, dismay, and disdain (Paechter et al. 2015). Academic challenges related to statistics anxiety arise from difficulties in research design, data collection, data management, data manipulation (analysis), and interpretation (Marcher et al. 2015). In a teaching context, statistics anxiety relates to the students' fear of (humiliation from) the statistics lecturer and fear of asking for assistance (Onwuegbuzie et al. 2017). Despite the introduction of various teaching strategies to reduce statistics anxiety, such as the humorous numerical methods approach, positive reinforcement from statistics teachers and lecturers, and current and participatory instructor-led e-learning of statistics, there is still a persistent general statistics anxiety, disdain, frustration, and dislike of research methods among students and faculty alike (Rock et al. 2016).

In most statistical education, statistics teachers and instructors are generally focused on improving the cognitive aspects of instruction with little interest in the emotional and psychomotor aspects of student learning (Prayoga and Abraham 2017). Currently, attitudes and perceptions towards statistics have gained increasing concern in statistics education and its application by college students in their careers (Gredig and Bartelsen-Raemy 2018). Attitudes towards statistics and research methods influence students' statistical behaviour inside and outside the learning environment and their willingness to attend statistics modules in the future (Mutambayi et al. 2016).

For developing African countries such as Zimbabwe, the interactive effects of general statistics anxiety and unsuitable teaching approaches limit the effective use of statistics education in higher education institutions (Chirume 2013). Research Methods and Introduction to Statistics are compulsory modules for all degree programmes, and they act as the theoretical framework on which students base their research projects in HEIs in Zimbabwe (Badza and Chakuchichi 2000; Mhlanga and Ncube 2003). However, there have been increasingly divided opinions on the importance of statistical education in the students' curriculum with regards to its instructional approaches and learning modes in higher education institutions across Zimbabwe (Chikoko and Mhloyi 1995; Zindi and Munetsi 2015).

Nevertheless, profiles of statistics and research methods show poor achievement, and the students display negative attitudes toward statistical courses during registration, within the semester, and in the final examinations, with some indicating unwillingness to be associated with statistical education in future careers in most higher education institutions in Zimbabwe (Chirume 2013). An array of factors, such as unbalanced curricula where content, andragogy, and technology are misaligned, and low applicability and contextual relevance to real-life situations, have been cited for the low uptake and pass rates in statistics-related modules in HEIs in Zimbabwe and worldwide (Mvududu 2003; Koh and Zawi 2014). For instance, at Chinhoyi University of Technology (the case study institution), taking and passing statistics is compulsory for all disciplines in the first year, as it is at the rest of the HEIs in Zimbabwe (Mhlanga and Ncube 2003; Mukeredzi and Chiome 2011; Zindi and Munetsi 2015).

Regardless, the persistent high failure rates in the discipline indicate that these strategies have not succeeded within Zimbabwe, and this reveals a research caveat on the factors and reasons behind the high failure rate in statistics and research methods among students enrolled in higher education institutions in the country. This research explored the current teaching and learning approaches in statistics education in higher education in Zimbabwe, with the

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use of Chinhoyi University of Technology as a case study. The aim was to explore alternative teaching and learning methods in statistics using information from both students and instructors. Specifically, the objectives were to: 1. determine students' attitudes toward statistics education at CUT in Zimbabwe, 2. establish the factors affecting statistics education at CUT, and 3. develop a framework to improve delivery modes in statistics education to students at CUT and similar institutes in developing countries.

2. Methods

2.1. Study Area

The Chinhoyi University of Technology (CUT), located in Chinhoyi Town in Zimbabwe (Figure 1), was established in 2001 (www.cut.ac.zw) and provides both undergraduate and postgraduate qualifications in agriculture, engineering, wildlife ecology and conservation, creative art and design, business sciences, hospitality and tourism, and natural sciences and mathematics. Teacher education and other courses are offered through the Institute of Lifelong Learning and Development Studies. The Department of Mathematics and Statistics is housed in the School of Natural Sciences and Mathematics (www.cut.ac.zw) and offers university-wide statistical courses, although each department is mandated to have a component in statistics and research methods within its curriculum.

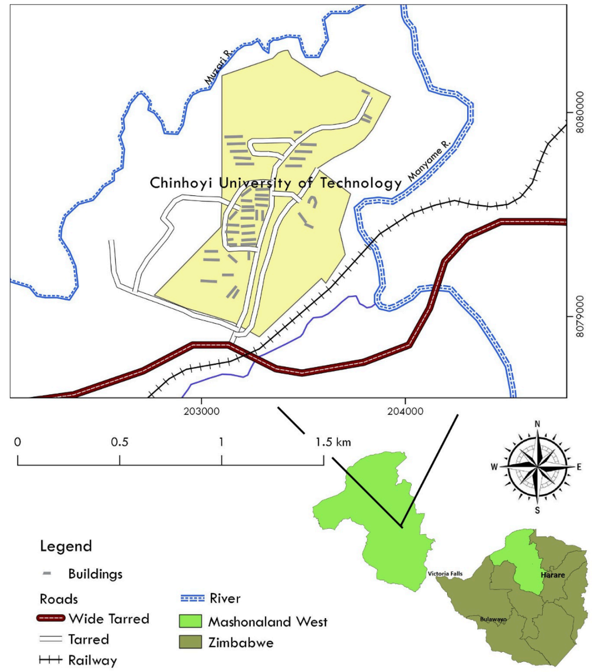

Figure 1. Location of Chinhoyi University of Technology in Zimbabwe.

2.2. Data collection

The research adopted an analytical case study research design integrating quantitative and qualitative methods in assessing the perceptions of students and stakeholders towards statistics education at CUT. The sample comprised 185 conventional and block undergraduate and postgraduate students drawn from all schools. Semi-structured questionnaires were administered to students in the third week of the semester opening, under the assumption that almost the whole student body would have started attending classes. University administrators from the registry, quality assurance, and all schools were also interviewed as part of the main respondents. After instrument refinement, the key informant interviews and focus group discussions were conducted simultaneously with the interviews. The Survey of Attitudes towards Statistics (SATS) instrument, which employs a 7-point Likert scale to assess students' cognitive and non-cognitive factors, was used. A pilot interview was conducted with seven students from all the schools in the university in order to refine the instrument.

2.3. Data analysis and procedure

The survey was taken from the Survey of Attitudes towards Statistics (SATS) instrument (Schau 2003;

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Vanhoof 2010), which assesses students' cognitive and non-cognitive factors. All items grouped into the six components were tested for construct validity in comparison with previous studies (Schau 2003). SATS employs a 7-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = neutral, 5 = somewhat agree, 6 = agree to 7 = strongly agree, or equivalently according to item statements). For statistical analysis purposes, items with negative wordings were transformed to positive wordings. Two main issues were analysed, i.e., the students' attitudes towards statistics education at CUT, and the factors affecting statistics education at the institution. The third issue related to teaching and learning strategies was also analysed in both a quantitative and qualitative manner.

