

Student Performance Applying Statistical Skills in Higher Education: A Qualitative Analysis with Recommendations

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Abstract:

This research paper aims to provide the reader with a comprehensive background for understanding current knowledge on applying statistical procedures in higher education and its impact on adaptive learning. We examined a set of empirical results from several statistics tasks, as well as investigating how to choose a relevant statistical test effectively. The participants were graduate students in the various departments at the University of Cape Town (UCT). We used qualitative methods to evaluate and interpret findings. The results highlighted four distinct major directions for an effective choice of statistical test. We focused on the emerged added value of confusion in the application of real life problems, as well as the limited evidence available and highlighted the significance of further implications. Finally, we set our thoughts on possible uncharted key questions to investigate the non-familiar statistical tests from a technical viewpoint.

Keywords:

Statistical Test, Student Performance, Confusion Concept, Statistical Procedures

1. Introduction

[1] point out that statistics is a part of the mathematics syllabus for secondary and primary school in several countries. Real world difficulties are multifaceted; therefore, it is vital to mix knowledge and information from various academic disciplines, including education, engineering, art & humanity, applied, natural and social sciences [2]. Based on what is learnt from diverse experiences, the aforementioned challenges are addressed simultaneously, in order to fulfil the reality of learning statistics [3]. This current research paper promotes a better understanding of the interaction between graduate students and their environment including relevant environmental issues. Understanding how the notion of statistics has been combined into academic research, is indispensable to contextualising practices and behaviours for quality

assurance [4]. The study opts for a large contextual background to assess postgraduate students' ability to apply statistical skills and deal with social and behavioural sciences at the relevant universities. An important aspect to take into account is that these students have completed statistics courses, in some cases, for one or two semesters, in other cases, for three years, as part of their degree programme. As mentioned previously, the statistics course is a tool for the understanding of research projects. It can also contribute to the accomplishment of a specific research project, instead of being a pure academic discipline [5]. This indicates that a lack of knowledge of statistics is a serious educational deficiency of students all over the world. The consequences of knowledge failure in learning statistics have a dramatic effect research in social and economic fields and therefore a detrimental effect on innovation in research and innovation [6]. Unfortunately too, there is a significant lack of data, and the existent data are of poor quality [7]. Urgent action is needed to address the problem of a deficiency of knowledge of statistics. If real effort were to be made in this area, the number of students with inadequate knowledge in statistics could decrease considerably, [8]. The present situation has raised many questions, which have motivated the initiation of this paper's research. The principle research question is, therefore, "How can statistics learning oriented policies at the University of Cape Town (UCT) in South Africa be improved efficiently?" "What are the actions already implemented, to reduce statistics learning failure?" and "What are the current and future consequences of statistics learning failure, if more attention is not paid to the problem?" The intention of this current research is to examine the knowledge level of postgraduate students, in applying appropriate statistical procedure in several situations. In other words, to identify factors associated with learning statistics that might inform researchers, policy-makers and other stakeholders to develop relevant preventative measures and interventions for research.

2. Data and Methodology

The design of the study employs a qualitative method. [9] acknowledge the use of an extensive data collection, which promotes concentration on a better understanding of an established area of statistics education, as well as new areas of research. Similarly, [10] emphasises the importance of using a qualitative research method for diverse reasons in statistics education research, including, creating space for new ideas, allowing the participants to provide their own perceptions, and investigating emerging areas of research. [11] asserts that the valuable role of qualitative research methodology in statistics education, which allows the development of hypotheses as part of the research process, is to mature an adequate theory, according to the observations that have been made.

All Masters and PhD/post-doctorate students, enrolled in postgraduate programmes, were eligible to participate in this research project. The selection method was purposive sampling, as the participants who were available provided easy access to special perspectives, as well as experiences that could facilitate a better understanding of the phenomenon under study. The researcher met the prospective participants individually, and requested their voluntary participation in the qualitative phase interviews. Consequently, 12 students were purposively selected from different departments at UCT. However, two students withdrew from the study during the interview sessions. The researcher conducted one-to-one, semi-structured interviews, prepared in advance, with each participant. The responses were transcribed and reported in categories or themes. Data was saturated when the researcher could no

longer gather any new information, or extract any new categories, or new inputs into new categories, from the data [12].

The qualitative method combines a predetermined set of open-ended questions, as well as detailed multiple statistical situations, formulated ahead of time. The semi-structured interview starts out with general questions, followed by pointed questions, and ends with questions that emerged during the interviews [13,14].

Individual meetings were set for the participants in safe, suitable, comfortable venues. Initially, the researcher made introductory small talk and revisited all the ethical considerations, before handing the participant the qualitative questionnaire of tasks (statistical test items) to complete. While the participant completed the questionnaire, no discussion took place. Unfortunately, two participants dropped out during the interviews, as they found the tasks (statistical test items) beyond their ability and knowledge to accomplish. After the questionnaires of tasks were completed, the researcher asked several analytical questions, such as “How did you decide?”; “Which information in the item notified or oriented you to that choice?”; “What will the test tell you?” Ultimately, the data were captured in one file (qualitative data).

3. Qualitative Findings

This section highlights the answers of the one-on-one, in depth interviews, preceded by “3-hour-long tasks” questionnaire that the postgraduate students at UCT were required to complete. The first part concerns a description of the participants’ characteristics. The second part involves the verbatim transcribed and reported responses of participants.

3.1. Description of the Study Participants

The sample size of the participants for the qualitative phase was twelve. Two respondents (female and male) withdrew during the data collection process. Only ten participants successfully completed the interview process. The study sample included two females (white and Black) and eight males (one white and seven Black). Five participants forty-five had Masters degrees, four PhDs, and one had post-doctorate status. Five participants were under thirty years of age, three were aged between thirty and forty-five years and two were older than forty-five. Furthermore, these students were involved in teaching assistance, particularly, tutoring undergraduate level statistics at UCT.

3.2. Participants’ Responses

The semi-structured interviews, which included the qualitative questionnaire with open-ended questions, provided real insights into the key issues perceived by the postgraduate students of UCT. All the responses from the ten participants (Respondents 1-10) are summarised below, in response to the semi-structured questions:

How did you decide to choose the test? Or on what basis did you choose the test that you have chosen?

Respondent 1: “Humm, based on my first year Stats course, three semesters of stats, so I know something about stats, but I’m like, about four years ago, and, and then any other experience I’ve had, was straight the research.”

Respondent 2: “Humm, it depends on the parameters that I would have there are two groups I just know that if one is dependent or not I will know the test.”

Respondent 3: “Humm, in general that it is in general you can say as what it is asking for like the measurement, the measures, then also the guide of methods that was supposed in that particular study, and then also the sample size for sampling frame so those are straight things that I am looking at to decide which one to choose.”

Respondent 4: “I looked at the method that it is appropriate so applied to the problem at time.”

Respondent 5: “So, I look at the type of the question that you are trying to ask, and if you are looking or if you are trying to investigate the effect size, then looking for something regression you are trying to test like the relationship between two things that it is probably a t-test or something that’s sort of like a guideline for that.”

Respondent 6: “Humm well I first checked the third question required a parametric or non-parametric answer and that’s why I decided to choose a certain test.”

“Well, I first decide like I look at the question and see whether it needs to be a parametrical or non-parametric method that you implemented from there I then choose the suitable test then splitting it between the two groups and then decide which test it is more appropriate for the data.”

Respondent 7: “Ok I just tried to remember some of the things that I previously on courses I took in statistics and then some work that I have done on my research, previous research based on what I have done in the past, that’s what influence my decision.”

