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Doctoral Thesis

Flipping the classroom to enhance student engagement in first-year statistics education

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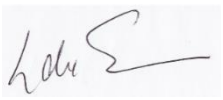
Declaration of Authorship

I, Liza da Silva, declare that this thesis titled, “Flipping the classroom to enhance student engagement in first-year statistics education,” and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at the University of the Free State.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have clarified exactly what others did and what I have contributed myself.
- Ethical clearance was obtained from the Faculty of Education’s Ethics Committee at the UFS (UFS-HSD2015/0658).

Signed: 

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Summary

This study explores the effectiveness of a flipped classroom (FC) variant based on students engaging with content outside of class by viewing video-lectures. The flipped classroom encouraged students to take responsibility for their own learning. When they were unclear on specific concepts, they could use technology to collaborate with their peers or the lecturer. To encourage viewing of the videos, an incentive was given in the form of weekly assessments that the students had to complete, which formed part of their semester mark. A randomised pre-test-post-test control design was implemented in a sample of Extended Curriculum Programme (ECP) students in a first-year statistics course.

The FC approach was exercised in the experimental group (Group A), while the control group (Group B) received traditional face-to-face lecturing. A comparison between the final scores of Group A and Group B was used to give insight into the effectiveness of this treatment. Each group consisted of 67 students. The results showed that a video-based lecturing pedagogy significantly improved ECP students' final scores.

In this study, students applied different learning activities such as inquiring about information, watching video-lectures, and practically applying the knowledge studied when completing weekly online assessments. Students collaborated with the lecturer and their peers via e-mail or WhatsApp to thoroughly understand the subject. Therefore, active learning, which fosters deep learning, was encouraged. This finding is consistent with the constructivist pedagogical theory, which emphasises the importance of interaction with others in knowledge construction and develops a deeper understanding of the subject matter. These findings align with other studies that report positive student perceptions of blended learning in first-year statistics.

This research found that the FC intervention, as applied by the researcher, resulted in a significant increase in student performance on their final marks, which indicates that the FC approach is an important pedagogical approach to increase student achievement. Further, the results confirmed that the FC approach improved student engagement. One factor that significantly enhanced student engagement was the

students' preferred place of study. Students from the experimental group studying at their place of residence significantly outperformed students from the traditional group who studied at their place of residence. Another factor that indicated that student engagement was enhanced was that student-staff interaction significantly increased in the experimental group.

Some interesting findings surfaced. An unexpected gender finding evidenced that male students in the experimental group significantly outperformed the male students in the control group. Furthermore, when the place of study was examined, the experimental group performed better when studying at their residences.

Many participants in Group A showed a favourable perception towards the videoed-lecturing approach as they enjoyed watching video-lectures at their own pace. They also indicated that they prefer this new variant of flipping because it motivated them to learn.

From the survey analysis, many students preferred watching video-lectures at their own pace, time, and space. An overwhelming portion of the participants indicated that the use of technology was pivotal in their learning. It was also derived that the more students participated in all their assessments, the higher their final score was.

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List of acronyms

ANCOVA	Analysis of Covariance
ANOVA	Analysis of variance
AP score	Admission Point Score
BIC	Bayesian Information Criterion
BUSSE	Beginning University of Student Engagement – first years
CHE	Council of Higher Education
CRS	Classroom Response System
CTL	Centre for Teaching and Learning
DHET	Department of Higher Education and Training
ECP	Extended Curriculum Programme
e-mail	electronic mail
FC	Flipping the classroom
HE	Higher Education
HIPs	High-impact practices
ICT	Information and Communication Technologies
LCF	Laurillard's Conversational Framework
LSSE	Lecturer Survey of Student Engagement
LMS	Learning Management Systems
MB	Mega Byte
NBTs	National Benchmark Tests
NSSE	National Survey of Student Engagement
QQ-plot	Quantile-Quantile Plot
SA	South Africa
SASSE	The South African Survey of Student Engagement
SD	Secure Digital
SNS	Social Network System
TIMSS	Trends in International Mathematics and Science Study
UFS	University of the Free State
UNISA	University of South Africa
USA	United States of America

List of appendices

1. The orientation of the study

"Globally, education has become the most important currency." – Adams Becker

1.1 Introduction

1.1.1 The state of higher education in South Africa

Education is pivotal in a country's social and economic development (Madani 2019: 100). It is trite that attaining tertiary education is vital for earning a liveable income (Adams Becker 2017:28). Rudimentary educational skills, such as reading and writing, can raise an individual's salary by 10%, which ultimately can help to annihilate poverty and hunger (Madani 2019:100), a goal of education for all policy. However, according to the Department of Higher Education and Training (DHET), on average, only 22.1% of students who enrolled at public South African (SA) universities in 2017 completed their three-year degrees with contact tuition in the designated time (DHET 2019:18). Interestingly, 69.1% of students that enrolled for the first time in 2008 finished after ten years. The Council of Higher Education (CHE) estimated that 55% of students never graduate (CHE 2013:15), resulting in students with enormous sums of debt without qualifications.

Numerous studies have noted that students who enter HE in SA for the first time are inadequately prepared to deal with the academic challenges of undergraduate study. One of the reasons for not completing a qualification is inadequate schooling (Jaffer *et al.* 2007:134). As a result, students may not be proficient in languages or mathematics, which is a global problem.

A Grade 12 qualification does not necessarily render a student academically competent for success at university. Furthermore, HE is under pressure to increase throughput against a backdrop of limited resources (Jaffer *et al*. 2007:133). Thus, the HE sector must enrol many students from diverse backgrounds (Strydom *et al*. 2010:2) with varying preparedness and multilingualism levels.

Low throughput rates and poor performance in high school likely stem from weak foundations in primary school. According to the Trends in International Mathematics and Science Study (TIMSS) 2015, 61% of South African primary Grade 5 learners could not do basic mathematics (Reddy *et al.* 2016:3). They could not add and subtract whole numbers, did not understand multiplication by one-digit numbers, and could not solve simple word problems (Spaull 2019:9).

Furthermore, it was shown that for every 100 children that start school in SA, approximately 60 would reach Grade 12, 37 will pass Grade 12, 12 will have access to HE, while four will complete an undergraduate degree within six years (Spaull 2019:9). Therefore, only 4% of children starting school in SA will complete an undergraduate degree within six years after completing Grade 12. In conclusion, it is not surprising that most first-year students have an inadequate mathematical foundation because of poor mathematics teaching at the school level (Jaffer 2007:134).

Surprisingly, in 2019, an astounding 59% of new applicants to the ECP, the program in which this study was done, were declined admission as they did not comply with the criteria, i.e., they either had mathematical literacy as a subject in Grade 12 or their Grade 12 Mathematics scores were below 40%.

Authors like Van der Merwe and Van der Merwe (2009:298) and Zewotir *et al*. (2011:1243) bear evidence that students' Grade 12 English mark is a better predictor of student success than their Grade 12 Mathematics marks.

Students' lack of preparedness when they enrol for studies in HE is referred to as the "articulation gap," *i.e.*, the gap between success at school and university. According to the CHE (2013:17), the "articulation gap is not confined to subject knowledge, but also a range of facets of learning like academic literacies, conceptual development, and socialisation." Therefore, this gap needs to be bridged through academic support. In addition, a whole set of new learning skills are required (Mayet 2016:2-3).

The low throughput and high dropout levels, particularly among historically disadvantaged students, suggest that the under-preparedness of students in SA HE is at an all-time high (Van Broekhuizen 2016:43).

1.1.2 History of statistics education

Undergraduate statistics emerged in SA universities in the 1930s (Zewotir & North 2011:3). Teaching undergraduate statistics presents various challenges across numerous disciplines (Forte 1995:207). It is not merely memorising and applying formulae; the lecturer must implement critical quantitative skills to solve real-life problems (Blalock 1987:165-166). The goals of teaching statistics include overcoming obstacles presented by students' math anxieties, beliefs, and negative attitudes towards statistics (Schau 2003:3673), motivating students, and overcoming high attrition and failure rates (Forte 1995:206).

In the early 1990s, George Cobb produced guidelines for teaching statistics at the tertiary level (Cobb 1992:5,7,10), which included recommendations like emphasizing statistical thinking, more data and concepts, less theory and fewer recipes, and fostering active learning. Statistical thinking implies that students must show how to use statistical ideas to extract helpful information from numbers (Cobb 1992:12). By the end of the 1990s, there was an increasingly active call for statistics educators to focus more on statistical literacy, reasoning, and thinking.

Wallman (1993:1) defines statistical literacy as "… the ability to understand and critically evaluate statistical results that permeate our daily lives – coupled with the ability to appreciate the contributions that statistical thinking can make in public and private, professional, and personal decisions." One of the main arguments presented was that traditional approaches to teaching statistics concentrate on skills, procedures, and calculations. Due to this traditional approach, students are unable to reason or think statistically (Garfield & Ben-Zvi 2007:5).

In 2005, the American Statistical Association endorsed a HE report, which included six guidelines for statistics education to produce statistically educated students,

which implied that students should develop statistical literacy and think statistically. The committee for guidelines for Assessment and Instruction in Statistics Education (GAISE College Report ASA Revision Committee 2016:6) revised the guidelines for achieving learning goals in 2016 to:

(i) Teach statistical thinking.
(ii) Focus on conceptual understanding.
(iii) Integrate real data with a context and a purpose.
(iv) Foster active learning in the classroom.
(v) Use technology to develop conceptual understanding and analyse data, reducing anxiety and increasing student participation (Ferrandino 2016:2; Cobb 2007:1).
(vi) Use assessments to improve and evaluate student learning (Garfield & Ben-Zvi 2007:6).

1.2 Theoretical framework

Key themes for HE research that were considered for this study, as identified by Tight (2014:103-107), are summarised in Table 1.1.

Table 1.1: Key themes for HE research

1. Teaching & Learning	**Sub-themes:** (i) Approaches of student learning: • Surface learning • Deep learning (ii) Academic literacies (iii) Different kinds of students (iv) Teaching in HE
2. Course Design	**Sub-themes:** (i) The HE curriculum: • Experimential & independent learning • Peer Tutoring • Portfolio development • Role of reflection • Service-learning (ii) Technologies for learning
3. Student experiences	**Sub-themes:**

	(i) On-course experience (ii) Success and non-completion (iii) Experience of different student groups (social justice)
4. Quality	**Sub-themes:** (i) Course evaluations (ii) Student perceptions and satisfaction (iii) Methods of assessment

Each item will now be discussed in detail:

1.2.1 Teaching and learning

Teaching and learning are the core of HE. As Tight (2012:51) indicated, lecturers teach, and students learn. This theme is closely linked with the other themes, notably course design, the student experience, and academic work. Within the theme of teaching and learning, the different approaches to learning have been the topic of extensive research and have been globally instrumental in academic development activities (Tight 2014:103). The different approaches will be extensively discussed below in section 2.3.

Student learning focuses on two basic learning approaches: surface and deep learning. A surface approach emphasises memorisation without understanding the logic, while deep learning is motivated by understanding what is being studied. The objective of teaching should be to promote deep learning approaches (Laird *et al.* 2008:470). There is considerable literature regarding the approaches to learning theory with the aim of advancing teaching practices in order to promote deep learning.

Most students enter the HE environment with learning strategies that result in surface learning. Lower cognitive levels are used in this learning method, and it can be described as “cutting corners” or “sweeping under the carpet.” Surface approaches are not concerned with wisdom and are encapsulated by aimless accumulation (Ramsden 2003:59-60).

The established author Ramsden explained surface approaches to “belong to an artificial world of learning, where faithfully reproducing fragments of torpid knowledge to please teachers and pass examinations has replaced understanding.” It results in a paralysis of thought, leading to students not understanding fundamental concepts, poor long-term recollection of detail, and the inability to put academic knowledge to use in real-life scenarios or problems. Once the study material has been regurgitated in this manner, a student soon forgets what they have studied, and it does not ever become a part of the student’s method of interpreting information (Ramsden 2003:59-60).

Students need to acquire problem-solving and critical thinking skills to be able to perform their tasks correctly (Biggs & Tang 1999:22). Critical thinking is defined by Chaffee (2006:48) as “making sense of the world by carefully examining the thinking process and clarifying and improving their understanding.”

According to Biggs and Tang (1999:24), students can adapt their learning strategies and use the most appropriate cognitive activities to complete their courses. That is called deep learning. Ramsden (2003:59-60) states that deep learning is related to “qualitatively superior outcomes associated with understanding a subject.”

Other characteristics of deep learning include the novel application of information, the appropriate interchange between knowledge and application, enabling one to come to correct conclusions, and the ability to create a solution to a complex problem. Vital concepts of deep learning entail having a comprehensive knowledge base, applying one’s mind to new scenarios, and integrating knowledge.

Undergraduate statistics modules are generally part of a service course. However, this does not mean that surface learning should be preferred. First-year statistics students also need to comprehensively understand the study material to develop the ability to apply their knowledge in order to complete their course successively. Statistic students must be not only able to study information but also be able to apply what they have studied to new examples.

A working definition of good teaching is moving away from a surface approach and towards a deep learning approach (Biggs & Tang 1999:28). Laurillard (2012:1,5) further elaborates that “teaching is to enable students to learn. Teaching is not rocket science. It is much more difficult. Rocket science is about moving atoms from a to b, but teaching is about moving minds so that the students become independent learners.”

Academic literacies have recently been integrated into HE research (Tight 2014:104). Activities to help students transition to university are critical as they allow the early formation of relationships. Timeous interventions like language proficiency courses (in English) and reading development are needed to help students transition to university successfully (Mayet 2016:3; Van der Merwe & Van der Merwe 2009:299). According to Barak Obama, “reading is the gateway skill that makes all other learning possible.”

Information and communication technologies (ICT) and all the developments coupled therewith have given rise to a new revolution called the Digital Revolution. The Digital Revolution has drastically changed societies and how people live in them. New notions like digital societies and tools and upcoming technology such as mobile devices and “smart learning cities” have arisen. Due to adopting and having to adapt to innovative technology, the education paradigm has been completely modified (Reddy & Sharma 2020:66).

Lea and Jones (2011:25-26) suggest that academic literacy must include digital literacy in teaching and learning activities within an ever-growing digital age. The rapid and constant development in digital technology demands people to have the required skills and abilities to complete tasks and solve problems faced in digital surroundings (Reddy & Sharma 2020:66).

Unfortunately, some students are “digital strangers” and enter university with limited exposure to technology. It cannot be assumed that all students are familiar with technology (McLean & White 2009:340; Schindler *et al*. 2017:20). As a result, technology can be a barrier for students as they do not have the required digital

literacy skills in order to succeed (Buerck *et al.* 2003:140; Elen & Clarebout 2001:88; Strayer 2012:172).

The researcher believes there is a significant drawback among HE students concerning the theme described above. The study is primarily aimed at improving student engagement. However, in order to attain enhanced student engagement, the researcher will attempt to modify the learning approach of students to ensure better success.

This research will try to shift students' learning approach from surface learning to deep learning. This shift will be accomplished by encouraging students to learn to apply their minds instead of studying intensively over a short period of time just before an examination merely to pass. Thoroughly understanding the study material may result in better application.

The researcher will make use of weekly assessments to compel students to continuously work throughout the semester to advocate for deep learning in contrast to surface learning shortly before semester tests or examinations. In addition, continuous assessment will encourage student engagement by prompting students to seek assistance on a weekly basis, either from the lecturer or fellow peers, when uncertain about the work that will be tested.

1.2.2 Course design

This theme can be described as the platform where lecturers plan, deliver and assess students (Tight 2012:65). It is critical for students to understand basic concepts before they can progress to higher levels of understanding. This notion is difficult for many students to embrace (Tight 2014:104).

For this study, only the following contemporary subthemes of course design will be considered as defined by Tight (2012:65):

1.2.2.1 The HE curriculum

Many researchers produce different approaches to the HE curriculum, but Tight (2012:67) summarises different approaches to curriculum and course design as follows:

(i) *Experiential and independent learning*. These strategies state that the curriculum must be adapted to transfer responsibility for learning from the lecturer to the student (Toohey 1999:59) (see section 2.3.3 for a detailed discussion).

(ii) *Peer tutoring.* This technique involves students directly in the teaching process where they interact with other students with a similar background, culture, and social class (Toohey 1999:18,63-64) (see sections 2.3.5 & 2.3.6 for detailed discussion).

This research will not consider other themes like Portfolio development, the role of reflection, and service-learning (as referred to in section 2.4.3.5).

This study will investigate the success of shifting the responsibility to students. By flipping the classroom, students are responsible for their own learning and have to discipline themselves to work through the video-lectures of the course material at their own pace.

1.2.2.2 Technologies for learning

Due to the integration of ICT in HE, the use of the blended learning pedagogy and a combination of face-to-face lecturing and effective online teaching practices has increased dramatically in HE campuses worldwide (Bliuc *et al.* 2007:233; Donnelly 2010:5; Lim & Wang 2015:8). Blended learning uses an innovative course design in which multiple teaching and learning activities are applied to accommodate a diverse student population. The blended learning practice is more resilient in times of disruption (DHET 2014:20). However, it can only assist students in achieving learning goals if it is structured in such a manner that face-to-face lecturing and

online assignments coherently support one another (Ginns & Ellis 2007:55). See Chapter 3 for a more detailed discussion.

This study will focus on implementing various forms of technology to increase student engagement. Various online platforms are intended to be used to make interaction between the student and the lecturer a lot easier and more accessible.

1.2.3 Student experiences

Students' perspectives are considered as to how they experience HE. According to Tight (2012:83), it needs to be ascertained whether the courses and support systems work in the ways intended or whether aspects of provision could be changed or improved.

The following subthemes are to be considered:

1.2.3.1 On-course experience

This theme describes the student experience after entering university. Wilson-Strydom (2015:2) found that one of the challenges for students making the complex transition into university was low confidence and competence because of the language of instruction. Students who speak the same mother tongue will interact and explain complex concepts to one another. Some students do not ask questions in class as their language skills are poor, and they cannot articulate which concepts they do not understand. As a result, language is a barrier to many students' learning.

1.2.3.2 Success and non-completion

This theme focuses on why some students succeed and why others drop out. Kuh (2003:28) argues that what a diverse pool of students brings to HE is not essential but rather what they do during their time at university. The more time a person spends on activities, the better they will become. Therefore, students must be fully engaged in learning in order to succeed.

HE research indicates that the best predictors of whether a student will graduate are academic preparation, motivation, and student engagement (Pascarella & Terenzini 2005:417-441). Unfortunately, the first two factors are very problematic for many HE institutions in SA. One of the most predominant themes of theoretical development in HE is student engagement (see section 2.4 for a detailed discussion on student engagement).

1.2.3.3 Experience of different student groups (social justice)

The South African Education White Paper 6 on Special Needs Education 2001 confirmed that students with disabilities must be allowed in HE institutions (DoE RSA 2001:6). It has further been affirmed that the HE sector must allow many students from diverse backgrounds to have access to tertiary education (Strydom *et al*. 2010:2) The South African Government encourages access of previously disadvantaged students to HE by way of providing funding to a large category of such students.

The importance of the widening participation objective of universities places much focus on non-traditional students described by Trowler as “mature students, part-time students, economically disadvantaged students, students from ethnic minorities, students with disabilities and students with family responsibilities,” and ensuring they have an equal chance of success (Trowler 2010:26-27).

As universities now accommodate a vast diversity of students, institutions must ensure they know how to engage all types of students with all their diverse needs. Due to enhanced access, the experience of non-traditional students has to be observed (Trowler 2010:26-27; Krause 2005:3).

1.2.4 Quality

This theme theorises about student satisfaction. Course evaluations are done during the academic year to understand better which factors contribute to student satisfaction regarding their course, degree, department, and overall university

experience so appropriate action can be taken where necessary (Richardson 2005:392-393; Tight 2012:105).

The researcher plans to compile questionnaires at the end of the study to determine student satisfaction or any hindrances that could be improved on.

The other themes, namely: system policy, institutional management, academic work, and knowledge and research, will not be considered for this research.

1.3 Research problem

Increasingly more focus has been placed on the teaching and learning aspects in statistics education in order to improve student learning (Garfield 1995:25; Garfield & Ben-Zvi 2007:22). Universities have become characterised by a diversity of all forms, such as “diversity of ability, age groups, and educational backgrounds” (Krause 2005:3). Teaching Statistics remains challenging for HE instructors since students come from different backgrounds and have unequal abilities.

Winquist and Carlson (2014:2) encapsulated one of the various challenges instructors face very accurately: students often reflect on “how easy statistics seems in class, but how difficult it is at home.” Upon much inspection, the learned authors realised that the above was not a compliment, but in fact, it showcased the dire problems that exist with course design. Students could not retain the course material long enough to be able to apply it themselves at a later stage.

There is minimal empirical research regarding enhancing academic performance in HE and student engagement in blended learning experiences (Halverson *et al*. 2014:28; Herrmann 2013:175). In addition, there are significant gaps in the literature regarding the effect of collaborative technologies (social networking sites) on student engagement. There is a serious need for research regarding collaborative technology’s impact on a student’s “attitude, interest and values about learning.” An investigation is needed to determine whether technology and collaborative learning can affect a student’s “sense of belonging within a learning community and their

motivation to learn" and to establish if it can encourage perseverance in a student to conquer academic challenges and satisfy or surpass the required standards (Schindler *et al*. 2017:18).

This research is dedicated to try and provide elucidation on the above-mentioned factors, and attempts to try and fill the void in the literature and test what effect, if any, technology has on student engagement. The researcher attempts to test whether collaborative learning and using technology can create unity among students to promote better understanding of course material and assist them with the challenges of tertiary education. This research is dedicated to improving student experience and success most effectively.

One possible emerging strategy that relies on technology for students to succeed is by "flipping the classroom" (also known as the FC approach). The FC approach has become quite trendy in our digital era, and it is quickly becoming a popular concept in HE (Wasserman *et al.* 2017:546; Milliard 2012:4). This flipped classroom is based on the theoretical framework that was developed in 2007 by two Colorado chemistry teachers, Jonathan Bergman and Aaron Sams. They noticed that students missed classes to attend competitions or other student activities. Other students had trouble with certain concepts, which hindered them from completing their assignments. These factors led to video-recorded lectures and presentations on YouTube to view and access whenever was convenient to the student (Siegle 2014:54).

The FC approach inverts traditional face-to-face lecturing associated with students taking up a passive role to that of self-study, where students spend time outside class using technology to study new work. This paradigm typically entails those students engaging with the content before attending a face-to-face class, say by viewing video-recorded lectures at their own pace. This form of the FC approach can be classified as the standard FC approach generally used.

The FC approach strives to encourage students to become more independent and self-reliant learners and not depend entirely on the lecturer. Active learning activities, such as online quizzes, must be done after viewing the videos. It is

commonly known that students do not engage spontaneously in active learning; they must be encouraged through incentives (King 1993:31; Baker 2000:13; Wilson 2013:194; Schindler *et al.* 2017:21). The FC approach appears to incorporate all the components as referred to in Section 1.1.2 regarding the GAISE College Report which promotes the achievement of learning goals (Zeleke & Lee 2018:2).

This research is aimed at trying to improve the challenges that HE instructors face within Statistics education. The researcher attempts to find a teaching and learning practice and an alternative course design that will accommodate students from all walks of life with ranging abilities and opportunities and assist the students to succeed. The researcher makes use of a variation of an FC by using video-lectures in an attempt to help students to excel in statistics by ensuring that they never miss a "class" due to medical, social, financial or personal reasons. The video-lectures are aimed to assist students who learn at a slower pace and can thus stop and start the video to suit their needs best. The videos can be replayed for the student who needs to repeat a particular aspect numerous times before understanding a concept. The video lectures are aimed to meet each individual's needs without hindering another student, as can be the case in a traditional classroom setting.