Descriptive summaries were done for demographic data using frequency tabulation. Statistical differences in the contribution of the demographic constructs of the respondents to each attitude component were analysed using the Chi-square tests of independence at the $P<0.05$ significance level. For each of the attitude components, the Cronbach's alpha test of reliability to test for internal consistency was done with a cut-off point of 0.70 for all items. Then a Kaiser-Meyer-Olkin (KMO) test and a Bartlet test, a measure of sampling adequacy, were done on the data, with a cut-off point of $p<0.05$ indicating an adequate sample size for proceeding with factor reduction analysis. After that, in each of the attitude components, factor reduction or factor analysis was done with the aid of an R-Matrix to reduce data from a group of interrelated variables to a smaller set of factors.

This was done to achieve parsimony by explaining the maximum amount of common variance in a factor correlation matrix using the smallest number of explanatory constructs for each attitude component. A factor loading or factor score matrix with factor correlation coefficients for each attitude component was then constructed, indicating the relationships between each variable in each attitude component. The cut-off point for the factors was 0.70-0.75 for each attitude component. From the retained variables for each attitude component, multiple regression analyses were done using the generalized linear model (GLM) in order to determine the best possible combination of explanatory variables to explain the attitudes of students and stakeholders towards statistics education at CUT. The non-parametric Kruskal-Wallis ANOVA was done to differentiate the responses to the Interest in Statistics construct based on the schools and ages of the respondents.

On the teaching and learning strategies associated with statistics education, commonly recurrent word sequences were identified and grouped into themes. The modal frequency of the themes was quantified and cross-related to demographic attributes using the Pearson correlation test at the $P<0.05$ significance level. A qualitative in-depth analysis of the themes was done with reference to published literature in order to explore the best and most plausible teaching and learning strategies for statistics education at CUT. All statistical analyses were done in the SPSS 25 version, with specific rejection criteria stated for each test.

3. Results and interpretation

3.1. Demography of the respondents

A total of n=220 questionnaires were administered to students at CUT, and n=185 fully answered questionnaires were used for the analysis, ensuring a return rate of 84%. The students were drawn from the Schools of Business Science and Management (n=67; 36%) > Wildlife Ecology and Conservation (n=32; 17%) > Agricultural Sciences and Technology (n=26; 14%) > Art and Design (n=15; 8%) > Hospitality and Tourism (n=14; 8%) > Engineering Science and Technology (n=14; 8%) > Medical Health Sciences and Technology (n=14; 8%)> Natural Science and Mathematics (n=3; 2%). There were significant differences (Chi-square, $p < 0.05$) in the representativeness of the schools in the study. This merely indicates the skewedness of the enrollment at CUT, where there are more students in the School of Business Science and Management than in any other school, with the least number of enrollments found in the School of Natural Sciences and Mathematics. Of the respondents, 49% (n=90) were females, and 51% (n=95) were males. The age ranges (in years) of the students were 17-21 (n=41; 22%), 21-25 (n=117; 63%), 26-30 (n=18; 10%), 31-36 (n= 9; 5%). There were significant differences (Chi test, $p<0.05$) in the age ranges of the respondents. The level of formal education reached by the respondents indicated that a majority (n=40; 22%) were in level two in the first semester or 2.1, with 19% (n=35) in level 1.2. At least 17% (n=33) of the students were in level 2.2, whilst 11% (n=21) of the respondents were at the postgraduate or MPhil/MSc/PhD level. A majority (n=168; 91%) of the students had taken at least one mathematics or statistics-related course at the university.

3.2. Extraction and analysis of the SATS 36 constructs

3.2.1. Attitude of students towards statistics

The Cronbach's alpha score for the affect construct was 0.78 and indicated adequate consistency of the scale. The Kaiser-Meyer-Olkin and Bartlet tests indicated significant sample adequacy (KMO test=0.702, Bartlet Sphericity test, p=0.0001) to proceed with factor reduction analysis in the affect component. Attitudes of students were examined statistically using analysis of variance and regression analysis. The total variance explained output indicated a suitable cut-off point between two and three factors, as the three-factor solution had an Eigen value<1 and explained at least 62% of the variation in the Affect construct. Analysis of the Rotated Component Matrix – R Matrix showed that students prefer the qualitative aspect of statistics for them to enjoy the statistics courses and are rather scared of quantitative statistics (Table 1). In fact, most students (n=121; 65%) indicated that they are frustrated and stressed during statistics courses, mainly due to the quantitative aspect of statistics education (Table 1).

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Significance ranking of factor	Factor 1>0.80	Factor 2>0.80
1	Prefer qualitative methods in statistics	Enjoy statistics courses
2	Frustration over statistics=	Scared of statistics
3	Stress during statistics courses	

Table 1. Factor reduction in the Affect component in the R Matrix

Anxiety, fear, stress, antipathy, and frustration over statistics and mathematics detected in this study resonated with studies by Gundlach et al. (2015) and Paechter et al. (2015), and with Prayoga and Abraham (2017), who indicated that undergraduate and postgraduate students exhibit higher levels of anxiety, fear, and dislike of statistics. Prayoga and Abraham (2017) indicated that most tertiary students prefer qualitative methods in statistics as they deem them easy to understand. This assertion dovetails with this study, where students indicated a preference for the qualitative aspects of the statistics courses. A sizeable portion (n=40; 22%) of the students indicated that they enjoyed the statistics courses in the study, implying that attitudes towards statistics differed among students. A majority of students (n=28; 70%) in the group who enjoyed the statistics courses have previously taken more than two courses related to mathematics and statistics. This suggests that the development of self-efficacy and antipathy towards statistics are dispositional antecedents developed from learners′ previous experience with mathematics and statistics (Marcher et al. 2015).

For further regression analysis, the retained variables in the Affect component were: preference of qualitative methods, frustration, stress, and fear of statistics. The regression output is shown in Table 7 and indicates a positive adjusted R-square value and a significant p-value of 0.000. This reflects that the model interlinking predictors such as fear, stress, frustration, and preference for qualitative methods in statistics was reliable and significant in predicting the likelihood of a student enjoying statistics courses. The coefficient model summary indicated that as stress increases and enjoyment of qualitative methods decreases, there is a likelihood of a student enjoying statistics.