Respondent 8: “Thank you for taking my time.”

“Yes, the first thing is no matter what I will do is to look at the analyzing principles, the questions that you want to answer, and then you look at the tiers that would allow you to answer such the questions. So that is what I use to analyse what I choose the answers that I choose for the various scenarios but I didn’t have enough time to sub-check each scenario or proper structure also of these could not be exactly what I will be doing right in the real science you know if I have time enough, you know, yeah.”

Respondent 9: “First with the available data, I have made different comparisons, qualitative data and quantitative data, I deal with one group or two groups, then the group of dependent and the group of independent, the data related like in which ...different of means ...”

Respondent 10: “I choose to answer the tests based on the knowledge first that I have about statistics and which relevant topics that applied to certain, humm certain description of data or information that I have to deal with.”

Which information in the item alerted you to that choice? What did the test tell you?

Respondent 1: “Humm, based on the description with each question, humm, I sort of worked out on how many variables there were and then any table was given, humm, I tried to relate that back to something that I had seen before, based on the Stats course I did. So, for example if there was just a simple two independent groups to test, I would use a t-test. So that’s what I would, that’s how I would answer the question.”

Respondent 2: “Euehe, information in the items, eumm, the variables, and then the numbers.”

Respondent 3: “So, I think the outcome measures may cope the statistics I hope the statistics yah, the one that actually let me decided which one to cope for.”

Respondent 4: “So most of the questions concerned humm comparisons and associations, so you look at the two items what are they interesting, so the next thing you have to do if are they qualitative or are they quantitative, so you based what test to use on the qualitative and the quantitative and then what you want to achieve.”

Respondent 5: “So, I look at the type of the question that you are trying to ask, and if you are looking or if you are trying to investigate the effect size, then looking for something regression you are trying to test like the relationship between two things that it is probably a t-test or something that’s sort of like a guideline for that.”

Respondent 6: “Humm, the question and what you’re trying to estimate so if the one say what you are trying to predict and the data presented.”

Respondent 7: “Most of the time I saw words like predictive statistics or maybe uummm ahhh what’s statistical procedure. And those I would like to use to say which one of the test that about listed here that which of them is possible right statistical test to use.”

“Humm, sorry, I don’t get it.”

“Most of the time it writes the T statistics, the P value or the F statistics or and Chi-square and value, I am trying to remember the one for statistics for Chi-square now. But I know it either F statistics or T stats and P value and then maybe x-square stats yeah for chi-square yeah.”

Respondent 8: “Basically say, is that aligned principles, what questions are you asking, what data do you have, what question do you want to answer with the data you have?”

Respondent 9: “The quality of the question you are asking about testing the difference of means then I know some kind of mean that kind of t-test, it fits like testing some kind of correlation, association, then, some kind of chi-square test, so, though just need the questions that the line coming us have been asked effect.”

Respondent 10: “Yes, there is a certain information that talked about the distribution, certain information that talk about variances, certain information talk about frequencies and then you know you can actually deal with frequency or you can largely give the distribution of variance so it depends on which term that actually you found or something that, as some data that give you an idea that actually they are looking for frequencies then you can actually ... “

Was it difficult to decide? / Which information in the item made it difficult?

Respondent 1: “Humm, maybe based on limited knowledge, of some of the options that there are available, cause I have never used, for example, humm, one of the may be Kruskhal-Wallis, one way-ANOVA and I’ve never used that before so I have no idea what that means, so I haven’t thought what that means, I don’t know if it’s applicable test. Okay.”

Respondent 2: “Yaahss, it’s somewhere very difficult because it is like the test you could do if for most of them and then subsequently, it then follows different statistically analysis. It became difficult on what...”

Respondent 3: “Yeah, it was difficult, because those statistics, I think maybe thus, my own problem because I haven’t thought I don’t know each and every one, that’s why may thus be mistake and also statistics is also not my kind of subject so I was struggling in that way for each one to decide.”

“Ok, some parameters, just by the methods, so, the methods used the one that would equal you to decide like some of them that I have no idea in answering the question and just finding difficult understanding of the data.”

Respondent 4: “So most of the questions concerned hum comparisons and associations, so you look at the two items what are they interesting, so the next thing you have to do is are they qualitative or are they quantitative, so you based what test to use on the qualitative and the quantitative and then what you want to achieve.”

Respondent 5: “Yeah, in terms of the scenarios it was little bit difficult but it was kind of ...”

“At a time like a person wasn’t so clear was trying to think further, think like and the amaze arises thing I think actually been looking for people because some were trying to answer so...”

Respondent 6: “Yeah, it was a bit tricky because some of the stuff I haven’t seen in a while.”

“Humm, the information that makes it difficult, I don’t know the whole story behind the data just makes the selection process a bit slow, but I think that’s what made it difficult people was just ... the data and what you want to straight achieve and then I think that would make direct the process could be a bit quicker.”

Respondent 7: “Yeah, there were times when most of the questions the required than difficult to decide or not test to choose from maybe because I have never done hummm analysis that involves such test before in my research work.”

“Mmmm, it is possibly because I have not thought about an analysis doing like that I can’t do I don’t know exactly but I note here some questions that you can’t easily be like this is the kind of test you need to perform and need to humm and maybe because I have not been exposed to statistical analysis study involves such items. Possibly that is why I couldn’t pick out whether I achieve it right which test is right or not.”

Respondent 8: “Yeah, I found difficulty in some of them, I have been never used some of the methods, so, I haven’t known where I mean, it is not everything there I know so, there are some methods there I didn’t know so, then I put in up to apply then.”

Respondent 9: “Yes, I mean some quizzes were easy, and some were not easy and some of the tests I have ... ok them, so thing is I’m not even test so they maybe some they would have been treating to, so this test that I would have been encountered before, so I wouldn’t be able to say for sure, yeah.”

“Some questions are dealing with understanding. Yeah, yeah. Maybe the language problem.”

Respondent 10: “Yeah, I will say yes at some point, because statistics actually where it is vast, and the way we through our career as a student, we probably deal with certain considering not movement ... not on certain rules of the topic, so it quite challenging but you may find other test that challenge you want to try to bring it back to which topic they belong to especially when you don't know any other topics that they can be really be part those who that look simple then you can now show actually than they took about.”

Did alternative possibilities come to mind? / Did you think about some assumptions that you suppose to apply?

Respondent 1: “You mean like to fill in the gaps in my knowledge, personally?”

I do have a Bio-Stats book that I have bought to prepare it properly but only if this applies to me, in my actual research where I have been use for it. So, when I come to reading, do stats and find the appropriate test, I will apply the appropriate test, but I understand statistics so I don't need to deal with this, like, on a daily basis.”

Respondent 2: “Yeah, in that I know like for some of these measures you need to know ehehehe the nature of the graph it is skewed or not and then decide the test. So like I wasn't have any net parameters to do that, just decided and observe is quite difficult.”

Respondent 3: “First thing, thinking that you would have just think or I think I don't understand things, so I wasn't thinking like that other options, that I would put otherwise I have just written like my own test to say I think I think so I think to the right cone because I did everything in the broad line.”

Respondent 4: “Humm, not really, my concern was because reading quiet a lot of activities there are almost covered everything most of the tests that could be applied so actually I didn't think outside what I have been given to because I think we over change or something alternative there.”

Respondent 5: “Humm, other alternative possibilities to these tests or yes there are some ones with instead of its ... like this, I think it's for the spearman and test something that it's humm a test but it's a non-parametric test that we got idea for I think is for the parameter measures related percent ...”