Limited evidence exists regarding the FC approach's effectiveness, especially in statistics education. Brush and Saye (2000:80) state that one of the reasons is that lecturers will have a substantial workload designing such pedagogies. Nevertheless, several studies investigating the FC approach's impact on student success in other disciplines have found that the FC approach produced significantly better results than the traditional approach (Eichler & Peeples 2016:197; Gillispie 2016:35; Mason *et al*. 2013:434; Wilson 2013:434; Hung 2015:93). Steen-Utheim and Foldnes (2017:308) report that carefully designed randomised trials show clear achievement gains in a flipped mathematics class relative to traditional lectures, as done by McGivney-Burelle and Xue (2013:485).

The researcher aims to ascertain the effectiveness of the variant of the FC approach applied in this study compared to the traditional face-to-face approach.

Triantafyllou and Timcenko (2014:1-4) introduced a flipped classroom in a statistics course and found that it can improve their performance in mathematics, provided it is carefully designed. The authors, as mentioned above, tested all the students at the beginning of the semester on their mathematics knowledge based on knowledge from previous semesters (pre-test) and then measured the students' performance at the end of the semester (post-test). Furthermore, all the students were subjected to the FC approach, where video casts were provided to students to be viewed outside class, and then students had to do in-class assignments to reflect on what they learned.

Winquist and Carlson (2014:8) found that their flipped approach in a statistics class outperformed students compared to the traditional approach. However, these conclusions depend on different methodologies, like Wilson (2013:195), who used Khan videos and did not generate her own videos; or Gillispie (2016:33), who compared two consecutive years, which is not a solid basis for generalisations. Wilson (2013:197) found that statistics students even had a decrease in anxiety as they had access to the resources 24 hours a day, seven days a week.

Other studies found that student outcomes remained similar when the FC approach and face-to-face classes were compared, but they changed the lecturer for the different groups and discarded students who did not complete the course (Jensen *et al*. 2014:2,9). Briggs *et al.* (2019:54) found that a few studies within introductory statistics had little benefits of the FC approach. It is, therefore, impossible to attribute the success of the FC approach in statistics education to such research.

On the contrary, Farmus *et al.* (2020:322) found that the FC approach can potentially increase students' performance in introductory statistics when comparing final exams between FC- and traditional- approaches.

As noted from the above studies, the studies were applied in several different approaches. The researcher aimed to conduct a study that is unique in the sense that she created her own video-lectures, the lecturer remained the same for both the experimental- and control- group, the pre-test scores used were the students'

matric mathematics marks, and the post-test scores were their marks for their tests, assignments, tutorials and their final semester marks, a variation of the standard FC approach was applied and the influence of technology also played a substantial part in this research. The researcher thus, in her own unique way, tested the effectiveness of the FC approach and was the study primarily aimed at determining whether the FC approach enhanced student engagement.

As has been stated, very little research is available regarding how effective the FC approach is due to the complexity of testing the method. The researcher recognized this shortfall and did she endeavour to investigate the research problem in a unique study of her own.

1.4 Research aim and objectives

This study will investigate how student engagement can be enhanced amongst first-year statistics students by applying the FC approach. Research on student engagement in the last decade highlights institutional high-impact practices (HIPs), "which are educational experiences that make a significant difference in student persistence, learning outcomes and student success" (Kuh 2009b 2;8;20). Some teaching practices have a higher impact than others do. When notable differences exist, a method can be labelled as having a *high impact* (CCCSE 2013:3) (section 2.4.3.5 for more detail on HIPs).

The objectives of this research are:

- To undertake a thorough literature study on HIPs in HE, how the FC approach improves student engagement, and how technology improves these attempts.
- To gather information on the experiences and perceptions of students during the FC approach using questionnaires and interviews.
- To analyse first-year Statistics students' assignments, tests, and examination papers for current findings on their academic performance.
- To formulate guidelines for implementing the FC approach for engaging first-year Statistics students.

1.5 Research questions

1.5.1 Primary question

To what extent does the FC approach improve student engagement in first-year Statistics Education, and why?

1.5.2 Secondary questions

- What does the current literature describe the FC approach to be and how can it be implemented?
- How does the FC approach relate to student engagement and performance in Statistics Education, and why?
- What part does technology play in HIPs, and how does it influence first-year Statistics students?
- How did Statistic students experience and perceive the FC approach as a strategy to engage students in Statistics Education?
- Why might flipping the classroom be a useful tool to enhance student engagement?
- Why do certain aspects enhance or hinder students' learning in a flipped classroom?

1.6 Research philosophy

Lincoln and Guba (1985:15) define paradigms as representing what we think about the world but cannot prove. Furthermore, they state that our actions in the world could not occur without reference to those paradigms: "As we think, so do we act." It implied that paradigms serve as the lens by which reality is interpreted (Maree 2017:52).

Lincoln *et al.* (2011) (in Kaushik & Walsh 2019:1) expressed that in social research, the phrase "paradigm" is indicative of the philosophical and elementary beliefs that

direct the actions and determine the researcher's worldview. The term "worldview", which is synonymous with paradigm, can be defined as "a way of thinking about and making sense of the complexities of the real world" (Creswell & Clark, 2011; Lincoln, 1990; Patton, 2002; Rossman & Rallis, 2003 in Kaushik & Walsh 2019:1).

Pragmatists recognize actual problems that exist in real-life social settings, meticulously define them, and institute investigation to attend to them (Kaushik & Walsh 2019:6). The rudimentary concept of pragmatism is the emphasis on practical outcomes and answers to resolve problems that are fitting for current situations or conditions (Sol & Heng 2022:93).

Renowned pragmatic philosophers Powell (2001) and Dewey (1859-1952) (in Parvaiz *et al.* 2016:68) opined that the objective of science is to advance human problem-solving and to obtain the type of understanding which is required to solve problems as they present themselves (Parvaiz *et al.* 2016:68). The pragmatic paradigm serves to unite scientific and humanistic domains of understanding (Kaushik & Walsh 2019:10).

The cornerstone of pragmatism is the concept of "what works". Pragmatism aims to answer real-life problems instead of being based on assumptions regarding the nature of knowledge (Creswell, 2014; Hall, 2013; Shannon-Baker, 2016 in Maarouf 2019:5). Pragmatism, as a research paradigm, contends that research must be designed and carried out in a manner that best serves "to answer the research questions regardless of its underlying philosophy" (Biddle & Schafft, 2015; Creswell, 2014; Glogowska, 2011; Johnson & Christensen, 2012; Saunders *et al.*, 2009 in Maarouf 2019:5).

Pragmatism empowers a researcher to utilize a range of research methods to fully comprehend the problem that is being investigated (Mingers, 2003 in Kamau 2022:51). Philosophers submit that you cannot obtain the "truth" about the real world by only using a single scientific method. Pragmatism allows the researcher to use a selection of research methods to fully appreciate the topic being investigated (Kamau 2022:51).

Integrating several research paradigms in this study demonstrates the researcher's pragmatic worldview. Pragmatists highlight the significance of testing different methods and subsequently assessing them in relation to their effectiveness. Thus, quality research embodies a process of trial-and-error (Savin-Baden & Major, 2013 in Sol & Heng 2022:94).

There is a compelling correlation between pragmatism and the promotion of social justice (Morgan, 2014 in Kaushik & Walsh 2019:11). The pragmatic paradigm grapples with investigating current social concerns and engages with topics like social inequality and power (Collins, 2017 in Kaushik & Walsh 2019:11). The researcher will adopt an axiological stance of pragmatism, which regards research as value-laden and is aimed at benefiting people and acquiring knowledge in pursuit of desired ends as influenced by the researcher's values (Kivunja & Kuyini, 2017; Scheffler, 2013 in Kamau 2022:52).

Pragmatic philosophy affirms that "human actions can never be separated from the past experiences" and the beliefs that stem from such experiences. Human thoughts are therefore inherently connected to action (Kaushik & Walsh 2019:3). Yefimov (2004) (in Kaushik & Walsh 2019:3) identifies one of the key elements of pragmatist philosophy to be "that knowledge and reality are based on beliefs and habits that are socially constructed."

Pragmatism does not view knowledge as "final, universal or absolute" and its never completed or perfect. Contrarily, knowledge is continuously in a process which can be reviewed and enhanced (Kaushik & Walsh 2019:10). Pragmatists are of the opinion that reality is not static – it constantly changes as events unfold. Likewise, "the world is also not static – it is in a constant state of becoming." The world is transformed by way of actions. Thus, actions have an intermediary function and are essential in pragmatism (Goldkuhl, 2012; Maxcy, 2003; and Morgan, 2014 in Kaushik & Walsh 2019:3).

Blumer (1969) (in Kamau 2022:52) argues that the centre of ontology in pragmatism "is action and change" and the relationship between knowledge and action. To

execute desired change, action has to be steered by knowledge and motivation. “The world is thus changed through reason and action and there is an inseparable link between human knowing and human action. This implies non-singular reality ontology, implying all individuals have their own and unique interpretations of reality” (Kivunja & Kuyini, 2017 in Kamau 2022:52).

For this research, a pragmatist epistemological approach will be applied as it accentuates “self-discovery and the testing of knowledge” (Bekker *et al.* 1976:36). Passive learning is discouraged, and students are implored to practice active learning where knowledge is discovered that can be applied when approaching real-life situations (Bekker *et al*. 1976:36).

One of the cornerstones of pragmatist epistemology “is that knowledge is always based on experience” (Kaushik & Walsh 2019:4). Every individual’s view of the world is determined by their social experiences and “each person’s knowledge is unique as it is created by her/his unique experiences” (Kaushik & Walsh 2019:4). Pragmatist epistemology does not consider knowledge to be reality (Rorty,1980 in Kaushik & Walsh 2019:4). Instead, knowledge is established with the objective to better govern a person’s existence and to participate in the world (Goldkuhl, 2012 in Kaushik & Walsh 2019:4).

Epistemological pragmatism maintains that “knowledge is a self-correcting process based on experience and is fallible” (Kaushik & Walsh, 2019; Ormerod, 2006; Hack, 2010 in Sol & Heng 2022:93). Therefore, it has to be assessed and reviewed in light of subsequent experience (Sol & Heng 2022:93). “Epistemology helps us evaluate how we make sense of the world around us and beyond” and acquire knowledge that we can apply to work out specific problems (Sol & Heng 2022:94).

1.7 Research design and methodology

The pragmatic paradigm guides the researcher's study because it is considered the best philosophical foundation for justifying the combination of qualitative and quantitative philosophies within one study (Tashakkori & Teddlie 1998:30).
According to McMillan and Schumacher (2001:31), a research design is the investigation structure used to obtain evidence to answer the research questions.

Mixed methods are defined as a procedure combining both quantitative and qualitative data simultaneously in the research process to understand the research problem (Creswell & Plano Clark 2011:3; Maree 2014:275). Both approaches have enough similarities to allow their combination within a single study (Maree 2017:315). This type of design is used when a secondary research question is different from the primary research question but related.

By applying a quantitative approach, relationships between variables were pursued, whereas utilizing a qualitative approach, the researcher pursued a meticulous understanding of individuals' experiences. Each method provided the researcher with beneficial yet different insights into the research problem. The researcher gathered both numeric and text information (Maree 2014:15)

A randomised experimental design was applied for this research, namely a **randomised pre-test - post-test control experiment**.

The researcher used a mixed-method approach, utilizing both quantitative and qualitative methods to address the research objectives. Using a single research approach would not be sufficient to interpret the complexity of the research problem. Using the combination of qualitative and quantitative methods as one mixed-method study allowed the researcher to obtain answers to both questions of "what" and "why." Further, a more comprehensive understanding of the research problem was obtained by "comparing the quantitative and qualitative findings." (Maree 2014:14-15).

A mixed method approach was needed in this research as a mixed method approach is used when a researcher needs to answer secondary research questions that differ but relate to the primary question (Maree 2014:275).

By applying a quantitative approach, relationships between variables were pursued, whereas utilizing a qualitative approach, the researcher pursued a meticulous understanding of individuals' experiences. Each method provided the researcher with beneficial yet different insights into the research problem. The researcher gathered both numeric and text information (Maree 2014:15)

Quantitative research was used by collecting the final grades of students in the control group as well as the final grades of the students in the experimental group. A randomised pre- and post-test control design was also applied (McMillan & Schumacher 2006:267).

All the participants were initially measured against the independent variable (pre-test) in this design. The students' final Grade 12 Mathematics marks were the pre-test scores considered. Subsequently, the experimental group received a treatment being the FC approach. The control group was subject to the traditional teaching approach.

Both groups were then measured against the dependent variable (post-test). The students' final marks comprise of continuous online assessments, tests, and a final examination. The final marks were to be considered the post-test scores. The two groups were then compared regarding their post-test scores to determine whether the FC treatment affected the outcomes (Maree 2014:150). Further, the difference between each group's pre-and post-test scores was compared.

The researcher analysed the numerical data using descriptive and inferential statistics. Conclusions were drawn based on the statistical significance of the results (Maree 2014:15).

Qualitative research was used to study students' experiences in the traditional classroom environment as opposed to the students in the flipped classroom environment. This specific study was used to answer one of the central research questions: "What are the experiences and perceptions of Statistics students of the FC approach as a strategy to engage students in Statistics Education?" Questionnaires were distributed to both groups' students, and interviews were conducted with selected students. The data from the questionnaires and the interviews were analysed to determine recurring themes. Conclusions were drawn from the similarities and differences in students' learning experiences (Maree 2014:15).

1.8 Selection of research participants

The population considered for this research was comprised of all the first-year Statistics Extended Curriculum Programme (ECP) students (being about 200 students) from the South Campus of the University of the Free State (UFS). All the students were invited to participate in the study. The study in its entirety and the benefits of using the FC approach were discussed with the students.

Should students agree to participate, there remained a risk that students would feel intimidated by the fact that the lecturer was in a position of power and had authority over them. There was a possibility that students may fear that the lecturer would negatively influence their marks should they wish to change their minds at a later stage and no longer want to be a part of the study. However, the students were assured that if they were not satisfied with the FC approach, they could leave at any time without any repercussions. Students interested in this experiment had to sign a letter of consent before commencing the research, permitting them to be part of the study.

The interested parties were randomly divided into two groups: an experimental and a control group. The FC approach was done in the experimental group (Group A), while the control group (Group B) received traditional face-to-face lecturing. Group B students were not allowed to join Group A and had to sign an attendance list when

attending the lectures. In that way, the researcher could ensure that students from Group A did not participate in Group B. The videos were e-mailed to the respective students in Group A only. The researcher taught both groups and was the only lecturer responsible for this subject at South Campus. Students who did not sign a consent letter also joined Group B but did not participate in the study.

1.9 Data collection

Data were collected in the following ways:

- Results from students' continuous online assessment tasks and their semester tests and examinations were used to compare the performance of the experimental and control groups.
- Questionnaires, consisting of closed- and open-ended questions, were completed by all the students to determine students' experiences and their perceptions about the FC approach.
- The researcher used a reflective journal to record her observations and experiences implementing the FC approach.
- Interviews were conducted with individual students. Purposive sampling was used to select eight students from the experimental group for interviews to gain insight into their perceptions and experiences of the FC approach (Maree 2014:178). The qualitative data obtained in this way would hopefully explain why there was an improvement in the results.

1.10 Data analysis and interpretation

The quantitative data were analysed and interpreted by making use of the following:

- Descriptive statistics to summarise the collected data in a meaningful way;
- Inferential statistics to draw the necessary conclusions;
- Cronbach α to measure internal reliability for the questions used Likert -scales in this study;

- Chi-square test to determine whether there was a relationship between the different variables of the two groups;
- Paired t-tests were used to compare the average scores for the pre-and post-test scores of the various groups; and
- Analysis of covariance (ANCOVA), which combines regression analysis and analysis of variance (ANOVA), to investigate the effects of the primary independent variable (Groups A and B) and, with causal inference, investigate which factors caused the differences between the groups.

The analysis was done using the statistical program R (R Development Core Team, 2019), and some more straightforward calculations were done in Excel.

By comparing the literature and quantitative and qualitative research findings (Glaser & Strauss 1967:224), a framework for implementing the FC approach as a HIP to engage first-year Statistics students was compiled.

1.11 Reliability, validity and confirmability

Lincoln and Guba (in Maree 2017:371) stated that *reliability* and *validity* are similar concepts in qualitative research, as "validity is sufficient to establish reliability." Since this study used a mixed methods research design, *validity* and *reliability* will be used when discussing quantitative data, and the term *trustworthiness* will be used in the context of qualitative data (Maree 2017:371).

1.11.1 Reliability of quantitative data

Kumar (1999:140) stated, "…if a research tool is consistent and stable, and hence predictable and accurate, it is said to be reliable."

The researcher enhanced reliability in this research by ensuring that all students were assessed on the same date, at the same time, and in the same venue at one specific institution, the UFS (McMilllan & Schumacher 2006:185). She was the only person responsible for teaching both groups. Furthermore, reliability was ensured

by applying randomisation during the data collection process. Validated software was used for data analysis, contributing to the study's reliability.

Action research was not considered to avoid a long, drawn-out period to implement the intervention program that could influence the research because different years imply students with different abilities, resulting in a potential threat to reliability (Maree 2017:372).

1.11.2 Validity (Trustworthiness) of qualitative data

"Validity refers to the appropriateness, meaningfulness, correctness, and usefulness of the inferences a researcher makes" (Fraenkel & Wallen 2008:147).

According to Kuh *et al.* (2001:9), the following conditions were reported as conducive to the validity of self-report measures:

1. The information requested is known to the respondents;
2. The questions are phrased clearly and unambiguously;
3. The questions refer to recent activities;
4. The respondents think the issues merit a serious and thoughtful response; and
5. Answering the questions does not threaten, embarrass, or violate the respondent's privacy or encourage the respondent to respond in socially desirable ways.

The four criteria that Guba (1981) (in Maree 2017:123) argues as the *trustworthiness* of qualitative research are *credibility*, *transferability*, *dependability,* and *confirmability*. McMillan and Schumacher (2006:330) suggested that the trustworthiness of qualitative research can be enhanced with strategies like ongoing fieldwork, participant verbatim quotes, triangulation (multiple-data sources), and mechanically recorded data.

Credibility deals with the issue of how the reader will be convinced that the researcher's findings are believable and trustworthy (Niewenhuis, 2007 in Maree 2017:123). According to Welman *et al*. (2005:107) and Kerlinger (1986:300),

credibility describes the degree to which changes in the response variable are due to the explanatory variable rather than any extraneous variables. Credibility can be attained by using at least two equivalent groups regarding the response variable and all extraneous variables (Welman *et al*. 2005:107). Durrheim and Wassenaar (2002:63) refer to credibility as the assurance that the researcher's conclusions are derived from the data. To further ensure credibility, participants were asked during the interviews to verify data gathered through the questionnaires about how they experienced the intervention, as suggested by McMillan and Schumacher (2001:408) and Maree (2017:374). Quotations from participants were included to justify the researcher's conclusions. The focus-group interviews were audio-recorded.

Dependability for this research was ensured through ongoing fieldwork by collecting data over five months, where continuous assessments were done, a questionnaire was completed, and focus group interviews were conducted to reflect on the participants' experiences. Furthermore, triangulation was used to ensure dependability, *i.e.,* by using multiple data sources to increase the credibility of findings (McMillan & Schumacher 2006:331).

Transferability refers to what extent the research findings can be generalised to people outside the experiment (McMillan & Schumacher 2006:116).

Transferability, *credibility* and *confirmability* were ensured by audio-recording the focus-group interviews and then transcribing and classifying them into themes of how students experienced the intervention. McMillan and Schumacher (2001:409) articulated that "verbatim accounts and direct quotes are highly valued as data." Hard copies of all questionnaires and signed informed consent forms have been maintained to establish the *confirmability* of this research.

1.12 Value of proposed research

This study aimed to engage students as primary stakeholders using the FC approach to increase student success in first-year Statistics. The study, therefore,

strived to enhance learner performance to increase final marks and improve the throughput rate of first-year students in Statistics. The researcher hopes that HE instructors in other disciplines may learn from this study and that this research can inspire and motivate them to investigate and experiment with the FC approach in their own teaching. As such, the study aimed to significantly contribute to teaching, learning, and course design in HE.

The researcher has already begun to contribute towards the scholarship of teaching and learning in statistics education by releasing an internationally peer-reviewed publication, Da Silva (2020), which investigated the success of the FC approach as opposed to the traditional face-to-face approach.

1.13 Ethical considerations

The principle of informed consent was adhered to in all data-collection activities. The necessary authorisation from the Head of the Department of Mathematical Statistics, the Dean of the Faculty of Natural & Agricultural Sciences, the Dean: Student Affairs, and the Vice-Rector: Research of the UFS was obtained. Ethical clearance was obtained from the Faculty of Education's Ethics Committee at the UFS (UFS-HSD2015/0658). Confidentiality and participant anonymity were ensured in all reporting. All data collected were stored in a locked cabinet, which only the researcher had access to, and electronic data were password protected (as applicable). The no-harm principle was also adhered to in all phases of the study. The researcher believed this study held no ethical threat as it was always possible to keep within ethical boundaries.

1.14 Layout of Chapters

The study was compiled according to the following structure:

Chapter 1 (The orientation of the study**)** provides a brief orientation of the study that includes key HE research themes related to this study.

In **Chapter 2 (***Student engagement in Higher Education***)**, the researcher describes a literature review on student engagement in HE. The principal purpose of this chapter is to identify how students learn and distinguish between the different perspectives to understand student engagement.

The focus of **Chapter 3 (***Technology and Flipping the classroom in Higher Education***)** falls on the use of technology in HE. The researcher presents an overview of the principles of good practice in implementing technology in the classroom, and attention is paid to the different technology-based strategies currently used in the learning process to engage students actively. The background is also provided on what a flipped classroom is.

Chapter 4 (*Research design and methodology***)** concerns this study's research design and methodology. The chapter defines the population under investigation, participant selection, data collection, and analysis methods. Subsequently, reliability and validity issues are also discussed, and the chapter ends with ethical considerations associated with this study.

Chapter 5 (*Reporting and analysis of research findings***)** presents and discusses the main findings of this investigation. The chapter gives a thorough description and analysis of the research that has been conducted to investigate the effect of flipping the classroom on student outcomes and student engagement. In addition, the perceptions and experiences of students exposed to the new variant of the flipped classroom are presented.

In conclusion, **Chapter 6 (**Discussion of results**)** provides a condensed summary of the main findings of this study and **Chapter 7 (**Conclusions, implications, recommendations, and limitations**)**, discusses the recommendations and limitations of this study as well as the concluding remarks of the researcher.

2. Student engagement in Higher Education

2.1 Introduction

This chapter investigates how students learn and how the researcher can enhance student engagement in a first-year statistics service course. In the present chapter, objective one, as indicated in Chapter 1 (see section 1.4), is pursued to undertake a thorough literature study of what student engagement and high-impact practices entail.

2.2 How do students learn?

It is essential to understand how students learn in general. Learning is not just about students remembering what they read or have been told (Garfield 1995:25). Students also need to be cognisant that effective study skills can be learned. These "skills are not magically and mysteriously endowed on some and not on others," as pointed out by Congos and Schoeps (1998:52).

Research dictates that individual learning preferences are found when students respond differently to different stimuli in the learning environment (Whillier & Lystad 2015:128). Students learn in different ways. For example, some students do not work well in the morning but excel in the afternoon. Some learners have a longer attention span than others. Every student has a personal and exceptional learning style (Ouda & Ahmed 2016:435).

Learning styles have been categorised into three main forms being:

1. Visual learners who think in terms of pictures and learn best using visual images;
2. Auditory learners who learn by listening, for example, listening to lecturers; and
3. Kinaesthetic learners who learn by doing and interacting with others.

Students can prefer one, two, or even three different learning styles (Gilakjani 2012:105-106). Accommodating the different learning styles can improve students' final marks and increase their motivation (Gilakjani 2012:111).

2.3 Learning approaches

Each learning approach illustrates different aspects of the learning process. The following theories can be combined and should not be used separately. Together, they can provide a comprehensive account of what it takes to learn (Laurillard 2012:45).