Thus, when a student is not afraid to tackle quantitative and qualitative aspects, there is a likelihood of enjoying statistics. Ncube and Moroke (2015) indicated that students with low statistics self-efficacy and low statistics self-perception have the potential to develop negative attitudes towards statistics and mathematics courses. It is imperative for statistics facilitators to first interrogate the attitudes and previous experiences with mathematics and statistics among learners in order to improve performance in statistical education (Stoloff et al. 2015). However, the low adjusted R value of 0.342 in Table 7 indicated that there are other factors not captured in the SATS generic form to account for the probability or likelihood of enjoying or hating statistics courses other than fear, anxiety, and stress. The low adjusted R value also pointed to the smaller size of the sample, which makes it difficult to consider all factors affecting students' attitudes towards statistics. Thus, in future studies, there is a need to increase the sample size for more accurate results (Montgomery et al. 2012).

3.2.2. Statistics cognitive competence

The Cronbach's alpha score for the Statistics cognitive competence construct was 0.72 and indicated adequate consistency of the scale. The Kaiser-Meyer-Olkin and Bartlet tests indicated a significant sample adequacy (KMO test = 0.758, Bartlet Sphericity test, p = 0.0001) to proceed with factor reduction analysis in the affect component. The total variance explained output indicated a suitable cut-off point of only two main factors, as the three-factor solution had an Eigenvalue < 1 and explained at least 64.32% of the variation in the statistics cognitive competence construct (Table 2). The Rotated Component Matrix – R Matrix showed that students prefer the qualitative aspect of statistics for them to enjoy the statistics courses and are rather scared of quantitative statistics (Table 2).

Significance ranking of factor	Factor 1 > 0.70	Factor 2 > 0.70
1	Do a lot of maths errors	I can learn statistics
2	No idea of what is going on	I understand mathematical and statistic formula and equations
3	I have trouble understanding statistics because of the way I think	

Table 2. Factor reduction in the Statistics cognitive competence component in R Matrix

There are two distinct sets of students in the statistics cognitive competence component. The first set consists of students who indicated that they make a lot of maths errors in statistics and have no idea of what will be going on in statistics courses and suggested that they have trouble understanding statistics because of the way they think, which is not mathematically inclined (Table 2). The second set of students indicated that they can learn statistics and clearly understand mathematical and statistical formulae and equations (Table 2). For further regression analysis, all the variables in the statistics cognitive competence component indicated in Table 2 were retained. The factor "I can learn statistics" was the dependent variable in this construct, and the regression output is indicated in Table 7. The regression summary indicated a positive adjusted R-square value of 0.0283 and a p-value = 0.000, implying that the model interlinking predictors such as: I find it difficult to understand statistical concepts, I do a lot of maths errors, understand statistical formulae and equations, I have trouble understanding because of the way I think, I have no idea of what is going, was reliable and significant ($p<0.05$) in predicting the likelihood of a student finding it easier to learn statistics. The ability to comprehend statistics and mathematics determines a student's ability to learn statistics (Weissgerber et al. 2016).

3.2.3. Effort in Statistics

The Cronbach's alpha score for the Effort in Statistics construct was 0.742 and indicated adequate consistency of the scale. The Kaiser-Meyer-Olkin and Bartlet tests indicated a significant sample adequacy (KMO test = 0.831, Bartlet Sphericity test, p = 0.0001) to proceed with factor reduction analysis in the Effort in statistics component. The total variance explained output indicated a suitable cut-off point of only two main factors, as the three-factor solution had an Eigenvalue < 1 and explained at least 64.32% of the variation in the effort in statistics construct.

Analysis of the Rotated Component Matrix –R Matrix showed that students planned to complete all of their statistics assignments (loading factor = 0.871), work (loading factor = 0.954), and study (loading factor = 0.914) hard for every statistics course and attend every statistics class session (loading factor = 0.878). In essence, this study indicated that all students either did put a lot of effort into statistics-related courses or were planning to work hard in statistics-related courses. The summary regression model shows that the adjusted R = 0.639 and the Anova p-value = 0.000, implying that the model interlinking predictor factors such as students' planning to attend every statistics lesson, study, and work hard in statistics with the completion of assignments in statistics is reliable and significant. Mutambayi et al. (2016) indicate that generally there is a high amount of effort input by students in statistics and mathematics courses at the university. However, effort in statistics is most often regarded as a mediated variable in interlinking attitude, cognitive ability, and performance in statistics, as effort alone does not result in higher performance in statistics and mathematics (Barbosa et al. 2019).

3.2.4. Value and Use of Statistics

The Cronbach's alpha score for the Value and Use of Statistics construct was 0.713 and indicated adequate consistency of the scale. The Kaiser-Meyer-Olkin and Bartlet tests indicated significant sample adequacy (KMO test = 0.831, Bartlet's Sphericity test, p = 0.0001) to proceed with factor reduction analysis in the Value and Use of Statistics component. The total variance explained output indicated a suitable cut-off point of only two main factors, as the three-factor solution had an Eigenvalue < 1 and explained at least 61.14% of the variation in the Value and use of statistics construct (Table 3). Analysis of the Rotated Component Matrix –R Matrix showed that most students (n = 109; 59%) disagreed with the suggestion that statistics is worthless for them and irrelevant in their lives. In fact, a sizeable portion (n = 101; 55%) indicated that statistics is required as part of their training and in their intended future professions and careers. In most universities, it is compulsory for undergraduate and postgraduate students to take up (and pass) at least one module in research methods and statistics (Yang 2017). At least 49% (n = 90) of the respondents indicated that statistics will make them more employable in the future, an indicator of the importance students place on the value and use of statistics in their everyday lives and future careers.

Significance ranking of factor	Factor 1 > 0.70	Factor 2 > 0.70
1	Statistics is worthless for me	Statistics is required as part of my professional training
2	Statistics is irrelevant in my life	

Table 3. Factor reduction in the Value and use of Statistics component in the R Matrix

The summary regression model shows that the adjusted R = 0.291 and a p value >0.05, implying that the model interlinking the value and use of statistics and the perceptions of students towards statistics' importance does not adequately explain the relationship. It also indicated that there were no significant differences (Anova, p>0.05) in the predictor variables for the construct (Table 7). It implies that statistics is valuable to most students who intend to apply it in real life and future professions. However, an equal proportion of students regard statistics as irrelevant to their lives and suggest that it may not be useful to their intended professions. This points to a need to first interrogate the attitudes and perceptions of students towards the value and use of statistics in their daily lives and intended professions before formulating appropriate teaching and learning strategies for effectiveness in statistics education, especially for developing countries (Stoloff et al., 2015).