Respondent 6: “There were quite a few and there were different alternatives.”

Respondent 7: “No, I didn't try too. I did not think about an alternative possibility. I am just thinking of if its either going to be one test that is suitable for a particular item or there I would know whether test that is important, suitable for it, Yaah.”

Respondent 8: “Not really in a short period of time. Yeah, because some of the things that I will tell than alternatives... if you look at my responses there are some particular tests that I use for multiple number of responses and scenarios.”

Respondent 9: “Yes, yes.”

Respondent 10: “Yeah, some alternatives came, but I was not quite sure whether those items would be, would match those topics because I cannot just start pick any topics that's actually you can see the same and other black spot around I would not quite sure which what item could be it's related to what topic.”

Why were some tests rejected?

Respondent 3: “Some of them because humm, maybe some of them are not exactly like the options are noted exactly phrase the way like I know them, you know, maybe I know like two samples paired t-test like that but also in there, they are also make phrase different maybe for me there are also the same.”

Respondent 5: “I didn’t go that far.”

Respondent 6: “I think they will be accepted.”

Respondent 9: “I just choose so if I read the questions and then I found that maybe two tests will be fitted so, I just choose the more relevant one according to me yeah, so I just reject the other one and pick the most relevant.”

Respondent 10: “Because not sure, I could not just put anything there that I have, I want to put something when I am sure.”

How confident are you about the decision you made?

Respondent 1: “Humm, in general, I’m very confident, pretty confident. Yes, (laugh).”

Respondent 2: “I would say like 80% confident.”

Respondent 3: “Yeah, I’m hoooo, I think some of them I was very confident. Maybe I was 60% confident.”

Respondent 4: “Yeah, so in which test? I’m above 80% confident.”

Respondent 5: “Humm partially, I even but, I haven’t seen some of these things for a while. So right, I’m 60% confident.”

Respondent 6: “Humm, about 60 till 70% because like I could have said, I haven’t seen some of this stuff in a while.”

Respondent 7: “Like I said, it’s still a very constraint that you spend some time when you to directing something very seriously and half-way between, not too confident, but also I’m not saying I’m not confident the board of my responses.”

Respondent 8: “I am only confident to the respect of the target that you have been given me. Realistically telling I will put myself as C because I didn’t have time to really subject each scenario, so I rate myself as C, yeah. C is 60% confident.”

Respondent 9: “Given that I don’t know all these tests and given that I haven’t done, most of these ones like undergraduate, I’m partially confident. I rate myself at 65% confident. Because the thing is like in the higher legal education we don’t really use most of these tests, they allow most of in the second year so...yeah.”

Respondent 10: “Based on the knowledge that I had about statistics as notion of statistics, and I see how the test related to the notion that I have actually I found that I’m confident thus what I have taken as a Maths student as it comes to, I tell them that a topic that they have to be applied.”

“I think I will fit in the average in the sense so I didn’t covered all the questions but for the things I did it’s that I have covered I’m sure that I must be able to score even half of the most if I have to meet mark on only the number of questions that I have covered, I must be able to score half or maybe more than half, that’s why I decided that I should have more than 50% and above.”

Please mention any items that you are not familiar with

Respondent 1: “Humm...humm, A Fischer’s z Transformation I don’t know what that is. humm, a Sandler’s A statistic, I don’t know what those two are. Thank you.”

Respondent 2: “I have seen Fischer but I don’t know what it is for. Semi-partial correlation, it sounds familiar but I don’t know. Euhm, I have seen Mann-Whitney U-test but I’m not used that before, Wilcoxon signed rank test, Friedman’s two-way ANOVA for ranked data I ‘m not used them. MANOVA I have not used that, Discriminant analysis no, I’m not used to, these ones I have seen in literature but I’m not done them like the basic courses.”

Respondent 3: “The factorial ANOVA, Goodness of fit Chi-squared, t-test, Mann-Whitney, Paired t-test, Post-hoc test for comparisons I know it now then most of these here, like partial correlation, factor analysis, Discriminant analysis, Factor analysis, semi-partial correlation, Sandler’s A statistics and path analysis.”

Respondent 4: “For those that I have listed here, I don’t think there are any of them I’m not familiar with. I think the path analysis, Sandler’s A statistics, I have been used these two before, yeah, I think I have been used these two before; but otherwise the rest I think yeah, so, the only think is you have to read the question that have been asked and try to relay them back so which is I mean need time, the time is the major problem. Because the question asked there you need to understand them first and relay them to the test that are used even you are familiar with the test, you need time to identify what test can be applied to the problem you can’t just say require with this method and this problem is then I can use any method.”

Respondent 5: “Humm, let’s see. Sandler’s A statistics, Path analysis are not whether I’m thinking is not partial but what I’m thinking Fischer z transformation ...”

Respondent 6: “Sandler’s A Statistics, Path Analysis and the Mann-Whitney U- test, don’t sound familiar to me at all. Yeah, there are those ones that don’t sound familiar, and the Post Hoc Test for comparison of means. Humm, I have never seen that before.”

Respondent 7: “So for all the test that I have listed in the items, I’m not familiar with multiple correlations, and Mann-Whitney, goodness of fit, spearman’s rank order correlation, humm, humm chi-square for association not too familiar with it, Humm, yahh I think there are the major ones that I’m not really familiar with. Thinkable I have done one to my daughter in-law so my work doesn’t involve a lot of stats analysis just a minor and statistics or analysis that I do for stats analysis, yeah.”

Respondent 8: “Here, humm, here I don’t know post-hoc test for what I know is that is I hardly used it. Friedmann Two-way ANOVA for rank data I don’t know what that test really. Path analysis, Sandler’s A statistics, I didn’t know what those tests. Otherwise the rest I think, I have fair idea about what do I agree.”

Respondent 9: “Mann-Whitney U- test, Sandler’s A statistics, path analysis, Fischer z transformation, I’m not sure, yeah, and Semi-partial correlation, Pearson’s product –moment correlation, that I have haven’t never seen before. Then the others, I have some ideas, yeah.”

Respondent 10: “There are actually so many, I’m familiar with the ANOVA thing, the ones that I’m not familiar with it’s the Chi-squared test of association, the z statistics, Spearman rank order correlation, Fischer z transformation, so, there are actually so many that I’m not aware of but it seems that like Sandler’s A statistics, Wilcoxon signed rank test, Discriminant analysis, Fischer z probability, like Kruskal-

Wallis One-way ANOVA, it's just certain thing that I'm not aware this is my first time to hear than though I have statistics course but, there are new concepts that I really really really really find. Thank you so much."

What factors hinder recovering the choice of statistical test?

Respondent 2: *"I would like to be thought you see what I mean so I know you could show me how to then observe the ways like I make up you see the data and then you decide which analysis they are declined. Because I have been following up I have done the training on literature, training on like English in terms of literature but such thing I have never seen any statistics course."*

"Can you make time to teach if you have to ...?"

Respondent 4: *"Because the question asked, you need to understand them first then; you need time to identify what test to be applied to the problem you can't just say require this method for this problem."*

Although scant research has been conducted on statistics learning in postgraduate studies, one way to ascertain the elements that constitute a supportive environment is to explore the specific behaviours that students rate most highly on their evaluations of choosing a right statistical test. A number of studies reveal a consistent pattern [38,39]. According to the data gathered from the participants, three main themes emerged, namely, the ability to choose a statistical test, the perceived failure to choose the right test, and non-familiar statistical tests. In order to achieve a better analysis, some of these themes were subdivided into sub-themes. Regarding the ability to choose a statistical test, three sub-themes emerged, as they highlighted major concerns about a choice of the correct statistical test, practical knowledge to choose a statistical test and confidence about the decision made. Referring to perceived failures to choose the right test, two sub-themes were established, regarding the causes of difficulty to select a statistics test, as well as the reasons of the rejection of some tests. The three general themes that emerged from the analysis are displayed in Table 1.