2.3.1 Behaviourism

Behaviourist pedagogies focused on how education was practised during most of the 20th century (Anderson & Dron 2012:2). Behaviourism is where certain behaviours are displayed and can be manipulated through "operant conditioning" without understanding how the mechanism of learning takes place. Here it does not matter how a student manages to obtain their grades. This theory cannot be dismissed as irrelevant because lecturers use marks, grades, credits, and qualifications as rewards to motivate students to focus on studying. According to this approach, it is considered sufficient if a student memorises and parrots to pass an examination. This learning theory does not help students become independent learners because it is teacher-centered (Laurillard 2012:45).

2.3.2 Instructivism

Instructivism is a teacher-centered learning environment where the lecturer gives instructions in class, *i.e.,* in the traditional approach, the lecturer controls what is learned and how it is learned. Here students have a passive role without any form of peer collaboration (Vij 2015:8).

2.3.3 Experiential (social) learning

This type of learning started with Dewey's (1938) characterisation of learning through experience. He argued that the learners' organisation of a problem situation enables them to develop new knowledge (Laurillard 2012:47). Dewey referred to the example of a child sticking his finger into a flame. It is not an experience when a child merely sticks his finger into a fire, but the experience is when the movement is connected to pain. He refers to that as "learn from experience" (Dewey 1916:139-140). Dewey further mentioned that the quality of the experience must be worthwhile educationally (Dewey 1938:33). Reflection plus experience equals learning, *i.e.,* experiential learning results from reflection upon experience (Dewey 1916:145).

McGill and Warner Weis (1989:248) define experiential learning as "… the process whereby people engage in a direct encounter, then purposefully reflect upon, validate, transform, give personal meaning to and seek to integrate their different ways of knowing. Experiential learning, therefore, enables the discovery of possibilities that may not be evident from direct experience alone".

2.3.4 Constructivism

Constructivism as a learning theory was developed by Piaget (1976) and described learning as actively constructing one's knowledge (Garfield & Ben-Zvi 2007:46; Von Glasersfeld 2008:39; Dewey 1916:303). Thus, the lecturer's role is altered to an instructor who guides them to generate knowledge themselves (Ouda & Ahmed 2016:431). This will be the guiding theory for this research.

Constructivists view students as bringing their ideas to the classroom and thus advocate student-centered learning (Vij 2015:8). Students restructure the new information to fit their cognitive frameworks (Garfield 1995:26). Constructivists debate that making use of interactive activities can motivate learning more effectively (Brandt 1997:113-117). The lecturer aims to present the required information and tools (Ouda & Ahmed 2016:431).

2.3.5 Collaborative learning

The formal learning process still references the work of Dewey (1938), Piaget (1976), and Vygotsky (1978) nearly a century later. What it takes to learn does not change, but how we motivate and enable formal learning evolves (Laurillard 2012:93).

Collaborative learning, also called cooperative learning, consists of students working with fellow peers to solve problems and make sense and comprehend difficult concepts. Topping (2005:631) defined peer learning as “the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions. It involves people from similar social groupings who are not professional teachers helping each other to learn and learning themselves by so doing”. Peer learning is possibly as old as any form of collaborative learning, find comfort in discussing questions in smaller groups before completing assessments. They find it more accessible to gain conceptual understanding from the stronger students in a position as their peers instead of relying on the lecturer (Hornsby *et al.* 2013:71,73). Vygotsky states that the more proficient learners help their less advanced peers (Vygotsky 1978:86,131). This learning approach promotes successful learning.

Research regarding collaborative learning in statistics education has observed positive results such as better attitudes among students, improvement in student achievement, and improved relations among different groups of students (Roseth *et al.* 2008:9). Grouping empowers students to share resources, to learn from one another and to enhance critical thinking (Koeckeritz *et al*. 2002:284). Interactions between peers have been positively correlated to improved grades and will lead to deeper learning (Astin 1993:75; Logan 2015:3).

2.3.6 Social Constructivism

When collaborative learning combines constructivism with social learning, social constructivism is established. Vygotsky (1978:90,125-131) was probably one of the

first educational theorists to state that learning occurs in individuals because of the social interaction, the society in which they function, and the tools they can access. He illustrates this with the example of a child pointing at an object. The child learns what the pointing gesture means from the mother's reaction. Bandura (1971:3-5) also articulates that a person develops new patterns of behaviour by observing that of others. A good example is a much better teacher than the consequences of unguided actions. A student's environment also largely influences how they learn, *e.g.,* you can learn German quickly when in Germany because you hear it constantly.

2.3.7 Connectivism

This pedagogy was recently developed by George Siemens and Stephen Downes for the digital age in the 21st century. According to Siemens (2008:11), connectivist pedagogy is "learning a process of building networks of information, contacts, and resources applied to real problems." This approach assumes that information is readily available on the Internet, and learners do not have to memorise or even understand everything but rather apply knowledge when needed. The connectivist approach relies on network connections between people, digital artifacts, and content. Therefore, technology defines this pedagogy (Anderson & Dron 2012:8). Wikis are ideally suited for this learning activity as instead of providing study guides or textbooks for learning, students research for an answer to assessments.

2.4 Student engagement

2.4.1 Conceptualisation

Shulman (2005:38) states that learning begins with student engagement. Student engagement is a buzzword in HE. Research shows growing evidence of the critical role that student engagement plays in learning and student success (Kahu 2013:758). The positive relationship between student engagement and student achievement is well documented (Kuh 2003:25-27; Pascarella & Terenzini 2005:602; Schreiber & Yu 2016:158-159).

The notion of student engagement has been studied for close to a decade, dating back to educational psychologist Ralph Tyler's focus on the positive effect that time spent on academic tasks has on learning (Kuh 2009b:6). However, many education historians agree that Astin's (1984) student involvement research deserves credit for originating the modern engagement research. According to Astin (1999:518), a highly involved student devotes considerable energy to studying, spends much time on campus, participates actively in student organisations, and frequently interacts with lecturers and other students.

For hundreds of years, "engagement" meant "tying oneself to a course of action by oath." Only recently, "engage" came to say, "occupying the attention of." We are "engaged" when we are entirely present and not elsewhere (Axelson & Flick 2010:40). Astin (1999:519) refers to engagement as attaching oneself to…; committing oneself to...; joining in…; participating in…; engaging in…; taking part in ...; to name a few.

Trowler (2010:3) defines student engagement as "the interaction between time, effort, and other relevant resources invested by both students and their institutions intended to optimise the student experience and enhance students' learning outcomes and development, and the performance and reputation of the institution."

Student engagement consists of two key components. The first part refers to what students can do with the amount of time and effort they devote to academic activities to optimise the student experience and enhance the learning outcomes. The second part refers to what activities institutions implement to encourage students to participate and benefit from (Kuh 2009a:683). Students' experience of a supportive learning environment with pro-active support services and positive relationships with staff have been linked to student success (McRae *et al.* 2017:6), reducing the problem of high dropout rates (Reason *et al.* 2006:151). Within HE research, student motivation is also related to how institutions allocate resources and organise learning opportunities to motivate students to participate in such activities (Kuh *et al.* 2005:9).

Pace (1998:28) describes student engagement as “what accounts most is not who you are or where you are but what you do.” However, student engagement extends beyond students’ time and involvement in their studies.

Evidently, a plethora of literature investigating the complex notion of student engagement exists, yet we are still left seeking a thorough comprehension thereof (Kahu *et al.* 2019:658). It has further been argued that the aspects which affect student engagement remain unclear, and further research is called for (Tani *et al.* 2021:500; Wilson *et al.* 2019:1931; Xerri *et al.* 2018:589). Another element which adds to the complexity of “student engagement” is the fact that educational approaches cannot be regarded as one size fits all because every country has different educational circumstances and conditions (Madani 2019:107).

2.4.2 Different perspectives on student engagement

The question is: “How do we engage *X* students most effectively in *type Y* learning processes so that they will attain *knowledge or skill Z*?” (Axelson & Flick 2010:41). According to Kahu (2013:758), there are four distinct perspectives to understand engagement as identified in the literature: behavioural, psychological, socio-cultural and holistic.

2.4.2.1 Behavioural perspective

The most widely accepted view of engagement in HE literature revolves around student behaviour and effective teaching practices (Kahu 2013:759). Chickering and Gamson (1987:3-5) outline seven principles to facilitate effective teaching and learning practices to improve student engagement, which will be discussed below:

(i) **Encouraging interaction between students and the lecturer.** Frequent communication between students and lecturers in and out of class is the most crucial factor in student motivation and involvement.

(ii) **Developing reciprocity and cooperation among students.** Learning is enhanced through a team effort, not a solo race. Good learning is

collaborative and social and not competitive and isolated. Working with others increases involvement in learning and deepens understanding. In large classes, students usually form learning groups of about five to seven students, meeting regularly to solve problems set by the lecturer. Peer tutors for students who need specialised help can also be used.

(iii) **Encouraging active learning.** Learning is not a spectator sport. Students do not learn by passively sitting in classes, listening to lectures, memorising assignments, or spitting out answers. Instead, active learning is imperative, whereby students must talk about what they have learned, relate it to previous experiences, and apply that to their daily lives. Thus, active learning promotes deep learning (Abeysekera & Dawson 2014:2).

(iv) **Prompt feedback.** Students need appropriate feedback on performance to benefit from courses. Students must reflect on what they have learned and what areas they still lack. Assessment without timeous feedback does not contribute to learning.

(v) **Emphasising time on task.** Time plus energy equals learning. Students must learn to use their time optimally. Computer-assisted instruction requires students to spend adequate amounts of time learning.

(vi) **Communicating high expectations.** Expect more, and you will receive more. When lecturers have high expectations for themselves, it mirrors through to students and will they also have high expectations to perform well.

(vii) **Respecting diverse talents and ways of learning.** Students bring different skills and styles to a university. Computer-based courses will allow students to work at their own pace.

The manner in which the behavioural perspective has defined student engagement is limited and unclear. Considerate focus is placed on institutional practices. Institutional practices influence student engagement in an essential manner, but they do not embody the psychological state of engagement. “By focussing only on elements the institution can control, a wide range of other explanatory variables are excluded, such as student motivation, expectations, and emotions.” It is undeniable

that learning is emotional, and unfortunately, the behavioural approach does not effectively measure students' emotions (Kahu 2013:761-762)

The behavioural perspective misses valuable information that would give a much deeper understanding of the student experience by failing to measure how students feel. However, it does not suggest that there is no value in the behavioural approach. This perspective does explain a portion of the complex and multidimensional notion of student engagement and the relationships between teaching practices and student behaviour. However, the behavioural perspective's understanding of engagement is too narrow. The psychological perspective attempts to address this problem (Kahu 2013:760-761).

2.4.2.2 Psychological perspective

This perspective relates to students' interest in academic tasks and how such tasks promote cognitive engagement. Fredericks *et al*. (2004:62-63) state that this perspective conceptualises student engagement as a construct of three dimensions:

(i) **Affective** engagement involves students engaging emotionally and experiencing emotional reactions such as interest, improved motivation, enjoyment, or a sense of belonging, thus establishing a level of commitment (Groccia 2018:14).

(ii) **Behavioural** engagement, paralleling parts of the behavioural perspective discussed in section 2.4.2.1, refers to students' behaviour that typically complies with behavioural norms, like class attendance and involvement. It relates to time, effort, interaction, and participation (Steen-Utheim & Foldnes 2017:310). According to Trowler (2010:6), if students attend lectures and participate enthusiastically, it can be a positive engagement, however it can contrarily be negative engagement when they boycott and disrupt lectures. If they skip lectures, it can be referred to as non-engagement, which influences their academic success negatively (Smallhorn 2017:44; Yeung *et al*. 2016:57).

The Centre for Teaching and Learning (CTL) at UFS (2018:2) specifically researched the topic of class attendance and it was found that one of the main reasons for students not attending classes was socio-economic challenges. An example of these challenges was that students indicated that with the limited amount of money they have, they would rather buy food than use it for transport to travel to campus. Some of the other reasons noted in the study were that students had to study for other subjects' tests and complete assignments, catch up on academic work that they fell behind with, they preferred self-study in response to the quality of teaching and learning because many lecturers just read off the slides (CTL 2018:2). According to the researcher, the FC approach can address many of these challenges.

When teaching, a lecturer can easily be discouraged by disengaged students that give you the "blank stare" or others "bolting for the door like freed prisoners the moment when it is safe to do so" (Barkley 2010:3). Lecturers get intimidated when having to teaching an unmotivated audience (Glazer 2012:14). Some students do not want in class and thus intentionally sabotage class morale.

There are several reasons why students are disengaged, for example students experience parental pressure to be at university, nothing better to do, or other life pressures (Glazer 2012:119). While lecturers create classroom conditions for the opportunity to engage students, it is ultimately the student's choice to engage in learning (Barkley 2010:39). Outspoken students can often intimidate the quieter student, although the quiet student has the correct answer (Glazer 2012:7).

(iii) **Cognitive** engagement indicates that students who invest in their learning, go beyond the requirements, and like a challenge. Cognition thus refers to deep learning and self-regulation (Steen-Utheim & Foldnes 2017:310). Trowler (2010:6) states that when students meet or exceed assignment requirements, it will be positive engagement, and if they submit their assignments late, it can be referred to as non-engagement. Cognitive

engagement also incorporates individual characteristics such as motivation, self-efficacy, and expectations (Jimerson *et al.* 2003:7).

It is possible to positively engage with one or more of these three dimensions while engaging negatively with others (Groccia 2018:14). Trowler (2010:6) reflects on this complexity by providing an example of a feminist student who attends all classes and completes all assignments and, therefore, complies positively with all behavioural engagement norms but negatively affects effective and cognitive levels of chauvinistic, antifeminist statements of the lecturer. Groccia (2018:14) underlines the importance of lecturers' empathy and understanding for student learning to improve student engagement.

2.4.2.3 Socio-cultural perspective

This perspective focuses on the impact of the broader social context on student experience, *i.e.,* how societal factors influence student engagement (Kahu 2013:763). It has been proven that social factors are central to a student's academic achievement (Mishra 2020:13; Akimov *et al.* 2023:1).

The experience of starting university is described by some students as a learning shock (Griffiths *et al*. 2005:276) or feeling like "a fish out of the water" (Thomas 2002:431). It offers fundamental ideas on "why" students become engaged or alienated at university, emphasizing non-traditional students (as referred to in section 1.2.3.3). These groups are often described as not having the necessary social, cultural, and academic skills to fit into the university culture easily (Kahu 2013:763-764).

Furthermore, literature indicates that socio-economic status significantly impacts "student learning engagement and outcome" (Bae & Han 2019:53). The learned authors Bae and Han (2019:62) suggest that students who have "greater access to monetary support" are more inclined to realize their learning gains during their university experience.

2.4.2.4 Holistic perspective

This perspective strives to draw together strands of theory and research regarding student engagement. In line with the constructivist approach (as discussed in section 2.3.4), universities should be about more than obtaining qualifications. The lecturers should facilitate the student's learning to construct their view about the subject and the world. Higher levels of engagement are perceived as self-sufficient in the student and less dependent on the lecturer (Bryson & Hand 2008:4-5).

Bryson and Hardy (2011:17-19) suggest that engagement is both a process and an outcome. The former is what institutions do and should be labelled "engaging students", whereas the latter is what students do and should be labelled "students engaging". Therefore, a cluster of factors influences student engagement (usually the more immediate institutional factors). In contrast, the outcome is student engagement – an individual psychological state with the three dimensions discussed earlier in section 2.4.2.2: affect, cognition, and behaviour (Kahu 2013:764).

2.4.2.5 The latest perspectives of student engagement

Xerri *et al.* (2018:601) conducted a study that adopted the third and fourth (socio-cultural and holistic) perspectives. Amongst others, it was found that the more a student interacts with their lecturer, the more engaged the student will be. It was explicitly established that stronger lecturer-student relationships resulted in greater student engagement in academic activities (Xerri *et al.* 2018:601). In addition, the above-mentioned study established that student-student relationships had a favourable effect on enhancing student engagement. This study reinforces the idea of establishing a learning community formed between students to promote student engagement (Xerri *et al.* 2018:602). Bae and Han (2019:62) also found that students with increased interactions with their lecturer are inclined to observe better learning gains during their university experience.

Tani *et al.* (2021:512) conducted a study in which the fourth (holistic) perspective was adopted. It was found that the behavioural intention of a student has a positive effect on student engagement. It was held that "behavioural intention is a critical determinant for student engagement" (Duque, 2014 in Tani *et al*. 2021:514). The data in this study shows that a student's attitude is "the strongest predictor of student engagement" (Tani *et al*. 2021:514).

The above-mentioned study further concluded that collaborative student-lecturer relationships improve student engagement. This finding supports the earlier mentioned research conducted by Xerri *et al.* (2018) in which it was concluded that students who have strong relationships with their lecturers are inclined to ask more questions and receive more feedback (Tani *et al.* 2021:514).

Kahu's (2013) framework on student engagement has been subject to much criticism in that it failed to clearly define exactly what it was that students were engaging with (Ashwin & McVitty 2015:344), which ultimately led to a revised framework (Bond & Bendenlier 2019:2). The earlier framework did not accurately depict "the interaction between students and institutions that is critical to engagement" (Kahu *et al.* 2019:658).

Kahu and Nelson (2018:67) revised Kahu's 2013 framework of student engagement, addressing its existing constraints and improving its applicability and validity for comprehending student experience. The learned authors employed a cultural lens to develop an educational interface which symbolizes the individual psychosocial space where elements of the institution and student integrate and student engagement takes place.

Three significant contributions regarding student engagement and success were made in that article.

Firstly, the educational interface portrays the intricate relation between a student and the institution, and the effect of these relations on student engagement. Kahu and Nelson's revised framework reiterates that HE is "a partnership between

students and their institution" (Kahu & Nelson 2018:67). The interface analogy emphasizes that student experiences continuously change, with every different class of students, every different interaction, and every different academic task (Kahu & Nelson 2018:67). The existence of the educational interface helps us remember that student or institutional factors seldomly impact student engagement independently and that the interaction between the two is paramount (Kahu & Nelson 2018:67).

Secondly, "the refined framework highlights four specific psychosocial constructs: self-efficacy, emotions, belonging, and well-being, which we contend are critical mechanisms for mediating the interactions between student and institutional characteristics and student engagement and success" (Kahu & Nelson 2018:58). These four factors emanate from the collaboration of a student with the institution and they function as pathways which can promote or reduce student engagement and subsequently success (Kahu *et al.* 2019:659; Kahu & Nelson 2018:68).

Lastly, the learned authors advance our "understanding of the experiences of non-traditional students" (Kahu & Nelson 2018:68). The revised framework sheds some light on why non-traditional students, who are typically said to have lower completion rates, go on to obtain their qualifications and why some do not (Kahu & Nelson 2018:58). Kahu and Nelson (2018) investigate the experiences of non-traditional students and identify the challenges they face. Although we appreciate their identities and knowledge, we cannot ignore the fact that the probability for non-traditional students to complete HE is lower (Kahu & Nelson 2018:68).

The minimal commonalities between a non-traditional student's past experiences and their current circumstances in HE may indicate that their experience at university is increasingly more taxing. "As shown in the educational interface, these challenges may be due to reduced self-efficacy, a lack of belonging, negative emotions, or decreased well-being and increased stress" (Kahu & Nelson 2018:68). Every one of those mechanisms can negatively influence student engagement and impede their learning, subsequently leading to failure. The end result can be withdrawal (Kahu & Nelson 2018:68).

A later study of Kahu *et al.* (2019:657,659) conducted, confronted the shortfall of the model of SE of Kahu and Nelson (2018) by using student narratives to produce a meticulous understanding of SE in their first year. This study makes use of a more holistic approach instead of isolating specific variables. The learned authors concluded that each individual student's experience is unique (Kahu *et al.* 2019:670).

Trowler *et al.* (2021:774) provided literature with a significant conceptual contribution through reviewing the Kahu and Nelson (2018) framework and refining it with a wider and more contextual comprehension of student engagement. Trowler *et al.* (2021:762-763) also argued that the Kahu and Nelson (2018) model does not satisfactorily account for the "nature of SE in a HE context".

Trowler *et al.* (2021) do not have the same view on student engagement as Kahu and Nelson (2018). They contend that Kahu and Nelson (2018) place "student engagement within the individual student," whereas they identify engagement to be a reciprocal dynamic (Trowler *et al*. 2021:762). This reciprocal dynamic can be expressed as "engagement of students, and engagement by students" (Trowler *et al*. 2021:762). Trowler *et al.* (2021:763) designed six "pathways to engagement" as opposed to the four "triggers of engagement" established by Kahu and Nelson (2018). The six mechanisms comprise: emotions, motivation, resilience, reflectivity, self-efficacy and belonging. Only three mechanisms overlap with the framework of Kahu and Nelson (2018) being self-efficacy, emotions and belonging (Trowler *et al*. 2021:763).

Since literature is continuously evolving, selecting which mechanisms to use to assess student engagement signifies "both a moment in time and our own subjective interpretation of these mechanisms" as emerging in the engagement interface between the student and the institution (Trowler *et al*. 2021:763). In light of this, coupled with the complexity of the topic of student engagement, it is inevitable that the framework of student engagement will keep changing. However, the researcher believes that the original four perspectives of student engagement,

as theorised by Kahu (2013), will always remain the essential point of departure of any given framework. The researcher thus regards the momentous literature of Kahu to be the leading force in this field of research.

2.4.3 Benchmarks measuring student engagement

It is essential to review evidence of the National Survey of Student Engagement (NSSE)' benchmarks (Kezar and Kinzie 2006:51) to understand the concept of student engagement. The NSSE, which was developed at Indiana University, United States of America (USA), first started with research in 1998 to investigate student engagement levels from the behavioural perspective (see section 2.4.2.1) (Kahu 2013:759). According to the developers, the NSSE items and scales are theoretically and empirically derived with excellent psychometric properties (Kuh *et al*. 2001:5). However, others disagree (Kahu 2013:759).

There is much controversy that implies the domain definition of student engagement in terms of NSSE is far too wide and several aspects lack theoretical justification. The NSSE's predictive validity is contested due to insufficient research regarding the correlation between the data and objective outcomes. A study has concluded that there are "very weak associations between academic success and the NSSE benchmarks" (Kahu 2013:759).

The researcher further disagrees with the above-highlighted critique and is of the view that these benchmarks due contribute to academic success. The researcher, however, believes that there are alternative methods that can be used to measure student engagement using these benchmarks.

Benchmarking is the process of continuously adapting the best practices to improve quality education (Kuh *et al.* 2001:5). These surveys provide institutions with information on how students are learning and to what extent institutions are employing effective methods to help students engage in educationally purposeful activities. Students are also required to reflect on what they put into their time at

university and the intellectual, personal, and social gains they have realised from their studies (Strydom *et al.* 2010:3).

In 2007, the first version of the South African Survey of Student Engagement (SASSE) was piloted at the UFS (SASSE 2015:6) and was administered nationally. The SASSE instrument includes the same information as the NSSE survey but slightly adapts to the SA context vocabulary. Words like “college” were changed to university, “faculty” changed to the lecturer, and “learning community” changed to “academic student societies” (law, psychology, etc.) (Strydom *et al*. 2010:5).

Table 2.1 illustrates the benchmarks of good educational practice that institutions use to estimate the efficacy of their improvement efforts (Kuh 2003:25). It can thus be used as an operational definition of student engagement (Abdullah *et al.* 2015:278). As discussed in Table 2.1, these benchmarks are based on 42 key survey questions mentioned in Table 2.2 (SASSE 2015:43-50).

Table 2.1: Five themes and Engagement Indicators used in SASSE

BENCHMARKS	ENGAGEMENT INDICATORS
Level of Academic Challenge	**Theme: Academic Challenge** Higher-Order Learning Reflective and Integrative Learning Learning Strategies Quantitative Reasoning
Active and Collaborative Learning	**Theme: Learning with Peers** Collaborative Learning Discussion with Diverse Others
Student-Staff Interaction	**Theme: Experience with Staff** Student-Staff Interaction Effective Teaching Practices
Supportive Campus Environment	**Theme: Campus Environment** Quality of Interactions Supportive Environment
Enriching Educational Experiences	**Theme: High-Impact Practices** Student Societies Practical Work Technology Research with Staff Service-Learning

Source: SASSE 2015:8

Table 2.2 gives a detailed explanation of each theme given in Table 2.1.