3.2.5. Difficulty in Statistics

The Cronbach's alpha score for the Difficulty in Statistics construct was 0.84, which indicated adequate consistency of the scale. The Kaiser-Meyer-Olkin and Bartlet tests indicated significant sample adequacy (KMO test=0.719, Bartlet Sphericity test, p=0.0001) to proceed with factor reduction analysis in the Difficulty in Statistics component. The total variance explained output indicated a suitable cut-off point of only two main factors, as the three-factor solution had an Eigen value<1 and explained at least 68.29% of the variation in the Difficulty in Statistics construct. Analysis of the Rotated Component Matrix – R Matrix showed the existence of two categories of students (Table 4). The first category of students indicated that statistics involves massive computations and calculations (n=104; 56%) and that the subject is highly technical (n=101; 55%), and thus, students have to learn a new way of thinking to comprehend statistics (n=89; 48%). The second set of students indicated that statistics formulae are easy to understand (n=71; 38%) and that statistics is a subject quickly learned by most people (n=51; 28%). The first set of students views statistics as a complex subject involving tedious calculations and thus regards the subject as difficult. This resonates with most research, e.g., Chew (2014, 2018) and Siew et al. (2019), who indicated that most students perceive statistics as too mathematical and hence regard the subject as too complex.

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Significance ranking of factor 1 > 0.75		Factor 2 > 0.75
1	Statistics involves massive computations	Statistics formulae are easy to understand
2	I have to learn a new way of thinking to do statistics	Statistics is a subject quickly learnt by most people
3	Statistics is highly technical	

Table 4. Factor reduction in the Difficulty in Statistics component in the R Matrix

This can be interlinked with low statistics self-efficacy and low statistics cognitive competences among students, which induce statistics anxiety and antipathy (Rock et al. 2016; Primi et al. 2018). As a result, such students either apply minimal effort or do not even try to apply themselves in statistics courses, as they think that it is imperative for them to learn new ways of thinking to do statistics, resulting in low performance in statistical education. The second set of students exhibited a high affinity for statistics and indicated that statistics formulae are easy to understand. They regarded statistics as an easy subject which can be learned by most people. This set of students indicates high statistics cognitive capability (SCA) and can readily apply knowledge and intellectual skills in using statistical operations to solve academic and real-life situations (Chirume 2013; Onnis et al. 2018). The key challenge in statistical education is how to craft effective teaching and learning strategies that cater to the two different groups of students with different SCA.

The summary regression model shows that the adjusted R = 0.161 and a p-value >0.05, implying the model does not adequately interlink difficulty in statistics and the antecedent factors, e.g., statistics is a complicated subject for me, and statistics formulae are easy to understand. In fact, an analysis of the model coefficients clearly shows the existence of two sets of students with significant differences (ANOVA, p<0.05) for the variables: statistics involves massive calculations (ANOVA, p=0.015) and statistics formulae are easy to understand (ANOVA, p =0.001); see Table 7. The existence of the two groups of students implies that environmental, dispositional, and situational antecedents related to mathematics and statistics have to be thoroughly investigated in order to ensure improvements in statistics education (Dablander et al. 2019).

3.2.6. Interest in Statistics

Analysis of students' interest in statistics indicated that most students somewhat agree that they are interested in communicating statistical information to others. A sizeable portion (n=112; 61%) indicated that they really do not know if they are interested in using statistics in their everyday lives or in future professions (Table 5). A significant number of students (n=155; 85%) indicated that they are interested in understanding statistical information and in learning statistics. Overall, the findings indicated that students are interested in learning statistics and using statistical information in their training and future professions. This is contrary to assertions by Otto et al. (2018) that university students have the perception that mathematics and statistics are abstract and therefore the learning of mathematics and statistics would yield no benefit to them. The challenge is that most students do not know where to apply and use statistical knowledge (Bui and Alfaro 2011).

Item Statistics	Mean	SD	Median	Valid N
I am interested in communicating statistical information to others	4.06	1.963	4.00	176
I am interested in using statistics	3.93	2.172	4.00	112
I am interested in understanding statistical information	4.57	1.909	5.00	174
I am interested in learning statistics	4.77	2.049	6.00	176

Table 5. Interest in Statistics among students at CUT

The fact that all the variables coalesced into one big component (interest in statistics) did not allow for factor reduction analysis, and further regression analysis was made redundant. Instead, differentiation of the levels of interest in statistics using the schools and ages of respondents was done using the non-parametric Kruskal-Wallis Anova test. There were significant differences ($p<0.05$) in the responses to the factors: I am interested in using statistics (Kruskal-Wallis Anova, $p=0.003$), I am interested in understanding statistical information (Kruskal-Wallis Anova, $p=0.026$), and I am interested in learning statistics (Kruskal-Wallis Anova, $p=0.017$) across the different schools at CUT.

However, the age of the respondents did not significantly affect (Kruskal Wallis Anova, $p>0.05$) the levels of statistical interest among the students. It appears that interest in statistics is determined by the disciplines or programmes of training, i.e., the school or faculty, and age is not a significant determinant. Onwuegbuzie et al. (2017) and Miller (2019) indicated that age, gender, and marital status are not significant determinants of the motivation and interest of students towards statistics and mathematics at the tertiary level in both developing and developed countries. Rather, the significance of statistics relates to the programme a student is taking (Zindi and Munetsi 2015), with natural sciences more inclined to grasp statistical concepts easily relative to humanities and social studies faculties, although emerging trends in business schools indicate otherwise (Otto et al. 2018).

3.3. Facilitating conditions for Statistics Education at CUT as a model for developing nations

Analysis of the ancillary factors helping the implementation of effective statistics education indicated that a majority (n=113; 64%) of the respondents strongly disagreed or were not sure that CUT provides all the facilities needed for statistics learning (Table 6). Most (n=118; 67%) of the respondents indicated that CUT does not provide adequate ICT infrastructure for use in statistical education.

In terms of policy, a sizeable portion (n=88; 50%) of the respondents strongly agreed or agreed (with mean=4.45 and mode=6) that CUT provides an opportunity for learning statistics (Table 6). However, a majority (n=110; 63%) of the respondents strongly agreed that CUT does not provide incentives for students learning statistics, with mean response=3.02 and mode=1. Most respondents (n=125; 71%) indicated that CUT has not provided training for students and lecturers alike to use e-learning tools in statistics education. Similarly, most (n=115; 65%) respondents indicated that there is a lack of technical help for using e-learning tools in statistics education. Most of the students indicated that the teaching of statistics is not stimulating (n=96; 55%) and motivating (n=94; 54%) at CUT. However, a sizeable portion (n=73; 42%) of the respondents indicated that the assessment of statistics at CUT is fair (Table 6).