Table 1. Description of the qualitative data.

THEMES	SUB-THEMES	CODES
Self-efficacy to choose a statistical test	Major concerns about a choice of statistics test	Inspection of the data, outcomes
		Understanding of the concepts
		Understanding of the problem
		Knowledge of assumptions
		Experiences In research
		Experiences in statistics
		Consultation of peer students
	Enough practical knowledge to choose a statistical test	Inspection of data, outcomes
		Interpretation of objectives
		Inspection of keywords
		Knowledge assumptions
		Experiences in statistics
	Confidence about the decision made	Checking different possibilities
		Complete confidence
		Much confidence
		Confidence/partial confidence
		Complete understanding of the items
		Less time spent t in choosing
Lack of statistics skills		
Conflicting choices		

		Contradictions, doubt
Perceived failures to choose the right test	Causes of difficulty to choose the right test	Lack of Information
		Lack of knowledge
		Real life problem
		Non-familiarity with the items
		Misunderstanding of the items
		Confusion in interpretation
		Conflicting concepts in statistics
		Different area of expertise
	Reasons for rejection of some tests	Lack of information
		Misunderstanding of the concepts
		Assumptions do not allow
		Confusion, frustration
		Less evidence, difficulty in choosing opinion of peer students
		failure to satisfy criteria for the test
Non-familiar statistical tests	Not familiar items	Discriminant analysis
		Effect size
		Factorial ANOVA
		Fischer Z transformation
		Friedman two-way ANOVA
		Kruskal-Wallis for One-way ANOVA
		Partial Correlation
		Path analysis
		Post-hoc comparisons of means
		Sandler's A statistics
		Semi-partial correlation
Sign test		

A detailed analysis of the three themes is discussed in the next section.

4. Evaluation of the Qualitative Findings at UCT

In this section, the respondents' comments are summarised in themes and sub-themes, and the detailed discussions of these findings are presented below.

4.1. Theme 1: Self-efficacy to Choose a Statistical Test

The data was exposed to thematic analysis. One of the most difficult (and potentially fear-inducing) elements of the research procedure for most students is selecting the precise statistical technique to examine the data. The determinant for choosing a relevant test for statistical analysis should be subject to the nature of the variables, sample size, procedure and assumptions. In addition, a postgraduate student has to be aware of all information related to the interview, as well as interested in being involved in the study.

The participants recognised that they were aware of achieving some tasks before the semi-interview. Their choice of statistical test, which helped to assess their level of ability and eventually highlighted or revealed the complex process of reasoning related to the difficulty of making a wise choice. Despite previous experiences in research methodology and statistics, some participants realised that the choice of the tests remained challenging; therefore, there was limited availability of information in those scenarios. Major concerns about the choice of a correct statistics test, sufficient practical knowledge to choose a test, how a student tackles the assignment of interpretation of a theoretical situation and confidence about the decision made, were

three sub-themes that resulted from the main theme. In addition, interaction among the participants enhanced the data quality.

Major concerns about a choice of a statistics test

The responses, generally, were related to inspection of the data, understanding of the concepts, knowledge of assumptions, experience in research methodology, experience in statistics and consultation with peers. The greatest shared reactions concerned data problems, such as, understanding of the concepts, lack of confidence due to the length of time since the preceding mathematics or statistics class, and grades. The results indicated that the participants found choosing the correct statistics test challenging, as indicated by their limitations in determining the methodology and the sample size. This could be due to an anxiety, which relates to worth of statistics, or fear of asking for help, during the learning process. [15] found that extremely anxious students frequently have fairly poor self-assurance, and little confidence in their self-efficacy beliefs. However it appears that the students became aware of, not only the mistakes they made, but also how to resolve them in future situations. This is a clear indication that assistance dynamics such as these tasks, help students to develop better learning strategies. The findings seem to agree with [16], who asserts that the external activities of the learning environment tend to influence the internal cognition of students. It appears that in some situations, learning is influenced by the students' insufficient understanding of the possible choices [17]. This experience was shared by participants 3, 4 and 5, who said that they experienced difficulties in performing choice procedures. The following quotations substantiate this:

“Humm, in general that it is in general you can say as what it is asking for like the measurement, the measures, then also the guide of methods that was supposed in that particular study, and then also the sample size for sampling frame so those are straight things that I am looking at to decide which one to choose.” **Participant 3**

“I looked at the method that it is appropriate so applied to the problem at time.” **Participant 4**

“So, I look at the type of the question that you are trying to ask, and if you are looking or if you are trying to investigate the effect size, then looking for something regression you are trying to test like the relationship between two things that it is probably a t-test or something that's sort of like a guideline for that.” **Participant 5**

The research findings in this study appeared to be identical to a previous study conducted by [18], who asserts that, in academic achievement, lower levels of self-efficacy are related to advanced test anxiety, as well as impaired task understanding. This is another instance where the interaction in learning environment becomes a process that prompts students to reallocate not only cognitive gains and effort, during the learning discourse, but also to critically examine possible sources of errors. This process is used individually and cooperatively. Studies have revealed that peer-interactions, during the monitors' learning process, are critically important [16]. In this sense, participants 9, 10, 1 and 7 acknowledged that the inspection of the data and their previous experiences helped them to achieve the relevant choice, as the following quotations reveal:

“First with the available data, I have made different comparisons, qualitative data and quantitative data, I deal with one group or two groups, then the group of dependent and the group of independent, the data related like in which ... different of means.” **Participant 9**

“I choose to answer the tests based on the knowledge first that I have about statistics and which relevant topics that applied to certain, humm certain description of data or information that I have to deal with.” **Participant 10**

“Humm, based on my first year Stats course, three semesters of stats, so I know something about stats, but I’m like, about four years ago, and, and then any other experience I’ve had, was straight the research.” **Participant 1**

“Ok I just tried to remember some of the things that I previously on courses I took in statistics and then some work that I have done on my research, previous research based on what I have done in the past, that’s what influence my decision.” **Participant 7**

Having the knowledge of assumptions enables graduate students to choose the correct statistics test, relevant to the scenarios. In this case, the findings revealed that the participants 8 and 2 asserted that the knowledge on assumptions was essential in statistical procedures, and constitutes a great challenge that could even lead someone to consult statistics monitors or peers. The following quotations refer:

“Yes, the first thing is no matter what I will do is to look at the analysing principles, the questions that you want to answer, and then you look at the tiers that would allow you to answer such questions. So that is what I use to analyse what I choose the answers that I choose for the various scenarios but I didn’t have enough time to sub-check each scenario or proper structure also of these could not be exactly what I will be doing right in the real science you know if I have time enough, you know, yeah.” **Participant 8**

“Humm, it depends on the parameters that I would have there are two groups I just know that if one is dependent or not I will know the test.” **Participant 2**

The participants were concerned about their experience in research and statistics, and were frustrated in their efforts to understand the case studies, in order to apply them more effectively. They expressed the need to learn how to apply their experience consistently. These findings were in accordance with the findings of previous studies. For example, a study conducted by [19] suggests that, the failure in learning statistics is due to an unsatisfactory grounding in preceding statistics classes. This lack of a firm and adequate foundation makes students fearful of statistical concepts; consequently, they think that they do not have sufficient mathematics experience to do well in statistics. The following quotations indicate this:

“Humm, based on my first year Stats course, three semesters of stats, so I know something about stats, but I’m like, about four years ago, and, and then any other experience I’ve had, was straight research.” **Participant 1**

“Ok I just tried to remember some of the things that I did previously on courses I took in statistics and then some work that I have done on my research, previous research based on what I have done in the past, that’s what influence my decision.” **Participant 7**

“I choose to answer the tests based on the knowledge first that I have about statistics and which relevant topics that applied to certain, humm certain description of data or information that I have to deal with.” **Participant 10**

The participants argued that the time required to complete all the items was too limited, making it difficult for them to respond effectively, as the following quotations indicate:

“Thank you for taking my time.” Participant 8

“Realistically telling I will put myself as C because I didn't have time to really study each scenario.” Participant 8

“Because the question asked, you need to understand them first then; you need time to identify what test to be applied to the problem you can't just say require this method for this problem.” Participant 4

Practical knowledge employed in choosing a statistical test

Students are likely to apply considerable time in looking for basic patterns they are familiar with in the hope that possible responses and explanations will arise progressively, lengthways with the conceptualisation of the problem itself [17]. Unfortunately, educational researchers do not focus on participants' individual thought processes, but on their final perceptions of the task. In so doing, awareness includes a performance of organisation, in which a condition is harmonised to patterns that changed from existed practices. For certain students the introduction to statistics was so unsatisfactory that it led only to a very fragmented understanding of statistical strategies, and therefore to the potential for disappointment and even disgrace. This is borne out in the literature and in the experience of parents, peers and peer monitors. In other students, the proto-typical pattern to which the condition is harmonised comprises the potential for stimulating and original creativity, calling for a mixture or addition of all senses.

In line with [17], the findings revealed that the participants viewed the items of practical knowledge they needed to choose a statistical test as a series of difficulties that they had to resolve. These difficulties consisted of the review of data and concepts, interpretation of objectives, identification of expected outcomes, description of assumptions, application of previous experience in statistics, examination of different options, and choosing the appropriate statistical test. Each item was regarded as a stressful experience.

The inspection of data and results were also regarded as challenging, frustrating and intimidating. The participants became dissatisfied and disappointed. This conclusion was consistent with the theoretical framework, described by [20] in which students with similar attitudes were expected to assimilate certain strategies during their learning process, such as learning from failure. Unfortunately, as with [20], the failure of this cohort of students to address the difficulty of selecting the correct approaches tended to be recurrent in statistical learning, as the following quotation expresses:

“Yes, there is a certain information that talked about the distribution, certain information that talk about variances, certain information talk about frequencies and then you know you can actually deal with frequency or you can largely give the distribution of variance so it depends on which term that actually you found or something that, as some data that give you an idea that actually they are looking for frequencies then you can actually ...” Participant 10

How a student tackles the assignment of interpretation of a theoretical situation.

The student starts with the goal of extracting individual sense from the item, which leads to a lively application of knowledge, in which the student tests the concepts, confirmations, and influences presented by the authors, attempts to appreciate correlations among the concepts offered, and thereby seeks to extend his or her bank

of individual knowledge and to establish a relationship with the outside world. This in turn, implies that the student is building information within a personal background. [21] postulates that the action establishes a system of expressive networks among the original evidence and earlier well-known ideas, thoughts, and accurate evidence.

Authenticity is achieved by drawing connections with the real-world to students' everyday life and to practise in the discipline, as well as the actual transformation of knowledge. Content is often situated in questions, problems, designs or attaching events that encompass important subject matter concepts, so that students learn how to process ideas and skills as they go about working. Meaningful problems create a need to know a situation, to learn specific ideas and concepts, and provide a reason to understand. They provide students with multiple opportunities to work with concepts around the driving questions, and the real-world problems under study. The following extract from the collected data reveals this process:

"I just choose so if I read the questions and then I found that maybe two tests will be fitted so, I just choose the more relevant one according to me yeah, so I just reject the other one and pick the most relevant." **Participant 9**

Regarding the interpretation of objectives and assumptions, the participants were annoyed when they considered that they had not achieved a satisfactory result from their choice. These results were in accordance with the findings of [22] who evaluates the effectiveness of statistics reasoning and assessment. [22] declares that, when students are faced with uncomfortable and incorrect data, they do not think beyond the content, since different their established ways of interpreting are based on different assumptions. Students will be confused because their reasoning and assessment will be based on uncertain intuitions, errors and misconceptions. The following quotations support this observation:

"Basically say, is that aligned principles, what questions are you asking, what data do you have, what question do you want to answer with the data you have?" **Participant 8**

"So, I think the outcome measures may cope the statistics I hope the statistics yah, the one that actually let me decided which one to cope for." **Participant 3**

Students are more concerned with assignment achievement than with refining their knowledge and abilities. Therefore, during the mechanical process of repetition and memorisation, students may well be unsuccessful in differentiating between vital opinions and secondary evidences, or between standards and illustrations. They may be doubtful about how to link indication and assumptions, or how to inspect the argument when using a relevant method. In fact, the participants realised that the application of previous experiences in statistical procedures should not be a stress-free task and could be confusing. Despite the fact that the assumption guidelines allowed them to move forward in a rigid way, they had to consider multiple decisions simultaneously, to appreciate the differences and similarities. Added to this, their different cultural backgrounds influence their way of coming to a conclusion. [23] assert that postgraduate students from different cultural backgrounds have a different ways of understanding. Learning statistics requires that students should approach new ideas and concepts critically. Some of them interpreted these approaches as different from their previous experiences, as the following extract indicates:

"Humm, based on the description with each question, humm, I sort of worked out on how many variables there were and then any table was given, humm, I tried to

relate that back to something that I had seen before, based on the Stats course I did. So, for example if there was just a simple two independent groups to test, I would use a t-test. So that's what I would, that's how I would answer the question." **Participant 1**

The development of knowledge could be understood as progressive in sense that it is the critical phase of reorganisation, reclarification of the information, and the conclusion is more or less, a broad imitation of the scenario. The innovative construction of the method to discern the learning idea had an acceptable attention. Even in this attention, there is a strong indication that the method accepted by the student is adjustable overtime. After the experience, a processing phase of reflection occurs. Reflection is an important human activity, in which students recapture their experience, think about it, consider it over again and evaluate it [24]. It is only when students bring their ideas to their consciousness that they can evaluate and begin to make choices about what they will, or will not do.

According to [25], students believe that choosing a statistical test is something they randomly select. The following quotation refers:

"Ok I just tried to remember some of the things that I did previously on courses I took in statistics and then some work that I have done on my research, previous research based on what I have done in the past, that's what influence my decision." **Participant 7**

Confidence about the decision made

[26] examines the opposing stages of essential and extrinsic incentive and their effect on students' methods of interpreting theoretical tasks. He determines that students, who have identified the motivating or pertinent item, were more likely than others to accept a reflective method. In contrast students who had not identified the trial demanding an extrinsic incentive because of nervousness, were inclined to accept superficial methods. For postgraduate students, most events that precipitate reflection emerge from normal occurrences in an individual's life. The motivation to reflect may arise from a loss of confidence in, or disillusionment with, an existing situation.