Table 2.2: Survey items from the five themes used in SASSE

SASSE BENCHMARKS
Level of Academic Challenge • Time spent on academic activities (preparing for class by studying, reading, writing, doing homework or lab work, analysing data) and non-academic activities (traveling to and from campus, taking care of dependents, or working) • Worked harder than you thought you could to meet a lecturer's standard or expectations • Number of assigned textbooks or subject readings • Number of written pages or assignments of 20 pages or more • Number of written pages or assignments between 5 and 19 pages • Number of written pages or assignments fewer than 5 pages • Coursework emphasised: Analysing the essential elements of an idea, experience, or theory, *e.g.,* by examining a case or situation in depth • Coursework emphasised: Synthesising / integrating and organising ideas, information or experiences into more complex interpretations and relationships • Coursework emphasised: Making judgements about the value of information, arguments, or methods, *e.g.,* by examining how others gathered and interpreted data assessing the accuracy of conclusions • Coursework emphasised: Applying theories or concepts to practical problems or in new situations • Institution emphasised: Spending significant amounts of time studying and on academic work
Active and Collaborative Learning (Students) • Asked questions in class or contributed to class discussions • Made a class presentation • Worked with other students on projects during class • Worked with classmates outside of class to prepare class assignments • Tutored or taught other students (paid or voluntary) • Participated in a community-based project as part of a regular course • Discussed ideas from readings or classes with others outside of class (students, family members, co-workers, etc.)
Student-Staff Interaction (Discussions with the lecturer) • Discussed marks or assignments with a lecturer or tutor • Talked about career plans with a lecturer or counsellor • Discussed ideas from readings or classes with a lecturer outside of class • Worked with staff members (lecturers or others) on activities other than coursework (committees, orientation, student life activities, etc.) • Received prompt feedback (written or oral) from lecturers on academic performance • Worked with a staff member (lecturers or other) on a research project outside the course or programme requirements
Supportive Campus Environment

- The campus environment provides the support needed to help you succeed academically
- Campus environment enables you to cope with non-academic responsibilities (work, family, etc.)
- The campus environment provides the necessary support to help you thrive socially
- Quality of relationships with other students
- Quality of relationships with lecturers and staff members
- Quality of relationships with administrative staff and offices

Enriching Educational Experiences

- Talking to students with different religious beliefs, political opinions, or personal values
- Talking to students of a different race or ethnicity than your own
- An institutional climate that encourages contact among students from diverse economic, social, and racial or ethnic backgrounds
- Using electronic technology (SMS, WhatsApp, Internet, E-mail, etc.) to discuss or complete assignments
- Participating in
    - Internships or field experiences
    - Community service or volunteer work
    - Foreign or additional language coursework
    - Study abroad (international exchange programme)
    - Study of a subject or course for non-degree purposes
    - The development of a community project using the knowledge obtained at university to address a problem in your community
    - Co-curricular activities (campus publications, involvement in SRC projects, residence duties, inter-residence duties, community services, etc.)
    - Academic student societies (law, psychology, etc.) where students engage in topics related to their subject

Source: SASSE 2015:43-50

The researcher is of the opinion that the NSSE and SASSE items and scales do not accurately measure student engagement. According to the researcher, the scales of their surveys do not accurately calculate the aggregated mean of engagement indicators. The researcher still believes there is much value in these benchmarks, but will this study attempt to make use of alternative methods of calculating the engagement indicators.

2.4.3.1 Theme – Academic Challenge

This level focuses on whether students find their academic work intellectually challenging because it is central to student learning. Universities promote student learning by challenging and supporting students to engage in various forms of deep

learning. It includes questions on the number of hours spent studying, the amount of reading and writing that has been done, items based on Bloom's taxonomy (see Section 3.3.3), and the emphasis that the campus environment places on studying and academic work (Kuh *et al.* 2005:11). The engagement indicators here are defined as:

1. ***Higher-Order Learning*** describes how much students' academic work emphasises cognitive tasks like applying learned information to practical problems, analysis, evaluation, and understanding data (SASSE 2015:16).

2. ***Reflective and Integrative Learning*** connects students' academic work by relating prior knowledge and personal experiences to the module content. They reflect on their views while examining the opinions of others (SASSE 2015:17).

3. ***Learning strategies improve students' learning and retention by actively engaging*** with the subject material, analysing information, and memorising. These strategies can help universities use interventions to promote student success (SASSE 2015:19), like using the FC approach (as discussed in section 3.4) as an intervention.

4. ***Quantitative Reasoning*** is the ability to use and understand numerical and statistical measures in their daily lives and use such information to examine real-world problems, reach conclusions and evaluate what others have concluded from numerical information (SASSE 2015:20).

2.4.3.2 Theme – Learning with Peers

Students must collaborate with others to master difficult concepts or solve problems and develop social competence to deal with complex issues during and after university. Thus, they are intensely involved in their education and are required to reflect on their learning. Here, questions are asked on how active students are in class through discussions, group work, or presentations, whether they are involved in tutoring or engaged in out-of-class discussions (Kuh *et al.* 2005:11). The engagement indicators are:

1. ***Collaborative Learning*** as discussed in Section 2.3.5.

2. ***Discussions with Diverse Others*** are discussions between students from different backgrounds (race, economic, and religious beliefs) and life experiences (SASSE 2015:24).

2.4.3.3 Theme – Experience with Staff

This benchmark relates to how students discuss their grades, future, and ideas with staff, whether they consulted lecturers on activities outside of class and how prompt feedback is. Effective teaching must be done in student-centered ways (Kuh *et al.* 2005:12). The different engagement indicators are:

1. ***Student-Staff Interaction***. Evidence shows that students who have regular and substantive interactions with their lecturer, like discussing career plans or subject matter outside of class, are positively influenced by increasing their cognitive growth, engagement, and academic success (Pascarella & Terenzini 2005:599-602).

   A study that Xerri *et al.* (2018:601) conducted proved that lecturer and student relationships have a positive effect on student engagement. It was explicitly established that stronger lecturer-student relationships resulted in greater student engagement in academic activities as opposed to weaker lecturer-student relationships (Xerri *et al.* 2018:601).

2. ***Effective Teaching Practices*** play an essential role in facilitating student learning, especially prompt feedback regarding tests and assignments that is formative and effective (SASSE 2015:27). Using more effective teaching practices like the FC approach (as discussed in section 3.4) could create opportunities for more frequent and high-quality interactions during and outside class (Strydom *et al.* 2017:47).

2.4.3.4 Theme – Campus Environment

This engagement indicator summarises students' perceptions of the institution's learning and development effort (SASSE 2015:31). Students are asked how they experience the campus environment to help them succeed academically, the quality of their relationships with other students, and their contact with lecturers and administrative staff (Kuh *et al.* 2005:13). The different indicators used are:

1. ***Quality of Interactions****.* Students who seek support from peers, lecturers, and support staff are more equipped to learn from those around them (SASSE 2015:30).

2. ***Supportive Environment****.* Universities that enhance student success should support students across areas like tutoring services, writing centers, wellness, campus activities, etc. This environment should encourage high student performance and satisfaction (Pascarella & Terenzini 2005:600-611).

2.4.3.5 Theme – High–Impact Practices (HIPs)

Enriching educational experiences focus on the number of complementary learning opportunities students participate in and outside the classroom. This strategy also entails using technology like WhatsApp, Internet, etc., to facilitate the learning process and promote collaboration between peers and lecturers (Kuh *et al.* 2005:12) (see Chapter 3 for a more detailed discussion about technology).

According to Kinzie (2012:1), the benefits of HIPs are higher rates of student-lecturer interaction, increased critical thinking and writing skills, a greater appreciation for diversity, and higher student engagement. HIPs assist students in deep learning (Kuh 2008:14). Therefore, HIPs provide substantial educational benefits.

The impact of HIPs depends entirely on how it is implemented (**quality**), how many students it reaches (**scale**), and how many practices students experience (**intensity**) (CCCSE 2013:4). These factors can be described as:

1. **Quality** states that educational practices' value depends on how they are designed and implemented. Universities do not have to reinvent the wheel. Still, they must determine which components (*e.g.,* time management or study skills) have the most solid relationships to student engagement and success (CCCSE 2013:4,35). The BUSSE 2015 survey administered at the UFS showed that first-year students underestimate time management (Strydom *et al.* 2017:65).

2. **Scale** refers to how many institutions implement HIPs. The effects of HIPs are severely limited because small percentages of the student population experience them.

3. **Intensity** specifies that multiple HIPs should be integrated to improve outcomes. CCCSE (2013:34) proved a positive relationship between intensity (the number of HIPs) and student engagement. Student engagement levels rise when they participate more in HIPs.

The different practices of HIPs include the following:

1. **Service-learning / community-based learning**. A key element in these programmes is that students apply what they learn in real-world settings before leaving the university. Students are giving something back to the community (Kuh 2008:11). Service-learning projects as a component of statistics courses can be like a student-run consulting programme that serves the local community (Van der Merwe 2012:63-66).

2. **First-year seminars and experiences**. These programmes regularly bring small groups of students together with lecturers and emphasise collaborative learning and other skills that develop students' intellectual competencies (Kuh 2008:9). These students are more likely to report that their campus is a supportive environment and are more knowledgeable about campus resources than students who do not participate (Brownell & Swaner 2009:27).

3. **Learning communities** help ease students' transition to the university and give them a sense of belonging on campus (Brownell & Swaner 2009:27). This programme's key goals are to encourage the integration of learning across

courses and involve students with questions beyond the classroom, where they engage on topics related to their subject (Kuh 2008:10). This item measures student involvement in enriching academic activities, like academic societies (law, psychology, etc.) (SASSE 2015:31).

4. **Collaborative learning,** as discussed in section 2.3.5, involves students working together in some way to aid their learning and can include study groups or team-based assignments. Here, the lecturer will not know the problem or solution the students will be researching (Kuh 2008:10).

5. **Common intellectual experiences** require advanced integrative studies and/or required participation in a learning community, *e.g.,* technology, to help students (Kuh 2008:9).

6. **Diversity and global learning** help students explore cultures, life experiences, and worldviews different from their own (Kuh 2008:10).

7. **Writing-Intensive courses** emphasise writing at all levels and across the curriculum. This practice's effectiveness "across the curriculum" has led to parallel efforts in quantitative reasoning, information literacy, literacy development, etc. (Kuh 2008:10).

8. **Undergraduate research.** Many colleges and universities now provide research experiences for students in all disciplines. Undergraduate research, however, has been most prominent in science disciplines. The goal is to involve students with actively contested questions, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions (Kuh 2008:10).

9. **Internships.** Students are provided with direct experience in a work setting and benefit from coaching from professionals in the field (Kuh 2008:10).

10. **Capstone courses and projects** are when students are required to create a plan that integrates and applies what they have learned toward the end of their university years (Kuh 2008:10).

As can be noted from the above-mentioned HIPs, a flipped-classroom was not listed as one of the HIPs that have been identified and studied in literature. The researcher however aims to use this study to investigate whether the FC approach can be classified as a HIP. This research further aims to ascertain whether the FC approach will be an effective HIP in order to enhance student engagement and increase student success.

2.4.4 The importance of student engagement

Measuring student engagement will enable institutions to:

a) **Improve teaching and learning practices**. Academic achievement is positively influenced by active participation in the learning process (Graham *et al.* 2007:233-234). A study by Hallinger and Lu (2013:606) suggested that active learning methods resulted in a positive change in student engagement and that students perceived themselves as more keenly and consistently engaged in their learning. Kirstein & Kunz (2015:1,18) suggest that effective teaching methods can be implemented successfully, even in large classrooms, when active student involvement is achieved. Krause (2005:10) claims that understanding engagement is to understand that it is a battle for some when they encounter teaching practices that are “foreign to them” or in a language different from their mother tongue.

b) **Improve throughput rates and retention.** It is vital to compare their performance to the five benchmarks (see discussion in section 2.4.3) with similar HE institutional types (universities or universities of technology) in SA (Strydom *et al.* 2010:10).

c) **Assess student satisfaction** (Strydom *et al.* 2010:11).

d) **Develop interventions** based on survey results that can be used to improve throughput and success rates (Strydom *et al*. 2010:11). It has been observed that if students fail their first year, they are likely to withdraw from their studies (Krause 2005:8).

e) **Improve accountability** internally by comparing the results of faculties with each other concerning the five benchmarks (see section 2.5.4), *e.g.,* identify areas that can be improved to maximise students' chance of success (Strydom *et al.* 2010:11).

f) **Improve equality/social justice** as referred to in section 1.2.3.3. Furthermore, Kuh and Gonyea (2015:269-270) assert that undergraduates' library experiences positively influence the selection of educationally purposeful activities, such as using computers and information technology and interacting with lecturers. Students who visit the library more frequently engage more in academically challenging tasks and higher-order thinking, especially in previously disadvantaged groups.

g) **Enhance lecturer and staff development** by focusing on initiatives on concerning effective educational practices that have been shown to maximise students' opportunities to succeed (Strydom *et al.* 2010:11). According to Groccia and Hunter (2012:3), learning requires "educational practices that engage students across disciplinary boundaries in learning experiences that tackle real problems, allow application of course content to those problems, and lead to sustained intellectual growth and a heightened sense of personal responsibility."

2.5 Concluding remarks of the researcher

The traditional approach makes use of behaviourism and instructivism learning approaches. It was expressed that the behaviourism approach does not encourage students to become independent learners because it is teacher-centred. It was further expressed that in the instructivism approach, student have a passive role without any form of peer collaboration. The researcher wants to use the FC approach to experiment with the concept of whether enforcing a different learning approach will enhance student success and/or student engagement.

The constructivism learning approach will be enforced by the lecturer on the experimental group by applying the intervention of the FC approach. By implementing the FC approach, the researcher will attempt to shift the responsibility to learn to the students. It will no longer be lecturer-centred but student-centred. It is intended that students become vastly more independent which aims to promote active learning. In this study by applying the FC approach, the lecturer will take on the role of an instructor by merely assisting students when they struggle and providing them with all the necessary tools to succeed.

This research will be assessing student engagement form both a behavioural as well as a psychological perspective. The views of the behavioural perspective will be used in this study with the aim of enhancing student engagement by encouraging active learning by implementing the FC approach video-lecturing style.

The second aspect of the behavioural perspective, which was a cardinal motivation for this study, was respecting diverse talents and ways of learning. The researcher is aware that students have different abilities and manners in which they learn. The video-lectures will aim to best accommodate all types of students. The video-lectures will assist slower learners while not hindering the faster learners, by allowing each student to work at the pace needed for the specific individual. The video-lectures will assist students with disabilities, for example, a student who has a hearing disability can view the videos and follow along with the subtitles.

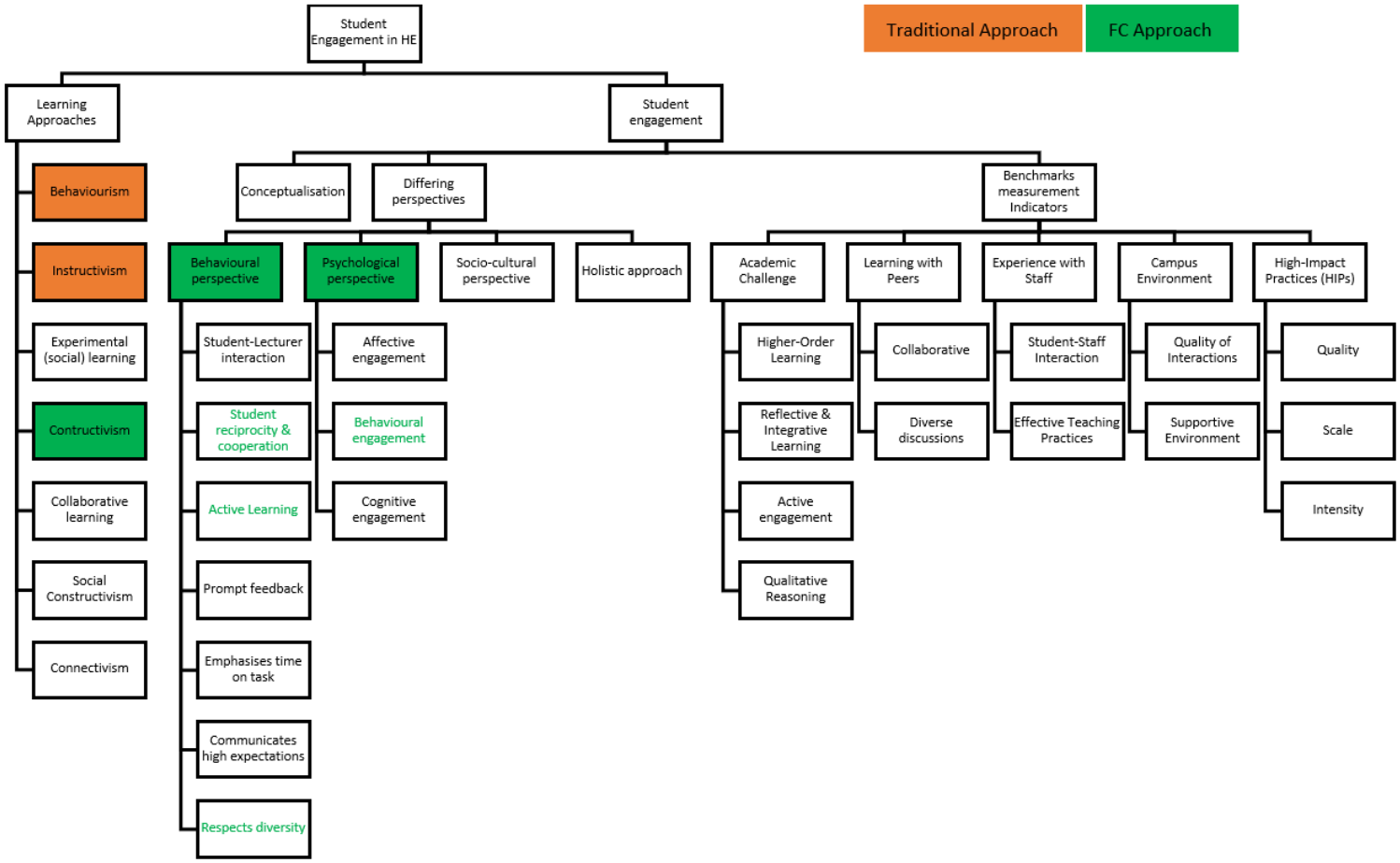
The videos will also aim to assist lecturers in times of uncertainty such as when students strike and classes are interrupted or when a global pandemic strikes and face-to-face classes cannot proceed as per usual. The researcher has identified a reoccurring problem that on a yearly basis there are a number of students who register late, thereby automatically falling behind. The video-lectures aim to address this problem by eliminating the fact that students cannot access past lectures and automatically begin the subject with a hindered approach. The video-lectures aim to increase student success by allowing students to be able to continue learning no matter what the circumstances are.

This study will also be assessing behavioural student engagement from a psychological perspective. The literature overview has identified one of the main reasons that students do not attend class is due to socio-economic challenges. This study will investigate whether the FC approach will aid these students' success and enhance engagement. The researcher is of the opinion that video-lectures can immensely improve student success of these particular students as they can watch the videos at home when they are unable to attend class on campus. This could possibly ensure that they do not fall behind or miss out on important concepts whereby diminishing their chances of success.

Behavioural perspective of student engagement represents institutional aspects whereas the psychological perspective represents how students feel. This study will thus be combining qualitative data as well as quantitative data to analyse the above.

The next chapter will first describe how to address technology use with students; second, how the FC approach can be applied as a HIP in first-year Statistics students to increase student engagement.

Figure 2.1: Summary of student engagement in HE



3. Technology and Flipping the classroom in Higher Education

3.1 Introduction

This chapter investigates how the researcher can enhance student engagement amongst first-year Statistics students by applying the FC approach as a potential HIP and evaluating how technology can realise this aim. This is done by pursuing Objective one as indicated in Chapter 1 (see section 1.4), namely, to undertake a thorough literature study on the FC approach as a HIP for student engagement in HE and how technology is improving these attempts by answering the following research questions (see section 1.5.2):

- How does technology play a part in HIPs, and how does it influence undergraduate statistics students?
- How can the FC approach improve student engagement?
- What are the current perspectives on the FC approach and its relation to student engagement in Statistics Education?

The outcome of the first part of Chapter 3 is to provide perspectives from the literature on the use of technology tools in statistics education, and the second part of this chapter will consider the FC approach as a potential HIP to improve student engagement.

3.2 Technology in the classroom

Educational technology is defined by the learned authors Januszewski and Molenda (2013:1) as “the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources.” Technological resources can be viewed as devices such as mobile phones and laptops and includes computer programs, videos, DVD disks and players to name a few. “The pool of resources has expanded with technological

innovations and with the development of new understanding regarding how these technological tools might help guide learners" (Januszewski & Molenda 2013:11-12).

Until the late 1980s, a photocopier was the only form technology used to enhance student learning. Telephones were also seldomly used (Johnston 2013:263). Technology has rapidly changed our lifestyles and has become a helpful component everywhere. Computers, mobile phones, and the Internet have found their way into our classrooms. These new media instruments provide immense opportunities in terms of HE and pose challenges to enriching teaching-learning processes. These new media technologies include online courses, the flipped classroom concept, e-libraries, mobile applets (apps), and social media platforms like Facebook, Twitter, Instagram, WhatsApp, or YouTube (Rego 2017:1).

Although lecturers are a significant determinant in student learning (Davis 1993:793-794), students expect technology to be part of their learning experience (Malm & Defranco 2011-2012:404). Technology is not an add-on but must be embedded in the teaching framework (Tucker *et al*. 2017:49). By using technology, education can be reformed from memorisation (surface learning as discussed in section 2.5.2) to understanding knowledge and enhancing student learning.

OECD (2015:4) states, "technology can amplify great teaching, but great technology cannot replace poor teaching." Academics are also not always willing to adapt to these emerging practices (Johnson & Adams 2011:10) due to a lack of technical knowledge about technology's efficacy in improving student learning (Schindler *et al.* 2017:2). Disruptions like the #FeesMustFall (2016) protest or the pandemic outbreak of the coronavirus (2020) forced lecturers, however, to rethink these practices as a tool to complete the curriculum within a given timeframe (Czerniewicz *et al.* 2019:1).

According to Glazer (2012:1;11), university students lead blended lives as they access news online, do online banking, online shopping, find directions online, and

communicate through e-mails and social networks. We access the world via smartphones – so why not access education that way as well?

Forbes identified one of the top ten skills employers wanted in 2015 as “proficiency with computer software programs.” Therefore, according to Tucker *et al.* (2017:48), students must learn to use technology, work in a group, communicate effectively online, and find digital resources to solve problems. Online skills are often neglected in the traditional classroom.

When smartphones were first introduced on the market, pragmatists adopted these tools when they realised all the added benefits that are coupled with these devices. On the other hand, Conservatives only got a smartphone when flip phones were no longer available. Eventually, everyone utilises new technology at different times for different reasons. The same is true for blended learning. Pragmatists want to see how it will make their lives easier, be more efficient, and better engage students. They will prefer to grade activities online using the Learning Management System (LMS) instead of paper-based activities. On the other hand, conservatives are waiting until paper-based systems are no longer an option (Tucker *et al.* 2017:41,43).

If well implemented, blended learning environments can allow every student to experience the learning he or she needs. Still, it is a possibility, not a guarantee (Tucker *et al.* 2017:3-4). Furthermore, they claim that the other part of the equation is the intangibles, such as culture, mindset, and lecturers’ actual preparedness. The flexibility of blended learning may help students improve their time management, *e.g.,* family, work, or commuting (Glazer 2012:119). Therefore, it allows students to access learning whenever and wherever they prefer without going to university (Owston *et al*. 2006:502-514). “Access to learning resources anywhere, anytime, and in various formats” could promote deep learning and let students form their own knowledge (Abaido & El-Messiry 2016:2).

These blended learning designs reflect the best of both worlds as they enhance traditional face-to-face lecturing with engaging social technology (Adams Becker *et al.* 2017:18).