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Item / Statistics	Mean	SD	Median	Mode	Valid N
Learning infrastructure					
CUT has provided me all the facilities I need for statistics learning	3.55	1.959	3.00	1	176
The ICT infrastructure at CUT is available when I need it for statistics	3.44	1.195	3.00	1	177
Institutional Policies					
CUT provides me an opportunity for learning statistics	4.45	1.929	5.00	6	175
CUT provides incentives to students for learning statistics	3.02	2.360	2.00	1	175
Training and Technical Support					
CUT has provided training for me to use e-learning tools in statistics	3.38	1.943	3.00	1	175
There is technical help available if required in learning statistics	3.64	1.961	4.00	1	176
Teaching and learning					
Teaching of statistics is stimulating at CUT	4.03	1.887	4.00	6	175
Teaching of statistics at CUT is motivating	4.10	1.963	4.00	6	175
Assessment procedures for statistics are fair at CUT	4.09	1.912	4.00	4	173

Table 6. Students' perceptions of the facilitating conditions for statistics education at CUT

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Construct	Valid Predictors	Adjusted R^2	Standard Error (SE)	df	Anova, P values
Attitude/affect	Frustration, fear, preference of qualitative methods, Stress	0.327	1.795	173	0.000
Statistics cognitive competence	No comprehension of concepts, lots of maths errors, wrong logical reasoning	0.283	1.578	171	0.000
Effort in Statistics	Work and study hard, attend every statistics lecture	0.633	1.221	177	0.000
Value of Statistics	Worthless to me, useful to me, not applicable in daily lives, irrelevant	0.291	1.590	174	>0.05
Difficulty in Statistics	Massive complex and technical computations. Easy formulae.	0.135	1.861	178	0.001

Table 7. Summary of regression analyses outputs for the SATS 36 constructs

N.B.: *The interest in statistics construct was compounded, and thus, the regression analysis was invalid*

Horton (2015) and Onwuegbuzie et al. (2017) indicated that most developing nations face challenges in ICT and e-learning resources for the total improvement of statistical education. This hampers the teaching and learning strategies that rely on multimedia devices and require consistent internet access for the upgrading of software (Hydorn 2018). CUT regulations, which are a policy, make it mandatory for every student to pick up and pass an introductory or basic introduction to statistics course, which explains the fact that students agreed that the institution provided them with an opportunity for learning statistics. This practice of making at least one statistics course mandatory is rife worldwide (Stowell and Addison 2017). The consequences of this setup are that statistics facilitators are often confronted with students who did not want to take up statistics and research methods, who are 'statistics illiterate', or who have 'statsphobia' (Onwuegbuzie and Wilson 2003). The fact that students at CUT do not feel motivated or stimulated to learn statistics by the teaching strategies used at the institution reflects a general resistance or statsphobia, and statistics antipathy. It may also reflect inadequate knowledge and understanding of the statistical dispositional and situational antecedents of the students on the part of administrators and lecturers, which results in the provision of an inappropriate and unconducive statistical learning environment. The consequence is that students develop dislike, anxiety, fear, and stress over the statistics courses, resulting in low performance in statistics education. Nevertheless, a general agreement that the assessment of statistics is fair places special emphasis on the choices of didactic methods and teaching approaches, which must be aligned with the assessment modes to be adopted at the university (Zindi and Munetsi 2015; Hydorn 2018).

3.4. Teaching and learning strategies for Statistics Education at CUT

An analysis of each aspect of the teaching and learning was done, and the most recurrent ideas and suggestions were coded into themes for each aspect; the results are summarised below.

3.4.1. Improvements in teaching and learning statistics

Five prominent themes were identified in the responses, and these comprised: Lecture Time, Teaching Resources, Teaching and Assessment Approaches, Technology and its Application, and others, a theme which covered suggestions that occurred sporadically.

Most respondents (n=92; 50%) indicated that there must be more engagement time (i.e., more lectures) between students and lecturers in statistics and research methods modules. This aspect was corroborated by all the statistics facilitators (key informants) who indicated that there is a need for more

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(active) engagement time between students and lecturers in statistics and research methods modules. More engagement time will enable more data analysis, coverage of the statistics curriculum/modules, and the identification of weaker students, especially those with minimal or no prior rigorous mathematical and statistical experiences. Hydorn (2018) indicated that statistics and research methods benefit students more when there is engagement between the learners and the facilitators. Onnis et al. (2018) are of the opinion that statistical education among andragogical learners can only be improved once there is a 'bilingual transaction' where the learner understands the language of the facilitator and vice versa, and this can only be achieved by more engagement time.

The availability of teaching resources, which starts with the recruitment of experienced statisticians and biometricians, was identified as a key improvement needed to enhance the teaching and learning of statistics at CUT. Most (n=106; 57%) respondents opined that "There is a need for more experienced lecturers and tutors and a conducive, not overcrowded environment in statistics modules". Other suggested statistics resources included a need for a dedicated statistics research laboratory and up-to-date software packages. Most students (n=97; 52%) clearly stated that "We need (to acquire and learn) more packages other than SPSS only."

Teaching resources are a vital cog in effective statistical education (Barbosa et al. 2019). Another recurrent theme was the need for the adoption of modern technology and its application in statistical education at CUT. Students frequently reiterated the need for upgrading the ICT infrastructure to be compatible with smart multimedia devices and to enable the constant upgrading of statistical software. Students suggested a need for online or e-learning statistical help platforms and virtual statistics laboratories to troubleshoot complex computations and reduce the need for physical space in the large and overcrowded statistics classes. The need to use e-learning statistical platforms was also suggested by all the key informants and was a recurrent suggestion in the focus group discussions. This requirement is in line with modern trends in the field of statistical education, where online platforms such as interactive gaming, simulation of field data and problems, and complex statistical problem solving have gained traction (Barbosa et al. 2019).

Teaching and assessment approaches are key in effective statistical education (Hydorn 2018). This aspect was the most recurrent theme (n=145; 78%) among respondents in this study. Various suggestions were made to improve the teaching of statistics at CUT, and these include: The use of more discussions or group activities with an emphasis on the reduction of group size, even in the tutorials. Moreover, students suggested the need to further break down the large classes using statistical iterative algorithms. For instance, in large schools such as Business Science and Management, through the use of alphabetical orders of surnames, facilitators can further break down the large-sized classes into smaller groups that have lectures and tutorials on different days. There was an emphasis on the need to use real-time or actual field-generated data and to conduct vigorous data analysis on practical life examples, applying the background theory in tutorials. This suggestion dovetails with assertions by Kirschener (2017) and Hydorn (2018), who indicated that engaging students in the practice of statistics through undergraduate research projects, mini-projects, or term projects realises better assessment outcomes than one-off contact done in lectures. Furthermore, Zindi and Munetsi (2015) advocated for the adoption of experiential approaches to teaching statistics and research methods as an effective strategy for enhancing statistics education in Zimbabwe and other developing nations with similar complexities.