This current study's findings are in line with [26] claims that learning methods used for students at the beginning of their study of statistics are the more passive ones and should be implemented by repetition until they are confident enough. The following quotations reveal this:

"Humm, in general, I'm very confident, pretty confident. Yes, (laugh)." **Participant 1**

"Yeah, so in which test? I'm above 80% confident." **Participant 4**

"I would say like 80% confident." **Participant 2**

In subsequent research, and in particular this research into how students learn it became evident that most students need support from experienced statistical monitors in order to make the transition from the surface learning approach to a deep learning approach. Only if students acquire a disposition to think for themselves [27] will they develop sufficient flexibility in their thinking to use and build on their existing knowledge. A 'thinking disposition' is a readiness to learn combined with the ability to reflect on various perspectives and decide on the most suitable answer in a particular situation.

The following quotations reveal that the students were still at the surface level of understanding (rote learning) and were unsure about how to build on their existing knowledge to cope with the new tasks:

“Some of them because humm, maybe some of them are not exactly like the options are noted exactly phrase the way like I know them, you know, maybe I know like two samples paired t-test like that but also in there, they are also make phrase different maybe for me there are also the same.” **Participant 3**

“Because not sure, I could not just put anything there that I have, I want to put something when I am sure.” **Participant 10**

“I just choose so if I read the questions and then I found that maybe two tests will be fitted so, I just choose the more relevant one according to me yeah, so I just reject the other one and pick the most relevant.” **Participant 9**

Although some students were reliable, most could be confidential as accepting either a profound or a superficial method to a mainstream of the tasks, although the perceptions of the participants improved as the tasks progressed. When the participants made their own decisions, they viewed this as a personal revelation of their strengths, as well as progress of their abilities. Similarly, while examining the students' ability, this current study confirmed the results obtained by [21], who claims that students tend to interpret new information according to the knowledge they already have, to construct their own meaning, by linking the new idea to what they already understood. The following quotations refer:

“Humm, in general, I'm very confident, pretty confident. Yes, (laugh).” **Participant 1**

“I'm above 80% confident.” **Participant 4**

“So, the only think is you have to read the question that have been asked and try to relay them back so which is I mean need time, the time is the major problem. Because the question asked there you need to understand them first and relay them to the test that are used even you are familiar with the test, you need time to identify what test can be applied to the problem you can't just say require with this method and this problem is then I can use any method.” **Participant 4**

Inappropriately, some of the students experienced conflict, doubt and reluctance about their choices. They required support from peer students and from statistics monitors. These findings concur with those of previous studies conducted, such as one by [28] and [29], in which the collaborative mentor-apprentice model was applied for post-graduate instruction. Therefore, the supervisor still holds a special place in acquiring training, maturity and knowledge. The following quotations reveal this need for some guidance or assurance:

“Mann-Whitney U- test, Sandler's A statistics, path analysis, Fischer z transformation, I'm not sure, yeah, and Semi-partial correlation, Pearson's product – moment correlation, that I have haven't never seen before. Then the others, I have some ideas, yeah.” **Participant 9**

Despite the fact that participant 2 completed the interview, he was still not confident enough about the selection and expressed his desire to learn how to apply connections between statistical procedures and the real world problems, as indicated in the following extract:

“I would like to be thought you see what I mean so I know you could show me how to then observe the ways like I make up you see the data and then you decide which analysis they are declined. Because I have been following up I have done the training on literature, training on like English in terms of literature but such thing I have never seen any statistics course.” **Participant 2**

4.2. Theme 2: Perceived Failures to Choose the Right Test

Little attention has been paid to the question of how participants choose the most suitable statistical test in an academic environment. The process of the above task usually causes participants some difficulty. In this current study, we were concerned about the perceived failure to choose a statistics test to fit the situation. The participants realised that their choice of a statistical test could eventually reveal their shortcomings in statistics. Two sub-themes were generated from this theme: Causes of difficulty to choose a statistics test, and Reasons for rejection of some tests.

Causes of difficulty to choose a statistics test

The learning process is measured by the quality of the knowledge, or skills acquired, or the level of understanding of the basic concepts of statistics. The findings indicated that the participants were often anxious about their difficulty in choosing the relevant test. However, the results were quite interesting from the researchers' perspective. The difficulties observed during the task practical, might be due to several factors, including, lack of information, lack of knowledge, real life problem, non-familiarity with the items, mis-understanding of the items, confusion in interpretation of concepts, conflicting concepts in statistics and different areas of expertise. These results were not consistent with earlier findings. [30] determined that the learning process guides students to become aware of, and confront their misconceptions. These results make sense, in view of the fact that a lack of information was reported by three participants.

“Humm, maybe based on limited knowledge, of some of the options that there are available, cause I have never used, for example, humm, one of the may be Kruskhal-Wallis, one way-ANOVA and I've never used that before so I have no idea what that means, so I'm told, I am told what that means, I don't know if it's applicable test. Okay.” **Participant 1**

“Yeah, it was a bit tricky because some of the stuff I haven't seen in a while.”

“Humm, the information that makes it difficult, I don't know the whole story behind the data just makes the selection process a bit slow, but I think that's what made it difficult people was just ... the data and what you want to straight achieve and then I think that would make direct the process could be a bit quicker.” **Participant 6**

“Yeah, there were times when most of the questions the required than difficult to decide or not test to choose from maybe because I have never done hummm analysis that involves such test before in my research work.”

“Mmmm, it is possibly because I have not thought about an analysis doing like that I can't do I don't know exactly but I note here some questions that you can't easily be like this is the kind of test you need to perform and need to humm and maybe because I have not been exposed to statistical analysis study involves such items. Possibly that is why I couldn't pick out whether I achieve it right which test is right or not.” **Participant 7**

The participants faced difficulties in choosing a correct test because of their lack of knowledge needed to complete some specific items. The students became discouraged, since they did not have the required tenacity, determination and commitment. The findings of a study conducted by [31] corroborate this claim that without motivation and construction of a work discipline achievement was impossible.

“Yes, I mean some quizzes were easy, and some were not easy and some of the tests I have ... ok them, so thing is I’m not even test so they maybe some they would have been treating to, so this test that I would have been encountered before, so I wouldn’t be able to say for sure, yeah.” “Some questions are dealing with understanding. Yeah, yeah. Maybe the language problem.” **Participant 9**

“Yeah, I found difficulty in some of them, I have been never used some of the methods, so, I haven’t known where I mean, it is not everything there I know so, there are some methods there I didn’t know so, then I put in up to apply then.” **Participant 8**

Unfamiliarity with the items and a misunderstanding of them were also another source of difficulty, which affected the ability of the participants to select a relevant test. [32] argue that the engagement of the student with the task requires previous knowledge and beliefs, his own clarification of the sense of the task, and its supplies. Participant 1 mentioned that she was not able to select the right test, due to some limitations, such as lack of awareness, knowledge and inexperience in doing such tests. The following evidence reveals this:

“Humm, maybe based on limited knowledge, of some of the options that there are available, cause I have never used, for example, humm, one of the may be Kruskhal-Wallis, one way-ANOVA and I’ve never used that before so I have no idea what that means, so I’m told, I am told what that means, I don’t know if it’s applicable test. Okay.” **Participant 1**

“Ok, some parameters, just by the methods, so, the methods used the one that would equal you to decide like some of them that I have no idea in answering the question and just finding difficult understanding of the data.” **Participant 3**

Additionally, scientists have been known to produce false or misleading statistical information because of, lack of knowledge of theories and lack of standardisation of their tests [33] As an example of this, participants 4 and 7 asserted that because the keyword in the item was ‘correlation’, he merely looked at other possibilities of correlation without checking the assumptions; evidently, he was confused about his procedure and could not make a useful assessment.