As is evident from the above, technology has become prevalent in learning among students in this digital era. Technology is available to all students regardless of whether they find themselves in a traditional face-to-face classroom setting or whether they are engaged in a flipped-classroom approach. However, it is important to note the distinct difference in this study between the two groups. The researcher implemented the use of technology in her variant of the FC approach by making use of pre-recorded video-lectures which is a technology resource that is not available to students in the traditional teaching approach but are only accessible to students in the FC group.

By implementing the FC approach, the researcher will attempt to shift the responsibility to learn to the students. All the video-lectures were simultaneously made available to students at the beginning of the semester and did the responsibility fall on the students to incrementally work through the content at their own pace. The FC approach differs from the traditional teaching approach in the sense that the students in the traditional group were to some extent held accountable by their lecturer by having to attend set weekly lectures and were they systematically guided through the course material week by week.

3.2.1 Principles of good practice with technology as a lever

Chickering and Ehrman (1996:1-7) adopted the seven principles of good practice (as discussed in section 2.4.2.1) to implement the new technology. These seven principles provide a cohesive framework for online instruction (Johnson 2014:48) and are as follows:

1. **Encouraging interaction between students and the lecturer.** Chickering and Ehrmann (1996:1-2) state that lecturer contact is one of the most important contributors to student motivation as it encourages independent learning

(Cobcroft *et al.* 2006:23-25). Chickering and Ehrmann (1996:1-2) further report that e-mails, video conferencing, Skype, and the World Wide Web facilitated student-lecturer communication effectively and speedily. Discussion forums like Blackboard Collaborate are also helpful in communicating with students (see section 3.3.5). Social media may also contribute to effective communication between students and lecturers (Mortagy & Boghikian-Whitby 2010:40; Kaliisa & Picard 2017:7). In China, educators use WeChat to facilitate student discussions and review assignments (Adams Becker 2017:20).

2. **Developing reciprocity and cooperation among students.** Computer-based tools encourage collaboration amongst students when they are not physically together (Chickering & Ehrmann 1996:2-3).

3. **Encouraging active learning**. Technology supports active learning and is most appropriate for self-motivated students who do not procrastinate (use as a prospective disadvantage because a lot of students procrastinate) (Koeckeritz *et al.* 2002:284-287; Estrada *et al.* 2019:2*)*. A weekly schedule must be provided for students to submit homework assignments at their own pace, but no later than the due date (Cates 1992:6).

4. **Prompt feedback.** Feedback can be provided through e-mails (Koeckeritz *et al.* 2002:285). Students receive immediate feedback when they do assessments online, as quizzes are graded automatically (Johnson 2014:45).

5. **Emphasising time on task.** Chickering and Ehrmann (1996:4) state that the online availability of resources could increase the available time by reducing commuting time. Internet, therefore, allows students to obtain more effective time management. Publishing the weekly timelines will enable students the flexibility to complete work faster; *e.g.,* a student expecting a baby can complete assignments in advance (Koeckeritz *et al.* 2002:285*).*

6. **Communicating high expectations.** Significant learning challenges must be set to drive students to acquire information and sharpen their cognitive skills of analysis, synthesis, application, and evaluation (Chickering & Ehrmann 1996:5).

7. **Respecting diverse talents and ways of learning.** The goal is to meet the students' needs with their varied learning styles, as discussed in Section 2.3 (Koeckeritz *et al.* 2002:286).

3.2.2 Skills needed for a student using technology

Tucker *et al*. (2017:97) report that for a student to use technology successfully, the following skills are imperative:

a) ability to take the initiative and work independently;
b) time management;
c) self-advocacy and resourcefulness in seeking help when needed;
d) ability to use digital tools provided; and
e) ability to comprehend and apply learning material presented through video and written instruction.

3.2.3 Technology-based strategies

Some examples of technology-based strategies that have become highly effective as tools in the learning process and thus engage students more actively with the course content are:

a) A **learning management system** (LMS) is a platform in which technology can be integrated into the curriculum to "give students and teachers more opportunities for communication, feedback, reflection, and revision" (Chance *et al*. 2007:3). It enables students and lecturers to access the learning portal from any location. LMSs can also be used for assessments, *e.g.,* online surveys and quizzes, giving instant scoring and feedback to students (Lumpkin *et al*. 2015:114-115). Therefore, it can be used for blended learning experiences (Malm & Defranco 2011-2012:403).

   The LMS is also used to monitor student participation and track student progress. The use of a university's provision of a LMS (Blackboard® is the platform at the UFS, which can even be viewed on cell phones, or Sakai, used

by the University of South Africa (UNISA) or Moodle) with supporting staff has encouraged and facilitated lecturers to use these instructional technologies. Malm and Defranco (2011-2012:401) state that there is almost no evidence to verify whether these strategies affect student learning. However, Turnbull, Chugh and Luck (2021:164) contradict the view of Malm and Defranco (2011) by affirming that LMSs are instrumental in facilitating and improving teaching and learning.

The researcher is inclined to agree with the learned authors Turnbull, Chugh and Luck (2021) instead of Malm and Defranco (2011). The researcher is of the opinion that implementing a LMS is a very useful tool to be used in student learning in both the FC and the traditional approach. A vast accumulation of information is encapsulated in one resource. The researcher has observed many benefits by making use of the UFS LMS - Blackboard®.

Blackboard® provides an effective and practical manner of communication between the researcher and all her students collectively. It provides a platform to post announcements, which additionally get communicated to all the students registered for the module by way of an email.

Several sources of information regarding the course material are uploaded to blackboard for access by all students. If a student needs to ascertain something regarding the course information, accessing blackboard as a first resort will be encouraged. The researcher's course guide containing all the practical aspects, rules and regulations in order to successfully complete the module, is uploaded. Numerous past papers are also uploaded on blackboard which students can work through and practice questions that have been assessed in the past. The past papers further enable students to get access to material that can assist them in additional preparation for assessments.

After this study was conducted, the video-lectures have also been uploaded on blackboard. The video-lectures have been uploaded in such a manner that does not require the student to use data to download or view the videos. This manner of uploading videos successfully accommodates students who face socio-economic challenges.

All the researcher's online tests and assignments are conducted on blackboard and do the students have to complete them there. Uploading the tests and assignments to blackboard allows for prompt feedback as the students can see their results immediately.

The researcher therefore believes that utilising a LMS has a substantial effect on learning.

b) Another strategy is carefully designed **PowerPoint slides**. Clark (2008:39) states that the key element in using these slides is that they are presentation tools that "increase and maintain student interest and attention to the lecture when combined with active teaching and student involvement." It can be uploaded on the LMS platform to be used by students to study (Debevec *et al*. 2006:304).

c) **Online discussion forums (blogs)**. Another use of a LMS is that students can be provided with blog prompts like Blackboard Collaborate. Bean (2011:209) refers to blogs as requiring "students to respond knowledgeably to some part of course content but then add their views and experiences." Student discussions using blogs have been shown to facilitate and enhance student learning (Cheng & Chau 2011:77). They also find that blogs help students construct knowledge at a higher collaborative level. Some students do not post questions but instead read others' posts. These students are referred to as lurkers as they prefer passive attention to overactive participation (Smith & Smith 2014:86). According to the literature, only a marginal percentage of students are active in online discussion groups (Gazit *et al.* 2018:1-2).

d) **Classroom response systems** (**CRSs**), like **clickers**, can also be used to discover students' opinions in debates or gauge their understanding of concepts. Clickers provide immediate feedback and stimulate critical thinking. It can also be used in large classrooms to encourage active learning and collaboration (Sevian & Robinson 2011:14-18).

Another tool of the CRSs is **Mentimeter,** a cloud-based solution that allows lecturers to engage and interact with students while teaching. It works similarly to clickers, but students use their phones or other devices to connect to the Internet. More than 25 million people worldwide already use Mentimeter for interactive presentations. A lecturer's PowerPoint presentation poses questions, followed by students who vote with their smartphones. The students, therefore, are engaged through interactive presentations. Mentimeter was recognised by Microsoft as the best User Interface (Office App Awards) in 2015 and received third place for the Most Business value in 2015 (Mentimeter 2019:4-5).

TurningPoint is another application that can be used to engage and assess learners by participating with their smartphones, tablets, or laptops instead of clickers (Speller 2018:1). Other applications, such as Prezi, Zeetings, Google Classroom, Socrative, Kahoot, etc., could also be used (McRae *et al.* 2017:12).

e) **Gamification** is still a very new concept in SA education. Marc Prensky introduced the term "digital game-based learning" in 2001 as a new learning paradigm (Prensky 2001:145). In 2008, the term "gamification" was first documented and entails implementing video games for educational purposes to ensure increased student engagement in a fun way (Olivier 2017:1). In addition, gamified elements, such as digital badges and leaderboards, may be integrated to motivate students to complete learning activities (Schindler *et al.* 2017:14). It can be implemented so that a student must first obtain 100% for a completed online tutorial, *i.e.,* more than one attempt, before being allowed to move up to the next level (following tutorial) (Cloete & Joynt 2019:14).

f) **Videos.** Hoover (2006:476-477) finds that video clips are learning devices, especially for first-year students who are visual learners, as students remember more of what they see than what they hear. Video lecturing is similar to the Khan Academy videos, a resource of thousands of educational videos and activities (Siegle 2014:51).

g) **Podcasts** (audio-only files synchronized with PowerPoint) and **Vodcasts** (audio-video files synchronized with PowerPoint) can be made of classroom sessions and then posted on an LMS (Johnston 2013:269). Lloyd and Robertson (2012:67) demonstrated that vodcasts "are an effective and efficient tool for enhancing student learning." At the same time, Ng'ambi and Lombe (2012:187) reported that podcasts enabled students to understand the material better as they reviewed it at their own pace.

h) **YouTube** is a popular video-sharing site that can engage students in their learning and support their digital learning style (Bonk 2008:22). Videos can be uploaded here for low data usage, and they can be set so that only registered students can view the videos.

i) **Social networking systems (SNSs)** like Facebook, Twitter, Instagram, WhatsApp, or Telegram also hold significant educational advantages. This social element is a lucrative business for those in the technology industry. While the primary use of SNSs is to socialise and recreation, an increasing number of students use these systems for academic purposes to collaborate (Johnston 2013:265).

The use of WhatsApp is increasing exponentially in our mobile-dominated context and can be used to foster a connection between students and lecturers (Ng'ambi et al. 2016:10). Therefore, the students' phones should be used as tools rather than the enemy of student success (Smith 2017:15). Students value the convenience provided by online learning materials and submission of assignments online; however, they also prefer the presence of an academic (Oblinger & Oblinger 2005: 2.11).

Smit and Du Plessis (2013:336-339) also determined that the different messaging platforms in education could increase learning and improve student interaction because they could "get instant answers to urgent questions." WhatsApp is inexpensive, easily accessible and allows for prompt feedback (Madge *et al*. 2019:272-273). Furthermore, it eliminates social barriers (Doering *et al.* 2008:9), increases students' motivation, and improves their reading skills (Plana *et al.* 2013:82-84).

A study found that WhatsApp creates a more engaging environment for students. The study also showed that class WhatsApp groups encourage intimacy within teaching and learning. Intimacy creates opportunities for "students to open up and ask questions on lessons they may have never asked in the usual classroom setting." The study further proved that WhatsApp promotes intimacy among students and lecturers and between students (Ujakpa *et al.* 2018:4).

Hertzog and Swart (2018:103) conducted a study that found that WhatsApp promoted engagement between the student and lecturer. Another conclusion of the study was that WhatsApp facilitates easy communication between the student and lecturer (Hertzog & Swart 2018:103).

A further study indicated that WhatsApp is a positive atmosphere for learning which supports academic growth (Annamalai 2019:10). It was found that students prefer WhatsApp "as a platform to interact" (Annamalai 2019:12). Another finding of this study was that WhatsApp served as a tool for students to take responsibility for their own learning (Annamalai 2019:14). This finding is in line with the previously mentioned study conducted by Ujakpa *et al.* (2018) who declared that Whatsapp creates room for students to engage in a more comfortable environment.

Another study discovered that WhatsApp contributed to 21st century learning skills since it champions collaborative and independent learning, and it enables students to learn anywhere and everywhere (Maphosa *et al.* 2020:90).

j) **Videoconferencing** is a virtual meeting space where technology enables the "delivery" of traditional face-to-face lectures to a remote audience with features like whiteboards, digital pens for presentations, videos, etc. (Schindler *et al.* 2017:7). Transmitting the lectures could also be done to accommodate large classrooms. Furthermore, the audience can access expert lecturers unavailable locally, like distance education (Lawson & Comber 2014:70). UNISA uses videoconferencing. However, Lawson and Comber (2014:70) refer to it as an "orphan" technology because it is not widely used as the equipment and maintenance thereof are expensive.

3.2.4 Advantages of using technology in the classroom

Kuh and Vesper (2001:95) report that students in a virtual classroom more often outscored those students that did not use computers as often. It was also found that the Internet connectivity, or the “wired campus” model as referred to by Hu and Kuh (2001:11-12), provided benefits to student engagement in some of the educational practices and improved motivation (Ruggiero & Mong 2015:173).

Forte (1995:205) and Meletiou-Mavrotheris *et al*. (2007:75) believe that using technology in statistics instruction improves students’ attitudes toward statistics. The use of technology can also counter learning disabilities such as dyscalculia, a mathematical disorder, a perception for some learners of numbers, as is the perception of letters for dyslexic learners (Laurillard 2008:20). Therefore, technology also meets students’ needs with different learning styles (Boyce 1999:200-201; Bonner 1999:12-13). It can also support students experiencing difficulties learning a different language than their mother tongue (Jaffer *et al*. 2007:131).

Another benefit of using technology is moving towards a paperless classroom, as the interaction occurs via e-mail or social media (Ruggiero & Mong 2015:171).

3.2.5 Disadvantages of using technology in the classroom

There is resistance and a lack of commitment by lecturers to change to technological innovations as ample time must be invested to integrate into information and communication technologies (ICTs) and online learning activities (Van der Merwe & Mouton 2005:22-25; Kaliisa & Picard 2017:8). There is also an underlying belief that students will quickly embrace the study and learning approaches involving technology. According to Dalstrom and Bishel (2014:34), this has not been the case because students prefer more traditional lecturing. However, the increasing use of technology will require students to change their studying methods (Miles & Foggett 2016:3).

Universities have assumed that students are skilled in technology, but this statement is not entirely accurate (Gosper *et al.* 2013:273). A study by Czerniewicz and Brown (2012:47) determined that nearly all students have cell phones, a form of technology. Still, they did not value it as a learning tool but instead used it as a communication method for social purposes. McLean and White (2009:345) found that students spent more time downloading music and videos than knowing how the technology works.

Case studies on student experiences done by Holley and Oliver (2010:699) showed that students from diverse backgrounds bring different levels of engagement with online technologies. Therefore, student engagement is more difficult for underprivileged students. It is thus crucial to educate students on how to effectively use online learning platforms and activities that are new to them.

One cannot assume that "technology plus students equals engagement" (Bond *et al.* 2020:4). It should be kept in mind that technology can result in disengagement if not applied appropriately. Educators are thus urged to ensure that students obtain sufficient and continuous training for the technology to be used (Bond *et al.* 2020:24).

Additionally, students need access to devices and data to engage effectively with educational technology. DHET, five months into the national lockdown in SA in 2020, explored students' experiences since most HE institutions managed to implement some form of remote learning. Interestingly, responding to how many devices they own to engage with their studies, 96% of the students indicated that they owned a device. Of those who owned devices, 89% owned smartphones, while 60% owned laptops (DHET 2020:23).

The researcher acknowledged this challenge, and did she thus create an explanatory video that served as a step for step guide on how to successfully view the videos and navigate the PowerPoint application. As was found in the study above, most students do have access to devices upon which the video-lectures could be viewed. In the unfortunate event that a student does not have a device,

on-campus resources in the computer labs could be utilized and thus nobody would be excluded from accessing the videos.

Other reported challenges of virtual learning include access to technology, network failures, power shortages, lack of internet connectivity, internet bandwidth, data costs, accessing campus wifi, shortage of devices and that audio files use too much data (Bond & Bedenlier 2019:5; Kaliisa & Picard 2017:8; Hertzog & Swart 2018:103; Dube 2020:144-145).

3.3 Theorists of learning

In Section 2.3, the researcher reviewed how students learn. Different learning theorists are subsequently considered, and each highlights essential insights into the learning process (Laurillard 2012:59).

3.3.1 Edgar Dales' cone of learning

A very accurate saying of the wise Chinese philosopher, Confucius, comes to mind when considering Edgar Dales' cone of learning:

> *I see, and I forget. I hear, and I remember. I do, and I understand.*

In the 1960s, Edgar Dale theorised that learners retain more information by what they "do" than what they "hear" or "see" and identified a range of possibilities. This "learning by doing" is called "experiential learning" (as discussed in section 2.3.3) or "action learning." His research led to the Cone of Experience (Anderson 2011:44). An unknown person(s) imposed the retention figures (*i.e.,* the percentages of what people remember) on the cone. It dates to the early 1900s or before, but no empirical research was done to prove those mythical percentages (Subramony *et al*. 2014:8,12,15). This author's cone of learning is graphically illustrated in Figure 3.1.

According to Dale's (1969) research, the least effective model for learning is passive learning, and is at the top of his cone, where information is gained through verbal symbols. Here, learners tend to remember 10% of what they read, 20% of what they hear, and 30% of what they see. They are thus spectators rather than participants (Seels 1997:358). The next level on the cone is where visual symbols are part of the passive learning process, and students tend to remember 50% of what they hear and see, *e.g.,* watching a demonstration or looking at an exhibit (Dale 1969:108).

As you move further down the cone, learning improves and so to the retention of information. According to Dale (1969), 70% of what students say will be remembered, *e.g.,* when they participate in discussions or give a talk. This is defined as active learning.

At the bottom of the cone is the most effective learning model, active learning, where direct, purposeful learning occurs, and it is the best mode for the desired outcomes in a teaching-learning process (Mayhew *et al.* 2016:3,6). Therefore, when an instructional method is chosen, it is essential to remember that it strengthens knowledge retention when students are involved in the process (Anderson 2011:45) since action-learning results in 90% retention of what students are both saying and doing, *e.g*., doing a dramatic presentation or simulating the real experience.

This approach of learning is immensely important in a HE subject such as statistics due to the fact that student success will depend largely on the students actually taking the time to practice different concepts and questions. A student cannot excel by merely reading the course content or just listening to the lectures. The researcher attempts to promote this approach by assessing her students on a weekly basis which promotes active learning.

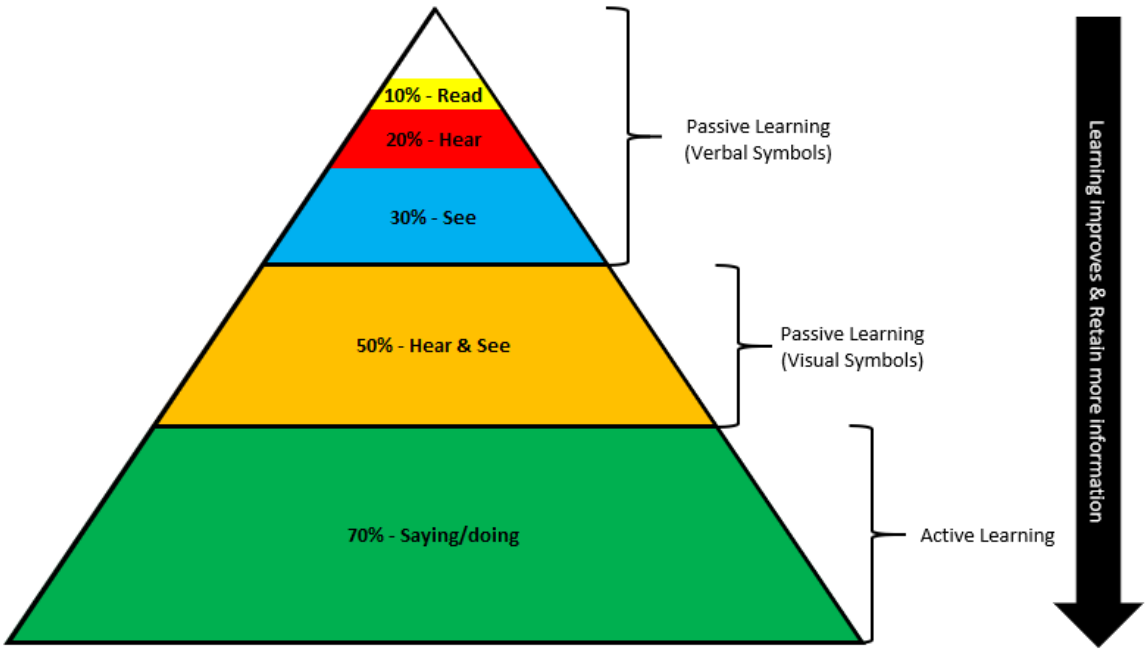


Figure 3.1: Dale's Cone of Learning

3.3.2 Mayer's theory of multimedia learning (CTML)

Cognitive scientists seek to understand mental processes such as perceiving, thinking, remembering, understanding language, and learning (Stillings *et al.* 1995:1). Therefore, cognitive science can provide insight into human nature (Sorden 2012:2). For thousands of years, spoken words have been the dominant form of instruction and printed words for the last few hundred years. Due to technological advances, pictorial instructions are more frequently available (Mayer 2001:31).

Some current multimedia forms were unavailable to lecturers when Dale proposed his notion of learning in 1969 (as discussed in Section 3.3.1) (Ausburn & Ausburn 2008:63). Some aspects of the original cone are not as relevant in a computer-based environment as when developed (Baukul *et al.* 2013:16). According to Richey (*et al.* 2011:86), the Cone can easily be updated to include modern technology to enhance learning. Dale's cone levels are consistent with Mayer's CTML discussed hereafter (Baukal *et al*. 2013:19).

Mayer and other researchers argue that multimedia supports how the human brain learns and popularises multimedia learning's cognitive theory. They assert that people learn more deeply from words and pictures than words alone, also referred to as the multimedia principle. Multimedia combines words and images that encourage deep learning (as discussed in section 1.2.1). The words can be spoken or written, and the images can be visual imagery like illustrations, photos, animations, or videos (Mayer 2003:127-128).

Mayer (2003:129-130) reports that the learner engages in three cognitive processes in multimedia learning. The processes mentioned hereafter occur iteratively and not one after the other (Mayer 2003:130):

1. The **selection** process requires obtaining information simultaneously processed through auditory (ears) and visual (eyes) channels. In a computer-based environment, the external representations may include spoken words, which enter through the ears, and animations through the eyes. In a book-based climate, the external descriptions may consist of printed words and illustrations, both of which enter through the eyes.

2. The **organising** process builds a coherent mental representation of selected words into a verbal model and chosen images into a pictorial model.

3. The **integrating** process is where the verbal and pictorial representations connect with prior knowledge (Sorden 2012:5).

Mayer states that there are also five forms of representation of words and pictures that occur as information is processed by memory:

1. The first form of representation is the words and images in the multimedia presentation itself.

2. The second form is sensory memory's sounds (ears) and images (eyes). Sweller (2005:29-30) defines sensory memory as the cognitive structure that allows us to perceive new information through holding pictures and printed text as visual images and auditory memory as spoken words and sounds as auditory images.

Schnotz (2013:11) pointed out that other sensory channels can introduce information to working memory, such as “reading” with the fingers through Braille or a deaf person being able to “hear” by reading lips.

3. The third form is the sounds and images in working memory, *i.e.,* the cognitive structure in which we consciously process information.

4. The fourth form of representation is the verbal and pictorial models in the working memory.

5. The fifth form is prior knowledge, stored in long-term memory, the cognitive structure that stores our knowledge base for an indefinite time (Mayer 2003:4).

When active learning occurs, the outcome is seen as a long-term memory that allows the learner to use it to solve problems (Mayer 2003:130). We are only conscious of information in long-term memory after it has been transferred from working memory. Learning is hindered when a cognitive overload occurs and working memory is exceeded (De Jong 2010:118).