Other suggested ideas included the need to reward high performers in statistics using monetary and non-monetary incentives such as new laptops and free software packages for motivating participation in statistics education. Key informants suggested the need to be rigorous in the recruitment of students to filter out those with a poor mathematical and statistics background and to carry out remedial programmes for them during the semester. These suggestions reveal a subtle thread among students where they are pointing to a need to consider the background of the student, the classroom environment, and the behavioural responses to the teaching approaches (Bond et al. 2012). Thus, there is a need to balance and integrate statistical antecedents such as the environmental, situational, and dispositional antecedents in order to improve statistical education (Dykeman 2011; Dablander et al. 2019).

3.4.2. Improvements in the assessment of statistics

Five prominent themes were identified in the responses, and these comprised: Assessment of Practical Work or Collaborative Assessment, External Formative Assessment of Students, Internal and External Peer Evaluation of Lecturers, Electronic Assessment, and others.

Most (n=81; 44%) students indicated a need to extend the assessment of statistics to group work assignments, practical field work, and even tutorial worksheets, other than in-class tests and the main summative examinations. This was mainly suggested as a measure to encourage all-around participation and fair assessment of students' ability/inability. Moreso, students indicated that various assessment methods will enable the identification of troublesome concepts and remedial action by the teachers in the course of the semester. A sizeable portion (n=67; 36%) of the students suggested a need for the assessment of students′ performance by external lecturers or experts to rectify the errors of both lecturers and students. Likewise, a majority (n=102; 55%) of the students indicated a need for external peer evaluation of the lecturers for the enhancement of teaching statistics. Most of the students suggested the use of electronic assessment (e-assessment) in statistics to increase fairness and enable quick evaluation and feedback, which would enable them to respond appropriately. Modern trends in the assessment of statistics include the electronic assessment of students' work (Garfield et al. 2011), and the assessment of practical work such as field data and projects (Hydorn 2018). Other suggested assessment methods included the use of weekly assignments for students. Key informants bemoaned the assessment of observational aspects only in statistics, leaving out the cognitive and psychomotor aspects such as the synthesis of real-life and practical concepts and deductive inferences. They also outlined the challenging aspect of scoring and grading statistics, especially among novice students.

3.4.3. Remedies to improve the teaching, learning, and assessment of statistics

Three main remedial themes were identified, and these included: The need for Small-Sized Classes, the use of Modern ICT Infrastructure, and Timely Assessment, Evaluation, Feedback, and Correction of grey areas during the course of the semester.

Most students (n=111; 60%) decried the large-sized statistics classes and suggested their breakdown into smaller units for them to gain specialised and individual attention. However, the key informants pointed out the large numbers enrolled in the compulsory statistics courses as the largest impediment to offering more individualised and effective attention. As a result, most of the teachers use the passive (chalk and talk or PowerPoint) mode of teaching. Thus, it appears the breakdown of large-sized classes would lead to the need for more lecturers to conduct the lectures, further constraining resources at the institution. The teaching and assessment of statistics for large-sized classes are challenging, more so in resource-challenged countries (Garfield et al. 2011; Hydorn 2018). The use of modern ICT and online platforms was suggested by most (n=107; 58%) students as a potential tool to enhance statistics education at CUT. Harrison (2017) indicated that ICT has the potential to unlock hidden statistical cognitive capabilities and break down the statistics difficulty complex among students, leading to a change in attitudes towards statistics and an improvement in statistical education. Collaborative assessment and an emphasis on the assessment triangle comprising cognitive ability, observation powers, and interpretation ability are imperative for the improvement of statistics education at CUT (Garfield et al. 2011).

3.5. Proposed learning, teaching, and assessment model/framework for statistics education

From the results of the study, a framework or model for teaching, learning, and assessment in statistics education at CUT was developed and is shown in Figure 2. The first point of analysis should be to consider the interest levels and the willingness to exert effort in statistics courses. Students at CUT are highly motivated, interested, and willing to put effort into statistics modules. Moreover, the mere fact that students are interested in statistics should lead one to consider how much value and use they attach to statistics modules (Figure 2).

The background, dispositional and situational factors, and the natural statistics cognitive capabilities can then be combined with existing interest and potential statistical effort to influence the students′ affect or attitude towards statistics. Then the statistical environment takes over. At this step, students advocate for intense use and investment in ICT infrastructure such as laptops, software, and a statistics research laboratory, which can always be driven by institutional policies regarding regulations on the statistics curriculum and ICT policy. The final step is to integrate all the cognitive and non-cognitive antecedents into appropriate teaching, learning, and assessment approaches, such as collaborative learning and teaching, e.g., through the use of group assignments and projects in the field of statistics. This stage must make use of e-learning and e-assessment. Ultimately, the goal is to improve statistical performance (Figure 2).

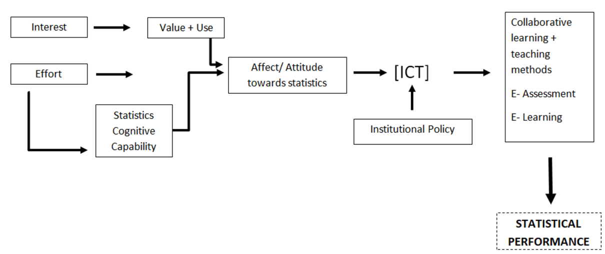

Figure 2. Proposed teaching, learning, and assessment framework for statistics education at CUT.

4. Policy and Managerial Implications

The case study has indicated the various perceptions (mostly negative) towards statistics education among students and even stakeholders. Various factors, such as conducive teaching and learning environments with adequate infrastructure, have been suggested in order to improve statistics education pass rates and its applicability in general society. What is clear is that almost all HEIs in developing and developed nations require a student to pass or merely attend a statistics-related module along the curriculum. This is a silent policy ensconced in the regulations, which tends to be mandatory at all HEIs. The danger is that this creates a forced situation where students reluctantly attend the module and tend to pass after so many failed attempts. What has never been made clear right from a pedagogical stage is that statistics is a branch of mathematics that must stand alone with some mathematical underpinnings, but statistics is not mathematics. As a result, the pedagogical curriculum mixes both mathematics and statistics, with feeble attempts currently being made to separate the two after or at the Matric or Form 5-6 level in most high schools, a stage right before university. This is where the policy, in the form of the curriculum, has confused students. This study is advocating for a national, if not international, Statistics Policy (SP) where a child/student, right from the formative Early Childhood Development (ECD) stage, is taught the difference between mathematics and statistics in a pedagogical format suitable for the environment, e.g., through visual learning and manipulation of counting toys. At the primary school stage, the distinction must be made clear, and learners must appreciate early what statistics is and what mathematics is, such that by the high school stage, a student will easily understand the difference between the two. As it is, most university students still do not and cannot distinguish between mathematics and statistics; worse still, most societal stakeholders cannot even distinguish between mathematics and statistics, inasmuch as the two are related.