“So most of the questions concerned hum comparisons and associations, so you look at the two items what are they interesting, so the next thing you have to do is are they qualitative or are they quantitative, so you based what test to use on the qualitative and the quantitative and then what you want to achieve.” **Participant 4**

“Mmmm, it is possibly because I have not thought about an analysis doing like that I can’t do I don’t know exactly but I note here some questions that you can’t easily be like this is the kind of test you need to perform and need to humm and maybe because I have not been exposed to statistical analysis study involves such items. Possibly that is why I couldn’t pick out whether I achieve it right which test is right or not.” **Participant 7**

Furthermore, when dealing with concepts and interpretations, it is important for the investigator to appreciate the basic concepts of the testing procedure in order to make sound decisions about choices, results and to draw accurate conclusions.

*“Yeah, it was a bit tricky because some of the stuff I haven’t seen in a while.”
“Humm, the information that makes it difficult, I don’t know the whole story behind the data just makes the selection process a bit slow, but I think that’s what made it difficult people was just ... the data and what you want to straight achieve and then I think that would make direct the process could be a bit quicker.” **Participant 6***

*“Yeah, I will say yes at some point, because statistics actually where it is vast, and the way we through our career as a student, we probably deal with certain considering not movement ... not on certain rules of the topic, so it quite challenging.” **Participant 10***

Data manipulation is a serious issue in statistical analyses. It is important to understand the data, concepts and fixing real problems, before choosing the right test to apply. However, participant 10 revealed that effective participants, with amenable shortcomings, should be assisted and guided to complete the tasks.

*“Yeah, some alternatives came, but I was not quite sure whether those items would be, would match those topics because I cannot just start pick any topics that’s actually you can see the same and other black spot around I would not quite sure which of the items could be related to what topic.” **Participant 10***

In addition, in Table 1 the area of expertise posed a challenge for the participants, who relied heavily on their prior experience in statistics. Statistics has different fields of specialization. Participants 3 and 7 reported that not being familiar with a specific field, may lead to the narrowing and distorting of the expected outcomes.

*“Yeah, it was difficult, because those statistics, I think maybe thus, my own problem because I haven’t thought I don’t know each and every one, that’s why may thus be mistake and also statistics is also not my kind of subject so I was struggling in that way for each one to decide.” **Participant 3***

“Yeah, there were times when most of the questions the required than difficult to decide or not test to choose from maybe because I have never done hummm analysis that involves such test before in my research work.”

*“Mmmm, it is possibly because I have not thought about an analysis doing like that I can’t do I don’t know exactly but I note here some questions that you can’t easily be like this is the kind of test you need to perform and need to humm and maybe because I have not been exposed to statistical analysis study involves such items.” **Participant 7***

Reasons for rejection of some tests

Students’ avoidance of certain statistical tests has proven a problem for many years. A complicating factor is that the reasons these tests are rejected remain mostly unanswered. In this current project, various reasons for rejection emerged, including lack of knowledge, lack of information, misunderstanding of the concepts, confusion, ‘assumptions do not allow’, insufficient evidence, not satisfying the criteria for the test and referring to peer students.

The ‘lack of knowledge’ item was revealed by the participants’ uncertainty in knowing what course of action to follow. Participants 3 and 10 showed frustration

when they were not able to come to an appropriate solution. [34] reveals that a student becomes more effective, when he refines the feedback, by interpreting the task, or adjusting internal goals, tactics and strategies. Even the revision of a student's field of knowledge, or motivational beliefs, is necessary, in case it influences subsequent self-regulation.

"Some of them because humm, maybe some of them are not exactly like the options are noted exactly phrase the way like I know them, you know, maybe I know like two samples paired t-test like that but also in there, they are also make phrase different maybe for me there are also the same." **Participant 3**

"Because not sure, I could not just put anything there that I have, I want to put something when I am sure." **Participant 10**

Another reason raised by the participants for their failure to reject some of the tests was the lack of information. This particular omission created uncertainty and affected their achievement. In this regard, [35] claims that if the individual's self-efficacy is strong and they also have self-assurance, they are more likely to try harder to do the task and usually the outcome is positive.

"Like I said, it's still a very constraint that you spend some time when you to directing something very seriously and half-way between, not too confident, but also I'm not saying I'm not confident the board of my responses." **Participant 7**

"Given that I don't know all these tests and given that I haven't done, most of these ones like undergraduate, I'm partially confident." **Participant 9**

The complexity of many statistical ideas, assumptions and rules constitute major challenges for students attempting to ascertain the degree to which their choice provides the desired outcomes. These include the assumptions do not allow, do not satisfy criteria for the test, and insufficient evidence. [36] argue that either the students' lack of familiarity with the concepts, or possibly the way they think about data causes them to fail.

"I just choose so if I read the questions and then I found that maybe two tests will be fitted so, I just choose the more relevant one according to me yeah, so I just reject the other one and pick the most relevant." **Participant 9**

"Because not sure, I could not just put anything there that I have, I want to put something when I am sure." **Participant 10**

The Participant 2 believes that the data (independent variables) determine the effects observed on the dependent variable while the participant 5 attempts to understand a problem, but does not effect a change. The difference between the best and the worst choice might be due to several factors, such as, a degree of familiarity with a specific test, the ability to select an adequate test, the ability to solve it, and the ability to apply prior experiences.

4.3. Theme 3: Non-familiar Statistical Tests

In this section, the attention is focused on the familiarity with statistical tests. The challenges arose because of the influence of the participants' multiple backgrounds on their learning processes, and the difficulty of unravelling the contributions of multiple approaches of teaching over time. These findings support earlier findings, as [37] argues that the self-efficacy beliefs influence the students' aptitude for study, their incentives and their achievements. The reason for this is that individuals will put real

effort into studying and completing only those tasks, which they trust they will be able to do successfully. Changes in the strategies of learning might reflect differences that could be observed in the various characteristics of students. [35] claims that the main principle of the self-efficacy theory SELS is that people like to work and do those activities they believe they are able to do. Notably, examining the accuracy of the participants' responses in this current study, it was evident that, even among participants with the same level of knowledge, exposed to the same programme and reality (teaching statistics courses in undergraduate level), there was a variation in what they understood a statistical test to be, and its usefulness.

"I have seen Fischer but I don't know what it is for. Semi-partial correlation, it sounds familiar but I don't know. Euhm, I have seen Mann-Whitney U-test but I'm not used that before, Wilcoxon signed rank test, Friedman's two-way ANOVA for ranked data I 'm not used them. MANOVA I have not used that, Discriminant analysis no, I'm not used to, these ones I have seen in literature but I'm not done them like the basic courses." **Participant 2**

"Sandler's A Statistics, Path Analysis and the Mann-Whitney U- test, don't sound familiar to me at all. Yeah, there are those ones that don't sound familiar, and the Post Hoc Test for comparison of means. Humm, I have never seen that before." **Participant 6**

"Here, humm, here I don't know post-hoc test for what I know is that is I hardly used it. Friedmann Two-way ANOVA for rank data I don't know what that test really. Path analysis, Sandler's A statistics, I didn't know what those tests. Otherwise the rest I think, I have fair idea about what do I agree." **Participant 8**

"I little be confuse in, between 28 and 20 (Partial correlation and semi-partial correlation), I have been exposed to it but I don't remember the difference, I read that but I haven't convince of my understanding. Sandler's A statistics, I haven't seen it in my life the rest I'm familiar with it but I wasn't able to use them in my answers, I wasn't confident enough." **Participant 9**

"Can you make time to teach if you have to ...?" **Participant 2**

As well as indicating the importance of self- efficacy in student learning, the above responses are important for another reason. They point to the need for more understanding of the different ways students from different backgrounds learn and therefore, the need for adoption of teaching strategies that take these differences into account.