Mayer (2009:183-195) reminded us that while designing multimedia lessons according to his CTML, it is essential to note that the multimedia instructional methods are learner-centered and not technology-centered. Technology should enhance learning, not become lecturing. The teacher behind the technology makes the technology powerful (Fulgham & Roberts 2017:19). Mayer (2003:137) reported that media environments do not cause learning but rather the learner’s cognitive processing that causes learning.

The researcher supports Mayer’s notion of CTML and is the aim of this research not to replace the lecturer but to shift the responsibility to learn to students. Whenever a student faces difficulty regarding the course, the lecturer will assist students whenever they need guidance.

3.3.3 Bloom's Taxonomy

In the 1950s, Benjamin Bloom and his colleagues developed a taxonomy of educational objectives through which lecturers could understand students' learning (Krathwohl 2002:212). In a typical face-to-face lecture, the emphasis is placed on the cognitive domain's lower level, namely knowledge, comprehension, and application. However, when students leave a class and attempt homework problems independently, they need to engage in higher-level analysis, synthesis, and evaluation skills without the support of their peers and the lecturer. This learning process is illustrated as follows:

> Before we can **understand** a concept, we must **remember** it;
> Before we can **apply** the idea**,** we must first **understand** it;
> Before we **analyse** it, we must be able to **apply** it;
> Before we can **evaluate** its impact, we must **analyse;** and
> Before we can **create,** we must have **remembered, understood, applied, analysed,** and **evaluated.**

According to Bloom, great emphasis must be on "…problem-solving, applying principles, analytical skills, and creativity. Such higher mental processes are emphasized because learning enables individuals to relate their learning to the many problems they encounter daily. These abilities are stressed because they are retained and utilised long after the individual has forgotten the detailed specifics of the subject matter taught in the schools…." (Bloom 1978:578).

Remembering is defined as the retrieving, recalling, or recognising knowledge of previously learned material from long-term memory (Anderson & Krathwohl 2001:66). Understanding is where the meaning is constructed from instructional messages, including oral, written, and graphic communication (Anderson & Kratwohl 2001:31). Application refers to situations where students must demonstrate their ability to use learned material through presentations, role play, scrapbooking, interviews, puzzles, simulations, animations, etc. (Wedlock & Growe 2017:34). Analysis happens when the material is broken up into various

components to determine how they relate to one another and differentiate between relevant and irrelevant. It may involve the ability to draw conclusions from data or explain a given statement. Evaluating is where judgements are made based on criteria or standards through checking and critiquing. Creating is the highest in the hierarchy because it is where elements of all categories form a coherent whole (Truschel 2015:6).

The researcher is of the view that Bloom's taxonomy is essential in HE statistics. A student needs to understand what they have studied to be able to apply what it and effectively recall such knowledge. This approach encourages deep learning which yields higher outcomes.

3.3.4 Laurillard's Conversational Framework (LCF)

What it takes to learn has not changed. However, how we motivate and enable learning does change (Laurillard 2012:93). Laurillard's Conversational Framework (LCF) is based on the concept that teaching is not merely an action imposed on students but a means of mediating their learning by interactively discussing and practicing the target structure (Laurillard 1999:114; Alshwiah 2016:43). The LCF is the only model that explicitly integrates technology-based resources into the teaching and learning activities to engage students effectively (Laurillard 2012:96). Laurillard argues that students need various learning activities to understand knowledge in a specific subject, which will lead to deep learning. She explains how different media forms optimally support different activities but states that the various events occur in different configurations at different times. None of the events or media forms are better than any other (Czerniewicz & Brown 2005:4). According to Laurillard, a good lecturer will use all the learning types she defined to continually prompt learners to generate and modulate their concepts and practice.

The LCF is based on Pask's (1976) Conversation Theory, which states that "learning is a conversation" between lecturer and student and between students themselves. This theory is like the approaches of Piaget (1976) and Vygotsky (1978) mentioned earlier (Pask 1976:13). According to Pask (1976), the conversation is

not merely an exchange of knowledge but is also a process of “becoming informed about each other’s informings” (Sharples *et al.* 2007:224; Pask 1976:14).

The LCF can be summarised in the following three communication cycles:

1. The **teacher-communication cycle** is where the lecturer orally expresses the concepts of the task that must be learned, and a student then asks a question or articulates his conceptualisation. The teacher and learner engage in an iterative process to challenge each other’s ideas until students finally understand (Laurillard 2012:89). Laurillard (2012:96) identifies three learning types within this cycle. Firstly, students need **acquisition** where learning occurs through reading books or websites, listening to lectures or a podcast, or watching video-lectures, PowerPoint slides, or YouTube videos (Czerniewicz & Brown 2005:5). This domain represents the lowest level of learning in the cognitive domain (Truschel 2015:5). Secondly, **inquiry** occurs where students learn by exploring resources, *i.e.,* learning through investigation. Non-digital-based activities can be like going to libraries, museums, or galleries. Nowadays, students search for information digitally (Czerniewicz & Brown 2005:5). Thirdly, **production** occurs when the lecturer motivates students to apply what they have learned.

2. The **teacher-practice/modelling cycle** is where the lecturer designs appropriate tasks to help learners achieve their goals. The most common way is for students to submit online assignments on the LMS platform, where automated feedback is given (Holmberg 2016:9). Here, the fourth learning type, according to Laurillard, known as **practice,** is applied where the students “reflect” and share their ideas with peers or the lecturer and may modify and improve their practice after receiving feedback (Alshwiah 2016:47).

3. In the **peer-communication/practice/modelling** cycle, students communicate with their fellow students outside the classroom using their mobile phones or a computer. Here, the learning type, **collaboration,** is used when students engage in interactive group discussions regarding problems they may experience regarding solving assignments. Collaboration is integral

to the learning process, but students do not have to collaborate to learn. In some forms, collaboration is an element of Bloom's; in others, it is just a mechanism that can facilitate higher-order thinking and learning (Churches 2008:2,5). Students can also ask the teacher questions via e-mail, WhatsApp, or a blog on the LMS platform (Holmberg 2016:5,8-10).

This approach is central to this study and is this research aimed at integrating video-lectures as a technology-based resources into teaching and learning activities to engage students effectively. This study is essentially aimed at investigating the success of this approach.

3.4 Flipping the classroom

3.4.1 What is a flipped classroom?

In the past few years, there has been an increasing use and interest in this new educational paradigm known as flipping the classroom (FC approach) (McLaughlin *et al.* 2015:1). It has its foundations in the social constructivist learning theory, as discussed in section 2.3.6. (Jarvis *et al.* 2014:5). This inverted classroom is based on an approach that got a foothold in the educational sector since 2000. This study was the first to introduce employing multimedia and the internet as a substitute for lecturers. It was defined as "events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (Lage *et al*. 2000:32).

Abeysekera and Dawson (2014:3) defined the FC approach as "a set of pedagogical approaches that move information-transmission teaching out of class, use class time for active and social learning and require students to complete pre- or post-class activities to benefit from in-class work fully." This concept provides students with engaging self-paced learning opportunities to learn more than traditional teaching (Kuh & Vesper 2001:87). Students hardly participate in traditional classes and are passive and disengaged learners, especially in large classes (Steen-Utheim & Foldnes 2017:308).

Large classrooms in HE are currently the reality. One of the difficulties is monitoring which students understand the different concepts. The lecturer usually teaches the stronger students, who are generally the more vocal students. The stronger students get frustrated if the lecturer must re-explain a concept to the weaker students (Hornsby *et al.* 2013:64,73). Another problem experienced in large classes is that lecturers do not always notice students with disabilities like partially sighted, hearing impairments, or any other form of an invisible disability (Van Jaarsveldt & Ndeya-Ndereya 2015:6).

Goodwin and Miller (2013:80) claim that it is not just the classroom that has to be transformed but also the entire teaching paradigm. There is no single way to flip a classroom (Siegle 2014:51; Bergman & Sams 2012:11). It should preferably be a model where lecturers are coaches who carefully observe students and guide them to higher levels of learning. Through this inverse instruction methodology, the delivery of course content is made possible in most cases with technological innovations such as recorded video-lectures (Steen-Utheim & Foldnes 2017:1). The instructional tools can be in various media formats such as podcasts, textbook reading, PowerPoint slides, or YouTube videos. These activities enable students to retain, understand and transfer more information instead of “read,” “listening,” or “observing,” as Dale (1969) proposed (Estrada *et al*. 2019:2).

Active learning activities, such as online quizzes, must be completed after viewing the videos (Baker 2000:13; Wilson 2013:194). Students do not engage spontaneously in active learning; they must be encouraged through incentives (King 1993:31; Baker 2000:13; Wilson 2013:194).

This control over time, place, and pace with digital technologies creates opportunities for millennial students to take responsibility for their learning (Hamdan *et al*. 2013:10). Students discover topics in greater depth and are challenged to obtain higher-order thinking skills. It gives students control over the “remote” (Bergman & Sams 2012:23-24).

Dixson (2010:7-9) categorized online learning activities as active (online discussions, online activities, problem-solving activities, group projects) and passive (test-taking, reading, watching lecture videos) and found no significant differences in student engagement levels among these activities. She concluded that not the activity type but the interaction provided in online courses affected student engagement.

Students are doing lower cognitive work levels (*i.e.,* remembering and understanding) outside class. Higher levels of cognitive work (*i.e.,* application, analysis, evaluation, and creation) occur in a class where they support their peers and lecturers that promote deeper learning. This is related to Bloom's taxonomy (Brame 2015:1).

Literature generally gives a positive perception of the FC approach for different educational levels and disciplines (Calik *et al*. 2015:455; Sowa & Thorsen 2015:26.175.13; Long *et al*. 2016:248). However, some researchers found no significant improvement in final exam scores when comparing the FC approach with traditional teaching (Whillier & Lystad 2015:130; Lape *et al.* 2014:24.1006.8). According to current literature, there are more positives than negatives (Cheah & Sale 2017:2).

3.4.2 Brief comparison between the original FC approach and the researcher's variant of the FC approach:

The FC approach inverts traditional face-to-face lecturing associated with students taking up a passive role to that of self-study, where students spend time outside class using technology to study new work. This paradigm typically entails those students engaging with the content before attending a face-to-face class, say by viewing video-recorded lectures at their own pace. This form of the FC approach can be classified as the original FC approach generally used. In other words, after the students have independently worked through the study material, they are to attend a traditional face-to-face classes in order to discuss the said study material.

A variant of the FC approach was used by the researcher due to the fact that the researcher's approach to a flipped classroom differs ever so slightly from the original FC approach. The researcher generated video-lectures which required the students to go through the study material independently at their own pace. The significant difference between the researcher's FC approach as opposed to its original form is that after the students have watched the videos, no face-to-face class occurred in which the study material was discussed. If the students struggled with certain concepts or chapters, then they were encouraged to approach the lecturer either by way of technology (email or WhatsApp messages) or face-to-face by arranging consultations with the lecturer or attending the weekly practical session.

Table 3.1: Comparison between the FC-Approach and the Traditional Approach in this study

Learning Types	Group A: FC-Approach	Group B: Traditional Approach
Acquisition of course content	Watch video-lectures outside the class	Listening to the lecturer during the class
When new material was introduced to students	All content made available to students simultaneously at beginning of semester	Study material was divided as presented by lecturer week for week throughout the semester
Explore resources (Learning through inquiry)	Outside the class	During the class & outside the class
Apply + Practice (Learning through doing)	Submit weekly online quizzes outside the class	Submit weekly online quizzes outside the class
Collaboration	Inside the class with lecturer & peers Outside the class with WhatsApp & e-mail	Outside the class using technology such as WhatsApp & e-mail with fellow peers & lecturer
Responsibility and Energy	Student-centred	Lecturer-centred

3.4.3 The four pillars implied by the acronym "FLIP."

Talbert (2014a:14) and Hamdan *et al.* (2013:5) define the four "pillars" of the practice that represent the acronym F-L-I-P (the FC approach) as follows:

(i) The first pillar is where the FC approach requires a **"F**lexible and adaptable environment**".** Lecturers can choose from various learning modes involving group work, research, and evaluation and encourage collaboration. Collaboration increases when students interact and explain things to each other. Some may grasp quicker than others and function as peer tutors (Bergman & Sams 2012:27). Therefore, it can be a more productive way to teach large class loads (Berrett 2012:2).

The flexibility of the FC approach assists students in managing their time efficiently (Bergman & Sams 2012:22). Some students prefer studying by viewing videos instead of attending traditional classes (Neshyba 2013:10). Lecturers often speak too fast, and some students fall behind (Bergman & Sams 2012:24).

Videos are also available to students who missed classes due to illness, sports tours, or other reasons like protests or pandemic outbreaks (Bergman & Sams 2012:3). It also helps students with a language barrier or other disabilities because students can watch, rewind, or fast-forward as many times as needed (Educause Learning Initiative 2012:2; Bergman & Sams 2012:23). Therefore, it is not limited to particular learners, a specific curriculum, or content (Bergman & Sams 2012:23-24). Another critical aspect of the FC approach is its ability to appeal to many learning styles, as described in Section 2.3.

(ii) The second pillar is where the FC approach requires a shift in **"L**earning culture**."** In the traditional face-to-face class, the lecturer is the primary source of information, *i.e.,* the sole expert who provides information to the students (King 1993:30). In the FC approach, the paradigm is deliberately shifted from a teacher-centered classroom to a student-centered one, where in-class time is meant to explore topics in greater depth. The FC approach emphasises students as the center of learning, not the lecturer as the lead act on stage. Instead, the lecturer is a facilitator in the background (Siegle 2014:51; Bergman & Sams 2012:14).

(iii) The third pillar is where the FC approach requires **"I**ntentional content**."** Active learning is associated with improved student academic performance (Hake 1998:71; Knight & Wood 2005:304; Michael 2006:165; Freeman *et al.* 2007:139), increased student engagement, and better attitudes towards learning (O'Dowd & Aguilar-Roca 2009:122). Research suggests that students who complete pre-class assignments are more likely to engage in active learning during class and perform better on assessments directly aligned with desired learning outcomes (McLaughlin *et al.* 2015:1;5-6). Thus, the FC approach cultivates confident, motivated, competent problem solvers who can solve new problems independently. Therefore, it encourages deep learning, ensuring a better understanding of the subject content and leading to higher student grades (Talbert 2014b:14).

(iv) The last pillar is perhaps the most crucial pillar where the FC approach requires **"P**rofessional educators,**"** even though their role "is less visibly prominent." It is a misguided concept by some critics that flipped learning through videos will eventually replace the lecturer. Skilled and professional lecturers are more crucial than ever and often more demanding than traditional face-to-face lecturers.

3.4.4 How flipping the classroom can enhance student engagement

Student engagement entails avenues by which students develop into active partners in forming their learning experience and creating their individual learning agendas (Burke & Fedorek 2017:13). The primary objective of active learning is to promote deep learning (Mayer, 2004 in Burke & Fedorek 2017:12).

It has been proven that the flipped classroom enhances student engagement and results in a greater understanding of the study material. As described earlier, the course content is provided to the student by way of video or any form of online lectures and they work through them at their own time and pace. In this manner the student acquires knowledge about the foundational concepts and theories outside

of class. This allows for available class time to be used for problem-solving, “application and knowledge building,” and for lecturers to devote “face-to-face time to strengthen the application of advanced concepts through active learning through collaboration.” It has been noted that students who receive their content in this manner, show a deeper understanding of the work (Bergmann and Sams, 2012 in Burke & Fedorek 2017:11-12).

The essence of the flipped classroom is active learning. It has been said that students “learn best when they are actively engaged in the learning process (Bradford, 2005 in Burke & Fedorek 2017:12). Active learning can be linked to increased student motivation and confidence as well as enhanced critical thinking skills (Machemer & Crawford, 2007 in Burke & Fedorek 2017:12). Active learning necessitates a lecturer to implement a learning-focused paradigm instead of a teaching-focused paradigm (Roehl *et al.,* 2013 in Burke & Fedorek 2017:12).

Constructivism is the epitome of active learning (Cannon & Newble, 2000 in Burke & Fedorek 2017:12). Flipping the classroom demands students to go through the learning material instead of passively absorbing the content which is being supplied to them by the lecturer (Burke & Fedorek 2017:12).

Student engagement increases when students collaborate with their peers in solving problems, and as a result, deep learning is attained (Light, 2001 in Burke & Fedorek 2017:12). Collaborative learning significantly contributes towards student engagement (Popkess & McDaniel, 2004 in Burke & Fedorek 2017:12).

Active collaboration among students within the flipped classroom results in deeper learning, improved confidence, and better achievement (Bond & Bedenlier 2019:6-7; Lee 2018:853).

Flipped classrooms exhibit numerous degrees of positive effects on teaching and learning (Lee 2018:852). In a study conducted by Lee (2018), students responded positively to the flipped learning approach. A flipped classroom fosters student-

centered learning without being concerned about missing essential material since video-lectures are employed.

The flipped classroom creates the opportunity to minimise the achievement gap between students with different academic capabilities by utilizing video lectures and "personalization of learning in the classroom" (Lee 2018:853). Flipping the classroom in which students watch video-lectures at home and receive individual assistance from lecturers and peers in class, can equip disadvantaged students with personalized support.

It must be borne in mind that within this variant of the FC approach, the video lectures "are not a pedagogical practice per se, but more of an educational tool. In other words, although the technology itself does not define a flipped classroom, it has a number of inherent benefits" (Lee 2018:853). Technology alone cannot result in student engagement. The determining factor thereof is found in the appropriate amalgamation of technology and pedagogy, thus, the educator acts as an essential contributor in promoting student engagement (Teng & Wang 2021:2).

The study that Lee (2018:853) conducted indicated that video lectures can assist underperforming students and encourage lecturer-student and student-student collaboration. Although technology might not be the solution, it can be a part thereof if utilised properly.

3.4.5 The philosophy of the FC approach

Why would lecturers flip their classes? Within the answer lies the philosophy of the flip. Firstly, the FC approach allows for the most optimal use of a lecturer's face-to-face time with their students (Strelan *et al.* 2020:2). Lecturers can spend time assisting students who require their help and students can help each other to work out complex problems instead of struggling on their own (Nwosisi *et al.* 2016:348).

Secondly, we cannot escape the reality that the education marketplace is constantly evolving. Therefore, lecturers have to adapt to meet their ever-changing demands.

Universities frequently face disruptions, such as students who protest or pandemic outbreaks like COVID-19. Students often miss lectures dealing with core concepts when they register late, generally due to a lack of funding or simply when they do not attend class due to other obligations or a lack of motivation. Students, therefore, automatically fall behind and are responsible to try and catch up by themselves. This was the greatest motivating factor for the researcher to flip her class. Students are in need of flexible education delivery, which will facilitate the above-mentioned hindrances and better meet their needs (Clarke, 2015 in Strelan *et al.* 2020:2).

The researcher's personal teaching philosophy is grounded in the phenomenon that learning is the goal and "teaching is not successful unless all learners learn" (Killen 2004:189). Thus the researcher's main responsibility as a lecturer is "to facilitate learning by creating a supportive learning environment in which each learner can engage with the subject matter in meaningful ways and to an appropriately high level of academic rigour" (Killen 2004:189).

The researcher intends to investigate whether flipping her classroom will help solve some of the social problems our country is facing and at the same time whether it will benefit her students by increasing their engagement and subsequently lead to better student success.

3.4.6 The disadvantages of the flipped classroom

There is no guarantee that students will participate; therefore, the FC approach depends on student willingness. Some students also dislike this approach because they still prefer traditional face-to-face lecturing (Mangan 2013:7,9; Roehl *et al*. 2013:48; Estrada *et al.* 2019:3). Students who come to university expecting traditional face-to-face lecturing, and must use the FC approach, may be dissatisfied with this alternative teaching strategy (Miles & Foggett 2016:4).

Students' concern about the FC approach is that the same activities in a traditional class are not all present in the FC approach (Lape *et al.* 2014:24.1006.15). In face-to-face contact sessions, lecturers can receive direct feedback by observing

students' expressions to see whether they understand the lecture. The lecturers are not present with videos, which means that they cannot follow the student's body language (K-12 Teachers Alliance 2015:2) and the "blank stare" (Wilson 2017:13).

Lecturers will initially have to spend more preparation time creating videos and online assignments (Educause Learning Initiative 2012:2).

What follows is a description of the methods used in Chapter 4, the analysis of the different data in Chapter 5, and a review of the conclusions, limitations, and implications of this research in Chapter 6.

4. Research design and methodology

4.1 Introduction

After completing a review of the literature, this chapter endeavours to pursue the following objectives, as indicated in Chapter 1 (see section 1.4), namely:

- To gather information on the experiences and perceptions of students during the FC approach, utilising questionnaires, and interviews; and
- To analyse first-year Statistics students' assignments, tests, and examination scores regarding their academic performance.

4.2 Research design and methodology

The following sections describe the research design and methodology and provide an overview of the data collection methods employed in this study.

4.2.1 Research design

The researcher used a mixed method experimental research approach, utilizing both quantitative and qualitative methods to address the research objectives. The following three characteristics distinguish an experiment design from other designs:

1. Manipulation takes place because some participants receive a treatment (intervention).

2. There is control in that some participants do not receive the treatment.

3. Randomisation is used to assign the participants to different groups (Maree 2014:149). The purpose of random assignment in this method was to reasonably minimise any differences between the groups that could account for results, minimise any biased responses between the groups, and ensure validity, reliability, and fairness (McMillan & Schumacher 2006:268-274). Strayer

(2012:189) found that he could not generalise about the population because he lacked random assignment.

A randomised experimental design was applied for this research, namely a **randomised pre-test - post-test control experiment**.

The experiment for this research involved an experimental (treatment) group and a control (comparison) group, in which the control group received no new treatment (McMillan & Schumacher 2006:257,267). In the pre-test of the experiment, the participants were first compared according to their final Grade 12 Mathematics scores. After that, only the experimental group received the treatment (the FC approach), and then both groups were again measured on the dependent variable (a post-test). The students' final marks were considered the post-test scores. All students who registered for this course were considered, even those that disappeared midway through the semester. This design examined the treatment's effectiveness (the FC approach) by comparing the differences between both groups' pre-and post-test scores (Maree 2014:150).

4.2.2 Selection of research participants for the experiment

This study comprised all the Extended Curriculum Programme (ECP) students registered for a first-year statistics course at the South Campus (200 students) of the UFS. One of this campus's primary roles is to draw students who did not meet the initial admission requirements in HE. These extended programmes enable learners to enter the mainstream curriculum after completing the South Campus's preparation courses. All these students were invited to be part of the study in the second semester of 2017. When inviting them, the FC approach was explained, and they were also assured that they could leave at any time without any repercussions if they were not satisfied with the FC approach. Students interested in this research had to sign a consent letter (see Appendix A) before the commencement of the study. By signing, they gave informed permission to be part of the study. This study was granted ethical clearance by the Faculty of Education, UFS (see Appendix D)

and approval from the UFS authorities for the participation of students/staff in research projects (see Appendix E).

The interested parties were then randomly divided into Group A (the experimental group), where the FC approach was applied. Group B (the control group) received traditional face-to-face lecturing. Each group consisted of 67 students (since only 134 students signed consent letters). Group B students could not join Group A, and they had to sign an attendance list at each lecture to ensure that Group A students would not attend the traditional classes. The students who did not sign a consent letter joined Group B but were not part of the study.