Thus, from a managerial perspective, these results, which show disdain, antipathy, and fear of statistics, should stimulate innovative strategies for encouraging and incentivising the uptake and use of statistics in HEIs in both developed and developing nations. It is not enough to force a reluctant student to pass a module that is vital in life by means of regulations which are a form of a harsh take-it-or-leave-it policy. Rather, stimulating students would increase interest and effort and may increase pass rates in statistical education. Management should take a holistic approach and also focus on the facilitators and their special needs for the subject, which is consistently failed at most HEIs. Monetary incentives must be the last resort in a functional system. The first reward managers must consider is adequate facilities, time, and support for the facilitator or statistics teacher, as they would give to a teacher handling special needs students in any institute. In the current dispensation (the COVID-19 era), where virtual learning may be the new norm, the use of online learning for statistical students who already struggle with contact or face-to-face lectures needs a thorough revision and new modes of transmission. Adequate e-assessment, follow-ups, and stimulation of self-help approaches to benefit weaker students need to be instituted with the statistics teacher at the forefront, as they are the managers of the students' learning. Practical and computer-simulated real-life data need to be used online to stimulate students who tend to lose interest in complex mathematical calculations, and management needs to provide adequate IT support for learners and teachers.

5. Conclusions and Recommendations

This study indicated that the perceived difficulty of statistics, low statistics self-efficacy in tandem with a lack of supporting and facilitating conditions such as modern statistics supporting ICT infrastructure and a conducive teaching and learning environment has led to fear, stress, anxiety, and antipathy towards statistics and research methods among students. Of significance is that half of the students interviewed still regard statistics as an imperative component of their training and future career pathways. Students and lecturers alike recommended a paradigm shift in teaching and

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learning statistics underpinned by supportive infrastructure, a correctly aligned curriculum with a strong emphasis on the frequent use of e-learning and assessment modes, and collaborative learning using practical daily examples familiar to learners. In the future, the administrative and policy challenge is to off-set massification, optimise resource allocation, and address the need to reduce class sizes in statistical education, which guarantees individualised attention for the benefit of weaker students in resource-constrained developing countries.

Statements and Declarations

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Conflict of Interest Statement

All authors declare no conflict of interest in this manuscript.

Availability of data and material

There were no supplementary data for the manuscript.

Compliance with ethical standards

Authors have complied with all research and ethical standards in this study.

Informed consent

All participants wilfully participated in this study, and all confidentiality was preserved.

References

- Badza, A., & Chakuchichi, D.D. (2000). Curriculum Issues. Harare. Zimbabwe Open University.1–8pp.
- Barbosa, T., Lopes, S., Leão, C.P., Soares, F., & Carvalho, V. (2019). Serious Game for Teaching Statistics in Higher Education: Storyboard Design. In: Brooks A., Brooks E., Sylla C. (eds) *Interactivity, Game Creation, Design, Learning, and Innovation. Arts IT 2018, DLI 2018. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, 265, 169-175.
- Blanco, A. (2008). Una revisión crítica de la investigación sobre las actitudes de los estudiantes universitarios hacia la Estadística. *Revista Complutense de Educación,* 19, 311-330.
- Bond, M. E., Perkins, S. N., & Ramirez, C. (2012). Students' perceptions of statistics: An exploration of attitudes, conceptulizations, and content knowledge of statistics. *Statistics Education Research Journal,* 11: 6-25.
- Bui, N.H., & Alfaro, M. A. (2011). Statistics anxiety and science attitudes: Age, gender, and ethnicity factors. *College Student Journal,* 45,573-585.
- Chew, K.H.P., & Dillon, D.B. (2014). Statistics Anxiety and the Big Five Personality Factors. *Procedia-Social and Behavioral Sciences,* 112, 1177-1186.
- Chew, P.K.H., Dillon, D.B., & Swinbourne, A.L. (2018). An examination of the internal consistency and structure of the Statistical Anxiety Rating Scale (STARS). *PLoS ONE,* 13(3), e0194195. https://doi.org/10.1371/journal.pone.0194195
- Chikoko, V., & Mhloyi, C. (1995). Introduction to Educational Research Methods. Harare. *The Centre for Distance Education*, 74-78.
- Chirume, S. (2013). Challenge and learning support needs of maths, research methods and statistics ODL students: The case for ZOU-Midlands region. *International Journal of Research In Social Sciences,* 3, 77-88.
- Creswell, J.W. (2012). Qualitative inquiry and research design: Choosing among five approaches, (3rd Edition) Sage publications, London.
- Cresswell, J.W. (2014). Research Designs International students edition (4th edition) Sage Publications, London.
- Dablander, F., Epskamp, S., & Haslbeck, J.M.B. (2019, February 12). Studying Statistics Anxiety Requires Sound Statistics: A Comment on Siew, McCartney, and Vitevitch (2019). https://doi.org/10.31234/osf.io/pfnys.
- Dykeman, F. (2011). Statistics anxiety: Antecedents and instructional interventions. *Education*, 132, 441–446.
- Garfield, J., Zieffler, A., Kaplan, D., Cobb, G.W., Chance, L.B., & Holcomb, J.P. (2011). Rethinking assessment of student learning in statistics courses. *The American Statistician*, 65, 1-10.
- Gredig, D., & Bartelsen-Raemy, A. (2018). Exploring social work students' attitudes toward research courses: predictors of interest in research-related

courses among first year students enrolled in a bachelor's programme in Switzerland. *Social Work Education*, 37, 190-208, DOI: 10.1080/02615479.2017.1389880