The UCT findings indicated that students had trouble with choice procedures because of the lack of information in the scenarios, their lack of practical knowledge, their misunderstanding of the concepts, or the fear of asking for help, among other factors, during the learning process. In this sense, [16] reports that the external activities of the learning environment tend to influence the internal cognition of the students. Some participants observed that examining previous data and experiences assisted them to make a meaningful choice. However, other participants became irritated and disillusioned. This finding supports earlier findings, as [20] asserts that such students who become easily discouraged, should try to adapt certain strategies during their learning, such as learning from their failures. Regrettably, instead, students to the difficulty of selecting the correct approach tend to be recurring in statistical learning. To avoid this disheartening repetition of failure, students must come to the realisation that in statistics they have to reconstruct knowledge within a

particular context. Validity is achieved by drawing a connection to the real world, such as experiences in the students' everyday life, practice in the discipline, and the need to transform knowledge.

The participants should also understand that the application of their knowledge from previous experience of statistical procedures is not easy and might even make what they are doing harder. Moreover their different cultural backgrounds tended to influence the interpretation of their previous experience. Generally, when students reorganize and reinterpret the scenario, they adopt an approach. Then, they have to incorporate the new ideas into their perception, so that they could evaluate and begin to make choices about what they will, and will not do [24]. Given that demotivation may arise from a loss of confidence in, or disillusionment with their existing situation, students should implement new learning approaches, which they should repeat until they are confident enough [26]. Statistics learning has been observed to be adjustable on the content and environment.

The decisions made by the participants were a revelation of their strengths and weaknesses in statistics and an indication of their progress. The fact that the perception of some of the participants improved as their work was significant and indicated they were building on their existing knowledge. As explained by [21], students interpret new information according to the knowledge they already possess, in order to construct their own meaning, by linking the new idea to what they had already internalised. Unfortunately, some of students were uncertain and hesitant in making their choices and were unable to integrate new information with what they knew. Therefore, the assistance of peers and statistics monitors was desired. Participant 2 expressed the need of statistics assistance to learn, in a practical way, how to apply specific tasks with statistical procedures.

5. Conclusion: How Do the Students Choose the Appropriate Statistical Test?

Participants, having been made aware of all the information concerning the one-on-one interviews, participated in selecting the appropriate statistical tests, on the various campuses of UCT. The responses, related to this research question, highlighted three sub-themes, namely, self-efficacy to choose a statistical test, perceived failures to choose the right test, and non-familiar statistical tests. The most common responses for self-efficacy focused on data issues, such as, understanding the concepts, knowledge of assumptions, the time since their last statistics class, and conflicting choices. The perceived failure to choose the right test, as presented in findings section, reflected the items: lack of information, confusion in the application of real life problems, as well as too little evidence. The non-familiar statistical tests indicated that the learning process of the respondents had failed to include the crucial stage of reorganisation and reinterpretation. Low self-efficacy is associated with anxiety and helplessness. The participants with low self-efficacy were anxious about their personal development.

Considering the practical knowledge necessary to choose a statistical test, the respondents encountered many difficulties, including in the inspection of keywords and objectives, as well as in their knowledge of assumptions. The lack of information about the items, as well as the lack of knowledge about their application to real world problems proved extremely useful in highlighting the participants' lack of confidence about the decisions they made (choice). Non-familiarity with the items and

insufficient evidence could be the elucidations observed, during the failures to select the test.

6. Policy Recommendations

This research paper has provided important information that could be useful to researchers in this domain. In addition, it could help to improve the orientation of schemes and programmes related to statistics knowledge and alert government authorities, planners and policymakers, to address statistics education in South Africa. However, it must be admitted that most of these recommendations do not have a scientific or empirical basis. Not all the information in this study emanates from present day South Africa as certain information comes from old scientific research that reflects the past realities of this country. The socioeconomic and cultural contexts of the university transform rapidly; therefore, the need for updated information is ongoing, even if only to confirm future results. Finally, this study has the merit of highlighting the particularities of UCT and universities in the Western Cape region of the country, regarding the state of statistics learning.

6.1. A Benchmark as a Guide for Future Research

There is no chance for good governance, without good knowledge of past and current situations, as well as a good vision and planning for the future. Policy making is one of the key methods of safeguarding decent planning, which is the minimum requirement of a sustainable development. Unfortunately, very few statistics education researches focus on this area. The United Nations agencies, and other international agencies, are not enough to cover the demands of policy makers, planners and other statistics users, regarding the wide range of student issues, such as statistics learning. Therefore, this study was initiated to provide a benchmark. One of the objectives was to serve as a guide for future research.

6.2. Knowledge Transfer Improvement in Statistics Monitors, Supervisors and Peers

The findings of this current research recommend an improvement of knowledge transfer from the statistics monitors to participants. Encouraging easy collaboration demands the availability of statistics monitors, and the appropriate communication between them and the participants; however, it also involves the building of more connections of reference, as well as equipping peers in their capacity for interventions.

The findings further indicate the need to pay more attention to statistics monitors, and, in particular, the conditions of the transfer. Knowledge transfers in statistics are only efficient under the requirement of context, during the transfer of knowledge. Additionally, improving actions against failure in statistics learning is crucial, when participants are in critical situation, just after the judgment has been made, and lack of proper knowledge established. This recommendation will lead to satisfactory results, if emphasis is placed to increasing the number of meetings (as well as statistics monitors, who are well trained in statistics issues), and making offices available for consultations in most departments. The latter recommendations aim at bringing consultations closer to participants, reducing distances, and improving conditions of good communication during knowledge transfer.

6.3. Consideration of Specific Population Groups with Important Impact

This recommendation aims at the inclusion of, or at paying particular attention to some sub-populations, because of the important impact they have on statistics learning levels. The results of the analyses revealed that the female population should be encouraged, or granted more consideration, in programmes and projects related to statistics learning, as at UCT for instance, female participants represented only 23.2% of the student body, compared to males. This situation may be due to lack of understanding regarding the importance of postgraduate studies, or cultural constraints, in terms of knowledge in mathematics, or female participants encountered more opposition, when seeking better employment opportunities. However, this recommendation highlights female participants as a target population for programmes and projects involving statistics learning.

Actions against failure in statistics learning should target female students from primary school. In addition, programmes including television and radio about statistics learning should be translated into ethnic languages, and awareness campaigns conducted in the various languages to ensure that the message reaches all population groups.

6.4. Need for a Specific National Survey on Statistics Learning

This recommendation proposes a regular survey of statistics learning, covering the major tertiary institutions where it is taught in this country. A national survey on statistics learning is necessary because censuses cannot cover education issues adequately. A university survey, incorporating both distant and immediate predictors in learning of statistics would provide better information, and allow better understanding of the problem, in all respects. Many actions are taken to reduce failure in statistics learning, but there is no deep research, covering the entire country with complete data on statistics learning in South Africa. Such data is crucial to refine existing knowledge on the issue. A regular execution of the survey would be very useful for the monitoring and implementation of programmes and projects. The incorporation of statistics education into current surveys or censuses could not replace the need for a full survey, well designed to capture and comprehend the issue. Further research studies need to be conducted into the improvement, or elaboration of a more precise methodology of statistics learning estimates, using full survey data.

Conflicts of Interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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