The data collection process can be graphically illustrated as:

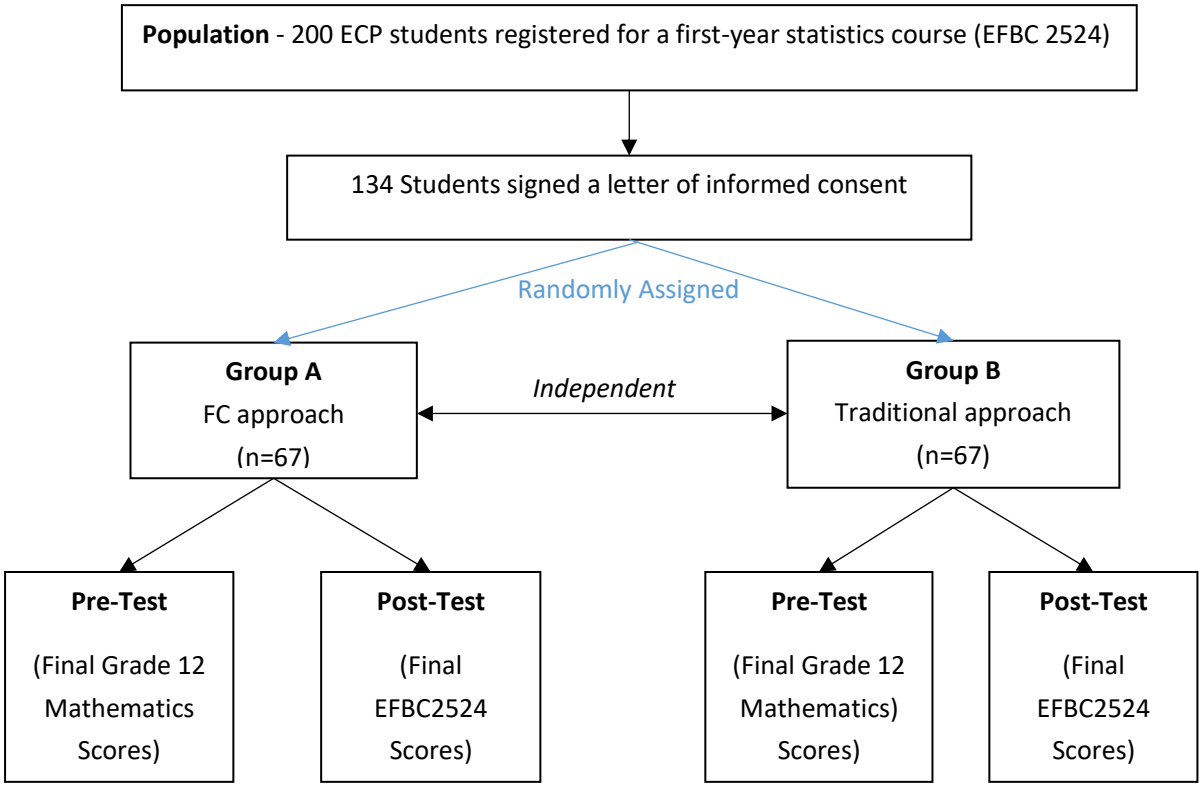


Figure 4.1: Graphical illustration of the data collection process

It must be noted from Figure 4.1 that Group A was considered independent of Group B. The pre-and post-test scores within a group might be associated or correlated, but Group A's pre-test scores were independent of Group B's pre-test scores. The same was true for the post-test scores of Groups A and B. In this research, data

were observed on two occasions, *i.e.,* the pre-test score (before) and the post-test score (after).

4.2.3 Course design for this study

4.2.3.1 Course Content

The curriculum for the first-year statistics course (EFBC 2524) consisted of the following course content:

- Confidence intervals (for the population mean; proportions; the difference between two population means; and the difference between two population proportions);
- Hypothesis testing (for one population mean; one population proportion; the difference between two population means for dependent and independent samples, and the difference between two population proportions);
- Analysis of variance (ANOVAs);
- Chi-square tests (for the goodness of fit test, test for independence in contingency tables, test for normality);
- Simple linear regression and correlation analysis; and

4.2.3.2 The Flipped classroom approach (Group A)

Group A had to watch videos the researcher generated as a series of audio-enhanced PowerPoint videos. All the videos were sent to their personal e-mail accounts at the beginning of the semester. The videos were sent to their personal e-mail accounts. The video lectures could not be uploaded on the LMS platform because all the students would then be able to access them. WhatsApp could not be used to send videos because a few students did not have WhatsApp or their phones were not WhatsApp-compatible. Sending the videos was another obstacle, as obtaining all their correct e-mail addresses took a few days. The next problem was that only 25MB could be e-mailed at a time. Therefore, videos had to be sent in a few batches.

The next obstacle was educating students on how to use these videos. The videos were generated with PowerPoint Mix, but the students could not watch them on their phones because they did not have PowerPoint. Therefore, they had to use a laptop/computer where PowerPoint was installed to use it as “videos with audio” and not only “slides without sound.” A video clip was subsequently put on the WhatsApp group to show students how to watch videos.

The time it took to digitise the lectures was extensive. Herewith are a few pointers to remember when creating videos: plug earphones/headset in even when recording with a desktop or laptop microphone, your phone must be on silent; the dog must be outside and not barking next to you, and the others must be instructed to give you a quiet space. The researcher, therefore, made the videos at night when everything and everyone was quiet. Another problem was that the entire content of the videos had to be planned before recording them. It was a first for the researcher because she had to write on a Genius pen tablet while looking at the computer screen, have a Logitech headset, and still concentrate on talking sense. It needed much practice.

Group A students were allowed to attend the weekly practical session where they could consult with the researcher face-to-face. Furthermore, they could use WhatsApp or e-mail to contact the researcher when they did not understand certain concepts.

4.2.3.3 The traditional classroom approach (Group B)

Group B had two hours of face-to-face lecture instruction per week and a two-hour practical session each week. Group B students were not allowed to join Group A and had to sign an attendance list when attending the lectures. In that way, the researcher could ensure that, hopefully, students from Group A did not participate in Group B.

4.2.3.4 Class facilitation

A WhatsApp group was created for all the students to increase collaboration between the students and the researcher. This WhatsApp group's purpose was to communicate various logistics regarding the continuous assessments and use this platform to promote constructive engagement of students in the learning process. Students always have their phones with them, but they do not regularly go on the LMS platform (Blackboard® at the UFS) to see relevant announcements. Implementing a WhatsApp group was frustrating for the researcher as much patience was required. The WhatsApp group had other disadvantages as well. Students can be very disrespectful. They even sent messages late at night when they were studying.

Furthermore, students must be assessed continuously to ensure they do not fall behind. They had to complete weekly online tutorials (20 marks), practical quizzes (10 marks), and assignments (50 marks). These tests were randomised questions generated from a pool of questions (see Appendix F). These online assessments contributed 30% towards their semester mark. Furthermore, three formative assessments (semester tests) and a summative examination (see Appendix F) were done.

The researcher taught both groups and was the only lecturer responsible for this course.

4.2.4 Variables of interest

This research focused on the following variables:

1. The **explanatory variable** in an experiment can be changed and affects at least one other variable (Welman *et al.* 2005:161). In this study, the teaching method, traditional lecturing, or the FC approach, referred to as Group, will be considered the explanatory variable.

2. **Outcome (response) variables** determined whether the intervention increased the student outcomes' by comparing the students' performance in their *final scores, tests, and online assignments*, which were the response variables.

3. **Extraneous (Control) variables** may impact the relationship between the explanatory and response variables (Kumar 1999:51). In this study, the extraneous variables were students' gender, Grade 12 Mathematics, where they were studying, where they stayed during their studies, and the various variables considered for student engagement.

4.2.5 Data Collection

4.2.5.1 Qualitative data collection techniques

An inquiry process was done to understand participants' views and write a literary account of their experiences (Maree 2017:309). The main types of data collection for qualitative data that were used for this research were the following:

(a) Reflective journal

According to Burns (2000:439), a reflective journal by the lecturer contains many professional activities that give precise information about work patterns. The researcher recorded all her experiences and observations throughout the study, including reflections on some changes to applying the FC approach (Maree 2014:303) (see Section 5.1).

(b) Face-to-face interviews and open-ended questions in the questionnaire

Purposive sampling was done to identify eight students for interviews about their FC approach experiences (see Appendix D). The researcher selected specific students from the experimental group by considering their semester marks from different categories, *i.e.,* 90%; 80%; 70%; 60%; 50%; 40%; etc.

After the second test (see Appendix B), a questionnaire was administered based on the SASSE instrument's questions (as given in Table 2.2) and several other sources investigating the FC approach. It was done to explore their experiences and

perceptions of the FC approach and to determine which other factors influenced their learning environment. The questions referred to in Table 4.1 were the only questions applicable to this research used in the questionnaire.

Table 4.1: Questions for the three themes used in this research

Theme 1: Active and Collaborative Learning • Students asking questions during class to fellow students to complete assignments and tutorials (Questions 30, 32, and 39 from the questionnaire). • Students work with their fellow students to complete assignments and tutorials outside class (Questions 32, 33, and 38 from the questionnaire). • Tutored other students (paid or voluntary) (Questions 35 and 40 from the questionnaire).
Theme 2: Student-Staff Interaction • Students discussed marks or assignments with lecturers or tutors (Question 37 from the questionnaire). • Students discussed ideas from classes with the lecturer during or outside of class (Questions 29, 31, and 34 from the questionnaire). • Students' received prompt feedback from the lecturer on their academic performance (Question 36 from the questionnaire). • Interaction with the lecturer influenced students' learning to succeed academically (Question 41).
Theme 3: Enriching Educational Experiences • HIPs – the intervention (FC approach) as discussed in Section 5.5.

4.2.5.2 Quantitative techniques

The researcher gathered numerical data to conclude whether the treatment improved the students' final marks and looked for probable cause and effect. Quantitative measures were used to collect data to test hypotheses and answer research questions (Maree 2017:307). The main types of data collection that were used for this research were the following:

(a) Closed questions in the questionnaire

The same questionnaire, as mentioned before, was used.

(b) Students' final Grade 12 mathematics marks and final marks

The students' final Grade 12 mathematics marks were considered as the pre-test score. Students do not all take National Benchmark Tests (NBTs) in their Grade 12

year as it is not compulsory. Therefore, missing data cannot be used for comparisons without further manipulations.

The students' final marks consisted of their predicates (50%), which were a combination of their average online assignments, tutorials, and practicals (30%) as well as the average of three tests (70%) and their final examination mark (50%). This mark was considered the post-test score.

(c) Beginning College Survey of Student Engagement (BUSSE) instrument

Students entering university for the first time have preconceived ideas of what is expected to complete their university studies successfully. Previous experiences from the school level influence their expectations of what they think university life will be like, either helping or hindering their learning (Ambrose *et al*. 2010:4).

BUSSE is administered online yearly from February to March at the UFS and was designed to provide institutions with data about first-year students to identify and address these students' needs and expectations. BUSSE is based on the Beginning College Survey of Student Engagement (BCSSE) used in the USA (Strydom *et al.* 2017:58), and has nine sub-scales, referred to as indicators and can be seen in Table 4.2. Miss H. Posthumus from CTL at the UFS provided the BUSSE measurements for the students in this research. Only 53 of the 134 students that were part of this research responded to the BUSSE survey.

Table 4.2: Subscales comprising the BUSSE survey (Source: Strydom 2017:58)

SUBSCALES	DESCRIPTION
HIGH-SCHOOL ENGAGEMENT	
Quantitative Reasoning (QR) • Reached conclusions based on your analysis of numerical information (numbers, graphs, statistics, etc.) • Used numerical information (numbers, graphs, statistics, etc.) to examine a real-world problem or issue (unemployment, climate change, public health, etc.) • Evaluated what others had concluded when they used numerical information (numbers, graphs, statistics, etc.)	High school engagement with analysis and numerical information
Learning Strategies (LS) • Identified important information from reading assignments • Reviewed your notes after class	Use of effective learning

• Summarized what you learned in class or from subject materials	strategies in high school
FIRST-YEAR EXPECTATIONS	
Collaborative Learning (CL) • Ask another student to help you understand subject material • Explain subject material to other students • Prepare for exams by discussing or working through subject content with other students • Work with other students on projects or assignments	The expectation to interact and collaborate with peers
Student-Staff Interaction (SSI) • Talk about your career plans with a lecturer • Work with a staff member on activities other than academic work (committees, projects, student groups, etc.) • Discuss your academic performance with a lecturer • Discuss subject topics, ideas, or concepts with a lecturer outside of class	The expectation to interact and engage with staff
Discussion with Diverse Others (DDO) • People of a race or ethnicity other than your own • People from an economic background different than your own • People with religious beliefs other than your own • People with political views other than your own	The expectation to engage in discussions with diverse others
Expected Academic Perseverance (PER) • Study when there are other exciting things to do • Find additional information for subject assignments when you do not understand the material • Participate regularly in subject discussions, even when you do not feel like it • Ask lecturers for help when you struggle with subject assignments • Finish something you have started when you encounter challenges • Stay positive, even when you do poorly on a test or assignment	Students' certainty that they will persist facing academic difficulty
Expected Academic Difficulty (DIF) • Learning subject material • Managing your time • Getting help with academic work • Interacting with staff	Expecting academic difficulty during the first year of university
Expected Academic Preparation (PREP) • Write clearly and effectively • Speak clearly and effectively • Think critically and analytically • Analyse numerical and statistical information • Work effectively with others • Use computing and information technology • Learn effectively on your own	Students' perception of their academic preparation

Importance of Campus Environment (CAMP) • A challenging academic experience • Support to help you succeed academically • Opportunities to interact with students from different backgrounds (social, racial/ethnic, religious, etc.) • Help managing your non-academic responsibilities (work, family, etc.) • Opportunities to be involved socially (not related to academic work) • Opportunities to attend campus events and activities • Learning support services (tutoring services, peer mentoring, writing centre, library, etc.)	Student-rated importance that the institution provides a challenging and supportive environment

4.2.6 Data analysis and reporting

The quantitative data were analysed and interpreted by making use of:

- Descriptive statistics to summarise the collected data in a meaningful way;
- Inferential statistics to draw the necessary inferential conclusions;
- Cronbach α to determine internal reliability for the Likert-scales used in this questionnaire;
- A Chi-square Test to analyse the relationship between demographic variables like gender, age, language, race, etc.;
- An independent t-test between the two groups' final marks was used to determine if there was a difference between the groups and explanatory variables, as defined in section 4.2.4.
- A paired t-test, which was used to compare if the average difference scores between the pre-test and the post-test scores differ from zero for the two respective groups;
- Multiple regression was done to determine if the performance of the students in their final scores was related to the extraneous variables defined in section 4.2.4,
- An Analysis of Covariance (generally known as ANCOVA) to test which group produced the best results. The ANCOVA combines regression

analysis and Analysis of Variance (ANOVA), primarily for comparing groups and/or measuring change resulting from experimental treatments (Dimitrov & Rumrill 2003:159,161). For this research, the ANCOVA investigated the effects of the primary independent categorical variable (Groups A and B) – the explanatory variable - on the continuous dependent variable (the post-test scores) – outcome variable - after adjusting for differences in the covariates (pre-test scores, as well as the demographic characteristics like gender, race, etc.) – control variables. The covariates are additional predictors and will increase the statistical power and control, given that a good covariate is used. Subsequently, their inclusion will reduce the error variance and create a better model than the ANOVA (Huitema 1980:25). The ANCOVA also adjusts each group's average on the dependent variable to gain the desired control. The rationale behind the adjustment process is that if one of the comparison groups had an above-average mean on the covariate (compared with the other groups in the study), then that group's mean score on the dependent variable will be lowered and vice versa (Huitema 1980:33). Therefore, this adjustment of means on the dependent variable makes the ANCOVA provide the best estimates of how comparison groups would have performed if they all possessed equivalent means on the covariate(s) (Huitema 1980:47).

The ANCOVA has certain assumptions:

- The residuals are normally distributed. A normal quantile-quantile plot (QQ-plot) of residuals can be used to confirm the normality of errors (Seltman 2018:246).
- The factors were randomly assigned; therefore, it can be assumed that the dependent variable scores are independent of each other if the sample sizes are equal across groups (Huitema 1980:99).
- Homogeneity of variance. When the covariate is approximately normally distributed, it is unlikely that the ANCOVA test is affected enough by heterogeneous variances to be of practical concern if the design is balanced, *i.e.,* with equal sample sizes (Huitema 1980:121).

- The relationship between the dependent variable and the covariate must be linear. If the relationship is non-linear, the ANCOVA adjustments will be biased (Hinkle *et al.* 1988:508). A scatterplot between the dependent variable and the covariate can be done to illustrate the relationship.
- The homogeneity of regression slopes can be confirmed by testing for interaction. A significant interaction implies that the assumption of homogeneity of regression slopes is invalid and will result in biased adjusted means (Hinkle *et al.* 1988:510). Interaction between two explanatory variables exists when the change in the value of one variable on the mean outcome depends on the value of another variable (Seltman 2018:247).

- Effect size as defined by Cohen (1998). According to Maree (2017:233), it is good practice to report the effect size as additional information when the hypothesis testing for the **difference between two means** is done, as small sample sizes could affect whether a p-value is significant or not. The effect size is not affected by the size of the sample and it measures practical significance.

  Effect size attempts to measure the effectiveness of the intervention that was applied in a study. Practical significance "can be understood as a large enough effect to be important in practice" (Ellis & Steyn 2003:51). Effect sizes are utilized since a finding can be statistically significant, but that does not mean that it will be practically significant.

Table 4.3: Effect sizes defined by Cohen when testing for the difference in two means

d	Meaning
0.2	Small effect on the significance of the differences between the two groups
0.5	Medium effect on the significance of the differences between the two groups
0.8	Large effect on the significance of the differences between the two groups

The calculation for Cohen-d:

$d = \frac{|\bar{x}_1 - \bar{x}_2|}{SD_{Pooled}}$ and $SD_{Pooled} = \sqrt{(SD_1^2 + SD_2^2)/2}$ (Cohen 1998:43-44)

Data with an effect size of 0.8 is considered to be practically significant (Ellis & Steyn 2003:52).

In the case of **correlations**, correlation coefficients (r) are used as effect sizes. When r = 0.1, it is regarded as a small effect, r = 0.3 a medium effect, and r = 0.5 as a large effect (Cohen 1998:79-80). Furthermore, in the case of multiple regression, the effect size (f^2) is calculated as $f^2 = \frac{R^2}{1 - R^2}$ (Ellis & Steyn 2003:53). Take note, r^2, the coefficient of determination, is the proportion of variation in the response variable explained by the fiited model. Furthermore, it is used with the following possible guidelines for its interpretation:

Table 4.4 Effect sizes when using multiple regression

Effect size (f^2)	Effect	Values of r^2	Conclusions on r^2
Smaller then 0.15	Small	Smaller than 0.13	Non-significant
0.15 – 0.35	Medium	0.13 – 0.25	Significant
Larger than 0.35	Large	Larger than 0.25	Practically significant

From Table 4.4, “non-significant” means that r^2 does not differ from zero (no relationship between variables x and y, “significant” implies a deviation from zero, while “practically significant” means that r^2 differs from zero and is large enough to imply a linear relation between the variables x and y (Ellis 2003:53).

The analysis was done by using the statistical program R (R Core Team, 2019). Some more straightforward calculations were done in Excel.

The qualitative data were analysed by organising, comparing, and categorising the data through coding, identifying patterns, and categorising data into themes and subthemes (Maree 2014:108-110; Creswell & Plano Clark 2011:14).

4.3 Ethical considerations

According to the Helsinki Declaration of 1972, obtaining ethical clearance from an ethics committee is vital when human subjects are involved in any research (Maree 2014:306). Ethical clearance was obtained from the Faculty of Education Ethics Committee at the UFS (UFS-HSD2015/0658; see Appendix E).

The next step was to obtain the necessary authorisation for the participation of students/staff in research projects from the UFS authorities, namely

- the Head of Department of Mathematical Statistics,
- the Dean of the Faculty of Natural and Agricultural Sciences,
- the Dean: Student Affairs, and
- the Vice-Rector: Research of the UFS (see Appendix F).

The principle of informed consent was adhered to in all data collection activities. All students interested in participating in the research process had to sign a consent letter (see Appendix A).

Confidentiality of data and participant anonymity were ensured in all reporting. All data collected were stored in a locked cabinet, which only the researcher had access to, and all electronic data were password protected (as applicable). Once students were randomly assigned to the respective groups, all participants were de-identified so that no one could be identified by inference within the research findings.

The no-harm principle was also adhered to in all phases of the study. The researcher believes this study held no ethical threat since it was always possible to keep within ethical boundaries.

The study's results are reported, interpreted, and analysed in the next chapter.

5. Reporting and analysis of research findings

5.1 Introduction

The previous chapter outlined the research design and methodology used to investigate whether the FC approach improved the final marks of first-year statistics students and whether the FC approach improves student engagement to achieve better academic results.

The first part of this chapter reflects on the researcher's experiences while implementing the FC approach. It also presents the participants' characteristics, such as race, age, home language, type of accommodation while studying, where students are most comfortable studying, and their final Grade 12 mathematics scores.

The second part explores the results of the tests, tutorials, practicals, assignments, and the students' final marks for investigating the apparent effect of the FC approach on the students' academic performance. Quantitative results and findings are discussed by comparing the treatment and control groups' performance.

The third part addresses how the two student groups experienced student engagement and whether the different factors influenced their outcomes.

The chapter concludes with this investigation's most important findings and results and provides an overview of the conceptual understanding of the two groups being studied. Comparative results for the experimental and control groups given in this chapter's second and third parts eventually enabled the researcher to conclude the FC approach's effectiveness.

5.2 The demographic information of participants

All findings were based on a 5% significance level for this research, *i.e.,* p-values of less than 0.05 will indicate a significant difference. P-values will be interpreted with nuance where borderline. Table 5.1 summarises the demographic characteristics of students for the two respective groups for this study.

Table 5.1: Number of participants

	Group A	Group B	p-value (χ^2 – test)
Gender			
Male	39	33	0.44
Female	28	33	
Did not respond	-	1	
Race			
Black	58	57	0.77
Coloured	4	4	
Asian	1	0	
White	4	5	
Did not respond	-	1	
Age			
18-19	25	17	0.37
20-21	35	42	
22+	7	6	
Did not respond	-	2	
Home Language			
Afrikaans	5	5	0.84
English	13	9	
Sesotho	22	19	
North Sotho	4	4	
Setswana	5	9	
IsiXhosa	8	12	
IsiZulu	4	2	
Xitsonga	1	0	
IsiNedebele	1	0	
SiSwati	1	1	
Spanish	0	1	
Deaf Student (Sign)	0	1	
Did not respond	3	4	

Type of accommodation while studying			
Private: Parents	12	15	0.87
Private: Flat	15	14	
Student House	23	19	
Student Residence on campus	16	15	
Did not respond	1	2	
Preferred place of study			
Their residence	29	30	0.98
Library	15	13	
Computer Labs	5	5	
Student residence and library	17	15	
Did not respond	1	4	
Citizenship			
International	7	1	0.07
South African	60	65	
Did not respond	-	1	

Significant p – value * 0.001; ** 0.01; * 0.05**

A chi-square test was used to compare the students' characteristics of the two groups, as indicated in Table 5.1. The hypothesis that was tested was:

H_o: There is no relationship (independence) between the group and the factor of interest

H_a: There exists a relationship (dependence) between the group and the factor of interest

From Table 5.1, the p-values did not show any significant difference in the gender distribution between the two groups. The same null hypothesis was tested for the other demographic variables to determine if these variables differed significantly. The p-values did not show any significant difference regarding the various variables. Thus, it serves as evidence that students' profiles in the two groups were similar and were thus comparable; therefore, it could be concluded that there was no evidence that randomisation was not done successfully.

Interestingly, it can be noted from Table 5.1 that only 20.3% (13 students from the 64 that answered) in Group A and only 14.3% (9 students from the 63 that answered) in Group B declared that English was their home language. English is a second or foreign language for many South African HE students, although instruction in classes and discussions with the lecturer must be in English. Research has shown that language and academic success are closely related (Cummins

2000:163), and thus, not being taught in their home language can be a disadvantage, compounded by poor schooling backgrounds (Jaffer *et al.* 2007:134).

It is evident from Table 5.1 that this sample is severely imbalanced across races and languages. Therefore, comparisons regarding race and language would not be reliable and were not considered further. Citizenship and age were also not considered for further investigations because some categories were too small.

5.3 Comparison of Pre-test scores

The two respective groups were compared based on their pre-test scores. The standard hypothesis test for such a comparison would be:

$$H_o: \mu_{Group\ A} = \mu_{Group\ B}$$
$$H_a: \mu_{Group\ A} \neq \mu_{Group\ B}$$

Table 5.2 compares the pre-test scores of Groups A and B.