- Greenland, S., Senn, S.J., Rothman, K.J., Carlin, J.B., Poole, C., Goodman, S.N., & Altman, D.G. (2016). Statistical tests, *P* values, confidence intervals, and power: a guide to misinterpretations. *European Journal of Epidemiology,* 31, 337–350.
- Gundlach, E., Richards, K.A.R., Nelson, D., & Levesque-Bristol, C. (2015). A comparison of student attitudes, statistical reasoning, performance, and perceptions for web-augmented traditional, folly online, and flipped sections of a statistical literacy class. *Journal of Statistics Education*, 23,23-31
- Harrison, H., Birks, M., & Franklin, R., & Mills, J. (2017). Case Study Research: Foundations and Methodological Orientations [34 paragraphs]. Forum Qualitative Sozialforschung / Forum: *Qualitative Social Research,* 18, 19-21.
- Horton, N.J. (2015). Challenges and opportunities for statistics and statistical education: looking back, looking forward. *The American Statistician,* 69, 138-145.
- Hydorn, D.L. (2018). Engaging students in the practice of statistics through undergraduate research. *Journal of Statistics Education*, 28, 87-91.
- Kirschner, P.A. (2017). Stop propagating the learning styles myth. *Computers & Education,* 106: 166–171. doi:10.1016/j.compedu.2016.12.006.
- Koh, D., & Zawi, M.K. (2014). Statistics Anxiety among Postgraduate Students. *International Education Studies,* **7**, 166–174.
- Lynch, T.L., & Gerber, H.A. (2018). The Ontological Imperative When Researching in the Digital Age. *International Journal of Multiple Research Approaches*, 10, 112-123.
- Macher, D., Papousek, I., Ruggeri, K., & Paechter, M. (2015). Statistics anxiety and performance: blessings in disguise. *Frontiers in Psychology,* 6, 1116-1119.
- Miller, E.M. (2019). Promoting Student Success in Statistics Courses by Tapping Diverse Cognitive Abilities. *Teaching of Psychology,* 46,140–145.
- Montgomery, D.C., & Peck, E.A., & Vining, G.G. (2012). *Introduction to linear regression 821*: 43-56. John Wiley & Sons.
- Mukeredzi, T.G., & Chiome, C. (2011). Learning Statistics as at a Distance: Analyzing the Causes of Failure in Statistics Courses in the Zimbabwe Open University. *Zimbabwe International Journal of Open & Distance Learning*, 1, 61-69.
- Mhlanga, E., & Ncube, N. (2003). Research Methods and Statistics: Reading Material for Course DEA 560 Harare: ZOU.
- Mutambayi, R.M., Odeyemi, A.S., Ndege, J.O., & Mjoli, Q.T., & Qin, Y. (2016). A Statistical Analysis of Students' Attitudes Towards Statistics: A Case Study of Undergraduate Bachelor of Science Students at the University of Fort Hare. *International Journal of Educational Sciences*, 14, 294-303. DOI: 10.1080/09751122.2016.11890504.
- Mvududu, N. (2003). A Cross-Cultural Study of the Connection between Students′ Attitudes toward Statistics and the Use of Constructivist Strategies in the Course. *Journal of Statistics Education*, 11, 3. DOI: 10.1080/10691898.2003.11910726.
- Nahm, F.S. (2016). Non-parametric statistical tests for the continuous data: The basic concept and the practical use. *Korean Journal of Anesthesiology,* 69, 8–14.
- Ncube, B., & Moroke, T.D. (2015). Students' perception and attitudes towards statistics in South African university: An exploratory factor analysis approach. *Journal of Governance and Regulation,* 4, 231-239.
- Onnis, L., Chun, W., & Lou-Magnuson, M. (2018). Improved statistical learning abilities in adult bilinguals. *Bilingualism: language and cognition,* 21, 427–433. Cambridge University press.
- Onwuegbuzie, A.J., Gerber, H.A., & Abrams, S.S. (2017). Mixed methods Research. *The International Encyclopedia of Communication Research Methods*, 23-45.
- Otto, D., Iddrisu, W.A., Kessie, J.A., & Larbi, E. (2018). Structural Model of Students'Interest and Self-Motivation to Learning. *Education Research International*. Article ID 9417109, 10 pages https://doi.org/10.1155/2018/9417109.
- Paechter, M., Luttenberger, S., Macher, D., Berding, F., Papousek, I., % Weiss EM., et al. (2015). The effects of nine-week summer vacation: losses in mathematics and gains in reading. *Eurasia Journal of Mathematical Science Technical Education*, 11, 1339–1413. doi: 10.12973
- Pan, W., & Tang, M. (2005). Students perceptions on factors of statistics anxiety and instructional strategies. *Journal of Instructional Psychology*, 32, 205-214.
- Prayoga, T., & Abraham, J. (2017). A psychological model explaining why we love or hate statistics. *Kasetsart Journal of Social Sciences,* 38, 1-8.
- Primi, C., Donati, M.A., & Chiesi, F. (2018). The Role of Statistics Anxiety in Learning Probability. In: Batanero C., Chernoff E. (eds) Teaching and Learning Stochastics. *ICME-13 Monographs*. Springer, Cham. https://doi.org/10.1007/978-3-319-72871-1_9.

- Rock, A.J., Coventry, W.L., Morgan, M.I., & Loi, N.M. (2016). Teaching research methods and statistics in E-learning environments: Pedagogy, practical examples and possible futures. *Frontiers in Psychology,* 7, 339-343.
- Schau, C. (2003). Students' attitudes: The other important outcome in statistics education. Paper presented at the Joint Statistical Meeting of the American Statistical Association, San Francisco, CA.
- Siew, C.SQ., McCartney, M.J., & Vitevitch, M. S. (2019). Using network science to understand statistics anxiety among college students. *Scholarship of Teaching and Learning in Psychology*, 5*,* 75-89.
- Stoloff, M. L., Good, M.R., Smith, K. L., & Brewster, J. (2015). Characteristic of programs that maximize psychology major success. *Teaching of Psychology*, 42, 99–108.
- Stowell, J. R., & Addison, W. E. (2017). Activities for teaching statistics and research methods. Washington, DC: American Psychological Association.
- Vanhoof, S. (2010). *Statistics Attitudes in University Students: Structure, Stability, and Relationship with Achievement*. PhD dissertation. Katholieke Universiteit Leuven Faculteit Psychologie.
- Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly,* 27, 425-478.
- Weissgerber, T.L., Garovic, V.D., Milin-Lazovic, J.S., Winham, S.J., Obradovic, Z., & Trzeciakowski, J.P, et al (2016). Reinventing Biostatistics Education for Basic Scientists. *PLoS Biology, 14*, e1002430
- Yang, D. (2017). Instructional strategies and course design for teaching statistics online: perspectives from online students. *International Journal of STEM Education, 4*, 34-38. doi: 10.1186/s40594-017-0096-x.
- Yin, R.K. (2014). *Case study research. Design and methods*, 5th ed. London, Thousand Oaks: Sage Publications.
- Zindi, F., & Munetsi, C. (2015). Experiential approach to teaching statistics and research methods. *Zimbabwe Journal of Educational Research,* 27, 1–15. Harare: HRRC.

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