Table 5.2: Pre-test scores

	Group A	Group B	p-value (t-test)
Sample size (n)	67	67	
Average ($\bar{x}$)	49.209	49.448	0.875
Minimum	39	36	
Maximum	75	80	
Standard Deviation (SD)	8.5	9.0	

Significant p – value * 0.001; ** 0.01; * 0.05**

A t-test generated a p-value of 0.875 (see Table 5.2), implying no significant difference in the two groups' average pre-test scores. We must accept that the average final pre-test scores for the two groups were practically identical and that the participants of both groups had the same level of mathematical competence. Table 5.2 provides no evidence that randomisation was not done successfully.

The histograms in Figure 5.1 showed that the scores are positively skewed, with most students having a pre-test score of between 40% and 50% for both groups. The reason is that extended programme students are selected based on an AP

score of between 18 to 24 and a final Grade 12 Mathematics score of 40% or more. Two students with Mathematics scores of less than 40% (36% and 39%, respectively) were also allowed into the programme.

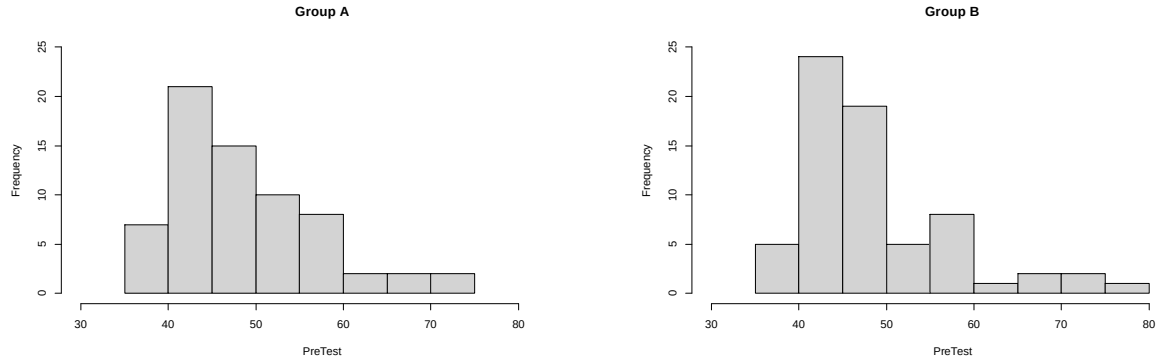


Figure 5.1: Histograms of Group A and B's pre-test scores

5.4 Power Analysis

According to Burger and Schall (2018:544), strict normality of the data is not required by t-tests and ANCOVAs to be reliable; instead, the model residuals in each case are sufficiently close enough to a bell-shaped pattern that the t-tests and ANCOVAs are trusted to produce appropriate results. Deviations from a normal distribution make the results less robust but not invalid, especially where there is a good reason to assume approximate normality. To illustrate this claim, consider Figure 5.2 for a plot of the standardised residuals when performing multiple regression, using the students' final scores compared with Pretest and Group. Figure 5.2 illustrated that the residuals are approximately normally distributed. So we proceed by considering the standardised residuals versus standard normal residuals. By artificially introducing and controlling the average difference between groups, we can draw proper curves and compare them. Power is calculated from either *m* standard normal samples or *m* bootstraps of the observed residuals respectively.

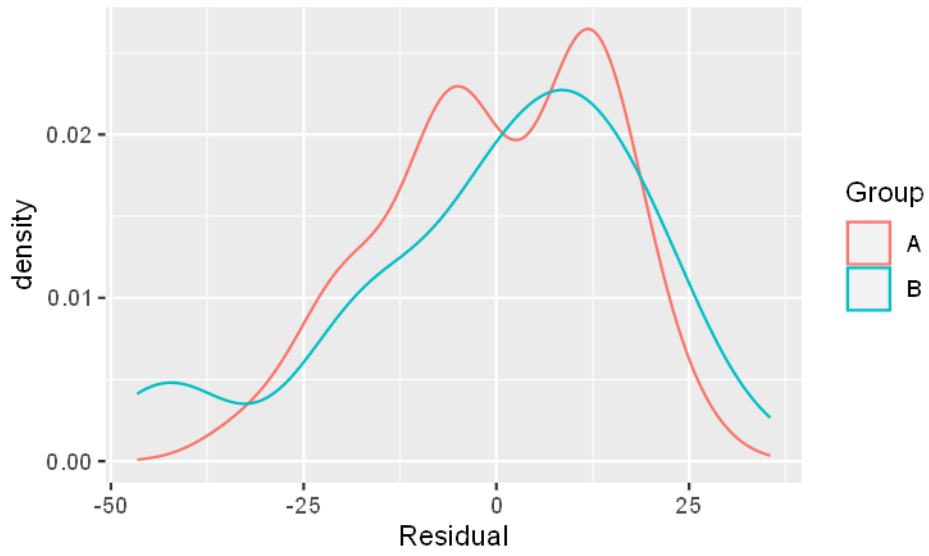


Figure 5.2 Plot of the standardised residuals for Groups A and B

In Figure 5.3, the full curve is viewed up to the observed effect size of 2.1, and then in Figure 5.4, zoomed in to smaller values. From Figure 5.4, it is clear that this study was well-powered. The test's accuracy and power were not affected by departures from normality, as referred to by Burger and Schall (2018:544). Therefore, the researcher made use of t-tests and ANCOVAs.

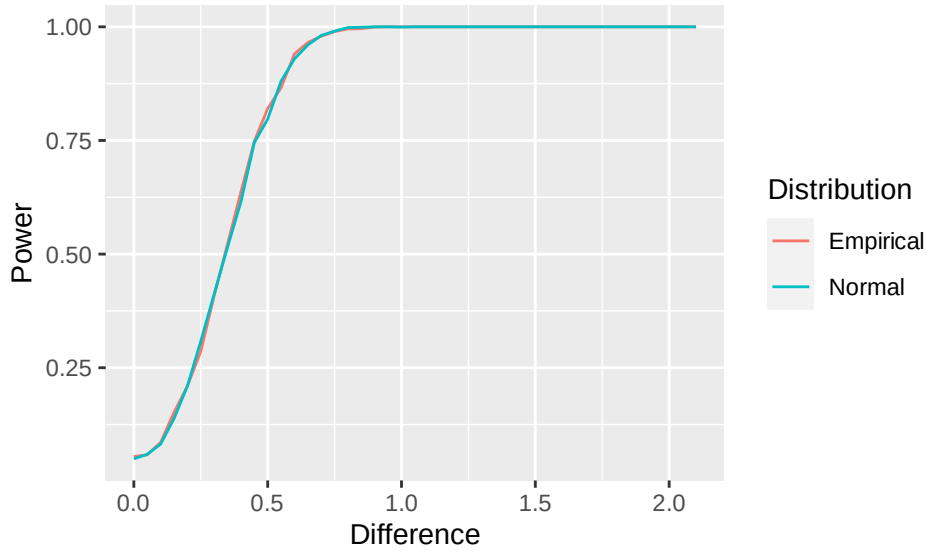


Figure 5.3: Plot of the residuals for Groups A and B

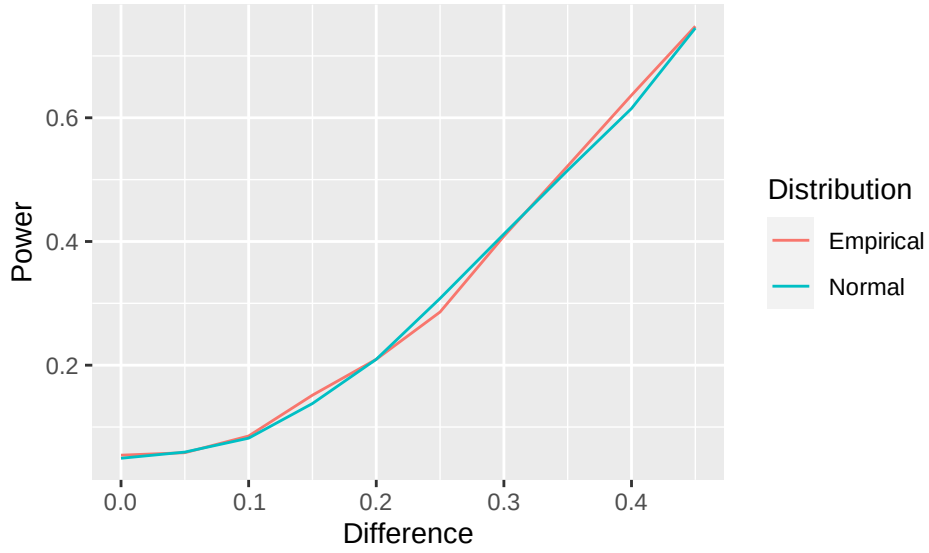


Figure 5.4: Plot of the residuals for Groups A and B

5.5 Comparison of the Post-test scores

A summary of the descriptive statistics for the two groups' post-test scores was presented in Table 5.3. Furthermore, a t-test was used to determine whether there were differences between the two groups regarding their post-test scores.

The hypothesis that was tested is:

$$H_o: \mu_{Group\ A} = \mu_{Group\ B}$$
$$H_a: \mu_{Group\ A} \neq \mu_{Group\ B}$$

Histograms of the two groups' post-test scores are illustrated in Figure 5.5.

Table 5.3: Descriptive statistics for Post-test scores

Assessments		Group A	Group B	p-value (t-test)	Cohen-d	Effect size impact
Test 1	$\bar{x}$	64.5	60.1	0.1643	0.24	4
	s	16.7	19.7			
	Min	17	7			
	Max	93	92			

Test 2	$\bar{x}$	56.5	50.8	0.0766	0.31	5.4
	s	17.4	19.7			
	Min	14	0			
	Max	93	89			
Test 3	$\bar{x}$	51.7	47.4	0.1653	0.25	3.7
	s	14.9	19.8			
	Min	0	0			
	Max	84	87			
Tutorials	$\bar{x}$	68.4	57.3	0.0059***	0.50	9.5
	s	19.0	24.7			
	Min	19	0			
	Max	94	91			
Practicals	$\bar{x}$	73.6	62.5	0.0073***	0.47	9
	s	19.2	27.4			
	Min	9	0			
	Max	96	95			
Assignments	$\bar{x}$	77.1	64.1	0.0003***	0.64	10.3
	s	16.1	24.0			
	Min	25	0			
	Max	99	98			
Final Mark	$\bar{x}$	59.6	53.3	0.0313*	0.38	5.4
	s	14.1	19.2			
	Min	25	6			
	Max	85	89			

Significant p-value * 0.001; ** 0.01; * 0.05**

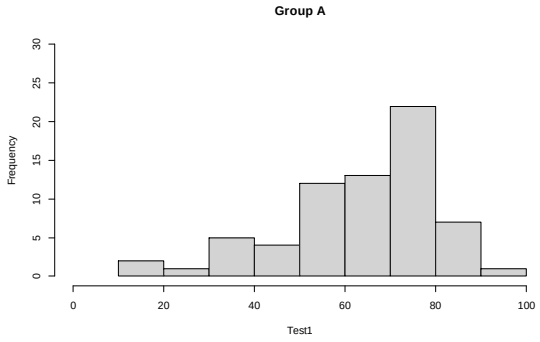
where $\bar{x}$ denotes the average of the sample and ***s*** the standard deviation of the sample.

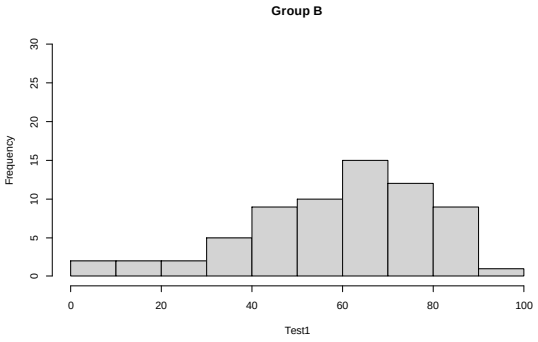
From Table 5.3, it can be concluded that significant differences in the average scores were found in the performance regarding their tutorials, practicals, assignments, and final marks. An effect size of 0.24 means that a student in the intervention group has an average score of 0.24 standard deviations higher than the average score of the control group.

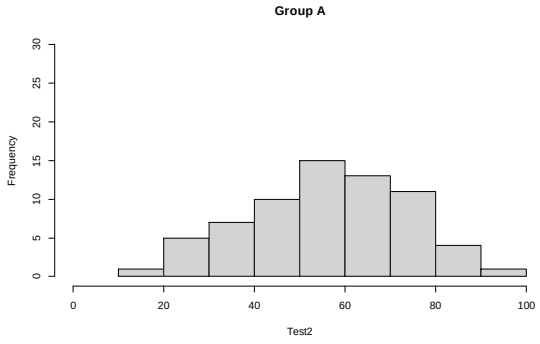
The effect sizes in Table 5.3 indicated that the treatment had a “medium” effect using Cohen’s (1988) terminology, as referred to in section 4.2.6, on the significance of the differences between the final scores, assignments, practicals, tutorials, and all three the tests of the two groups. The results indicated that the FC approach positively affected student achievement.

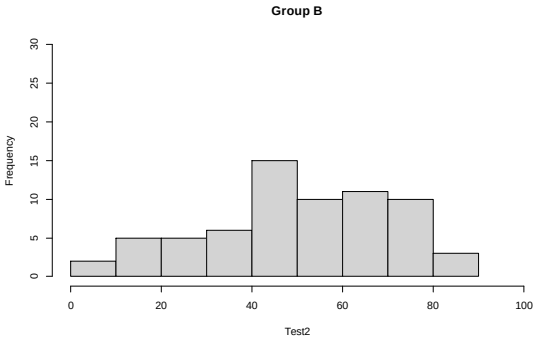
Although the intervention did have a positive effect in the study, the quantification of the effect was only “medium”. The effect size was therefore not large enough to classify as practically significant.

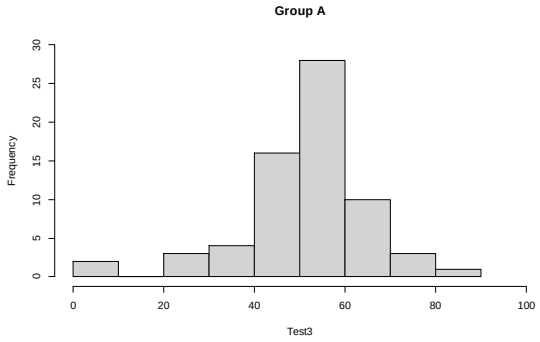
The researcher is of the opinion that a higher average can be attributed to increased understanding of course material and concepts. This may aid the student to better understand future courses and/or maximise time to learn in other courses. In the long run, this could increase the likelihood that a student will graduate, secure a job and/or successfully enter the workforce with superior knowledge. Kindly take note that this is merely the researcher’s opinion and as such can only constitute as speculation.

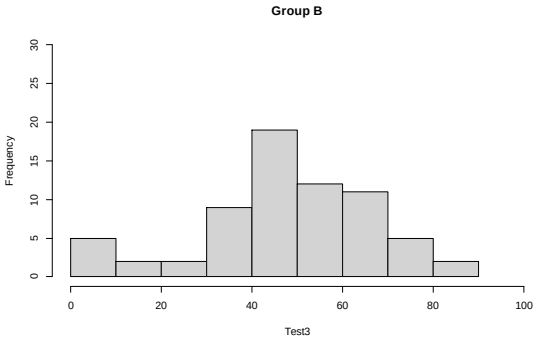












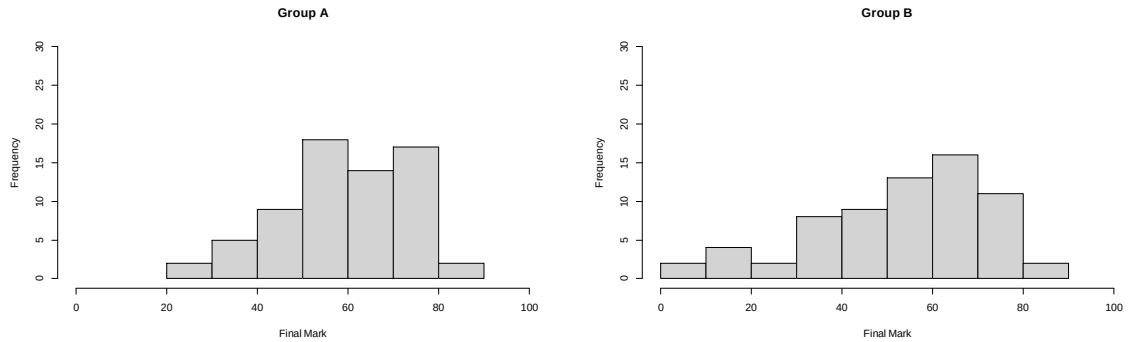


Figure 5.5: Histograms of Groups A and B for Test1, Test2, Test3 and the final scores

5.6 Relationship between Pre- and final marks as the Post-test score

The scatterplots in Figure 5.6 and the correlations in Table 5.4 showed the relationship between the pre-and post-test scores of the two respective groups. Figure 5.6 showed no clear relationship between this study's pre-and post-test scores. Table 5.4 showed that the respective correlations were very low, and non-significant p-values appeared. Thus, we will assume no relationship between the pre-and post-test scores of the respective groups in this study.

Table 5.4: Correlations of pre-and post-test scores by group

	Group A	Group B
Correlation	0.0759	-0.0831
p-value	0.54	0.50

Significant p – value * 0.001; ** 0.01; * 0.05**

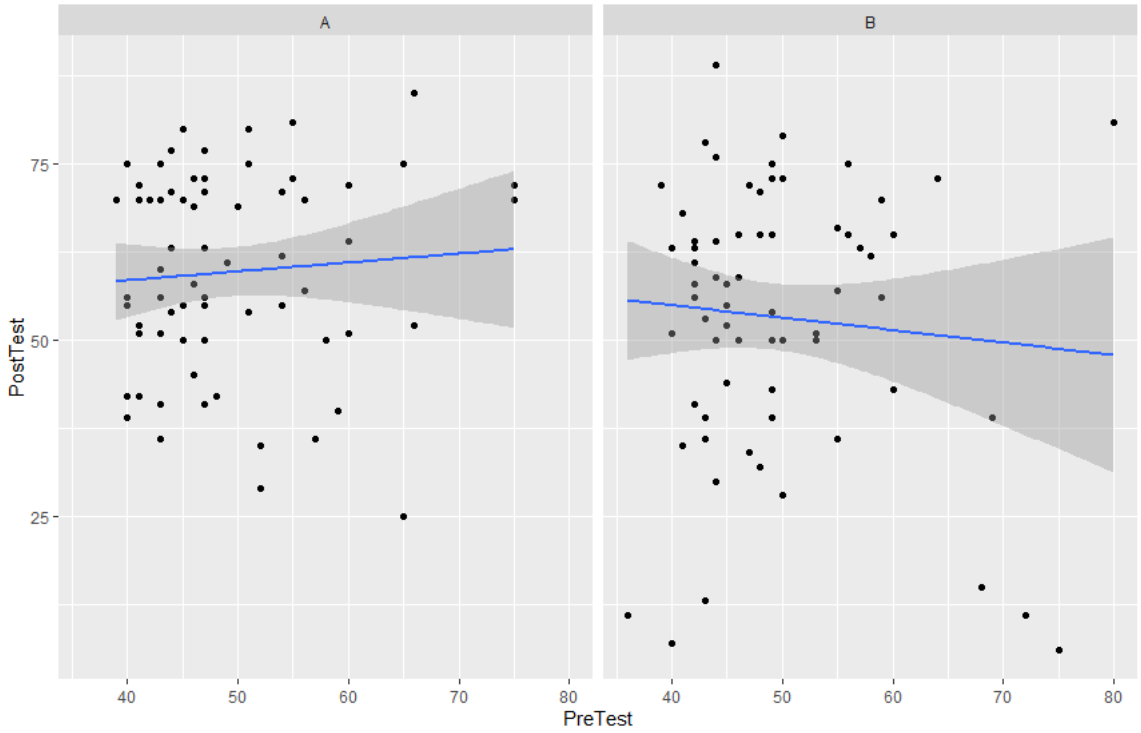


Figure 5.6: Scatterplots of Post-test (y) against Pre-test (x) for the two groups

A paired t-test was done to determine whether there was a difference between the two groups' average pre- and post-test scores. The results are illustrated in Table 5.5.

Table 5.5: Paired t-test results between Pre- and Post-test scores

	Group A	Group B
PreTest	49.2	49.2
Post-test (Final Mark)	59.6	53.3
p-value (paired t-test)	<0.0001***	0.16

Significant p – value * 0.001; ** 0.01; * 0.05**

From Table 5.5, Group B showed no significant difference between pre-and post-test scores. It implies that students' average post-test scores attending traditional lecturing did not differ significantly from their pre-test scores. However, Group A significantly differed between their pre-and post-test scores. Thus, the average final score of students in Group A significantly improved from their average pre-test scores. The assumption is that both pre- and post-tests measure the same abilities.

5.7 Comparison of Post-test scores applying Analysis of covariance (ANCOVA)

5.7.1 Introduction

Next, the researcher investigated if the treatment affected the outcomes while controlling for key covariates. Student characteristics, in the form of background characteristics (*e.g.,* gender), pre-university qualifications (*e.g.,* Grade 12 Mathematics scores), and general living arrangements (*e.g.,* living on campus), were chosen as covariates. These measures have been found to influence student engagement, as Pike and Kuh (2005:281) stated. Pike and Kuh (2005:289), Trowler (2010:36), and others found that students living on campus are more engaged, resulting in "greater gains in their learning" as they can more likely interact with peers and lecturers and use campus facilities. Off-campus students, on the other hand, may experience transport issues and have "to balance multiple obligations to complete their studies" (Simpson & Burnett 2017:3). However, according to Simpson and Burnett (2017:14), students' academic performance is not influenced by where students are staying but rather by the time and energy devoted to their studies. Thus, this research partly considered whether 21st-century students' living arrangements influence their academic performance.

5.7.2 ANCOVA results for the final marks

Table 5.6 presents the ANCOVA results for the students' performance regarding their final marks when the two-way interaction between Group and Gender, PreTest, Study place of preference, and accommodation type was considered. Interaction between gender would test, for example, if male students performed differently from female students when applying the FC approach. Similarly, this will test whether students with higher pre-test scores respond differently to the flipped classroom than students with lower pre-test scores.

Table 5.6: ANCOVA - Final marks as the post-test score with the interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	989	989.1	4.161	0.0438*
PreTest	1	90	89.9	0.378	0.5398
Gender	1	2509	2509.4	10.558	0.0015**
Accommodation Type	3	507	168.9	0.711	0.5477
Study Place Preference	3	3120	1039.8	4.375	0.0060**
Group*PreTest	1	122	121.6	0.512	0.4760
Group*Gender	1	510	510.2	2.147	0.1458
Group*Study Place Preference	3	1648	549.3	2.311	0.0802
Group*Accommodation Type	3	655	218.5	0.919	0.4341
Residuals	109	25907	237.7		

Significant p – value * 0.001; ** 0.01; * 0.05**

From Table 5.6, it can be concluded that there was no significant interaction between group and gender, pre-test scores, place of study preference, and accommodation type regarding their final marks, which confirms the assumption of homogeneity of regression slopes (as referred to in Section 4.2.6). Including interaction could lead to over-fitting. No interaction terms improved the model fit. Thus, it suggests that the gender and treatment effect may operate independently of the course outcome. At the very least, the researcher has no evidence to suggest that one gender benefitted more from the treatment according to this data set. The same is true for the other control variables considered for this study.

Figure 5.7 illustrates the regression slopes from Table 5.6. As indicated in Table 5.6, no interaction exists between the Group and covariates. Furthermore, it shows that Group A performed better than Group B regarding the covariate Gender. These illustrations in Figure 5.7 will also be confirmed later in Tables 5.8, 5.9, and 5.10. Consequently, as a final model, it may be appropriate to re-run the ANCOVA, excluding the interaction terms, as shown in Table 5.7.

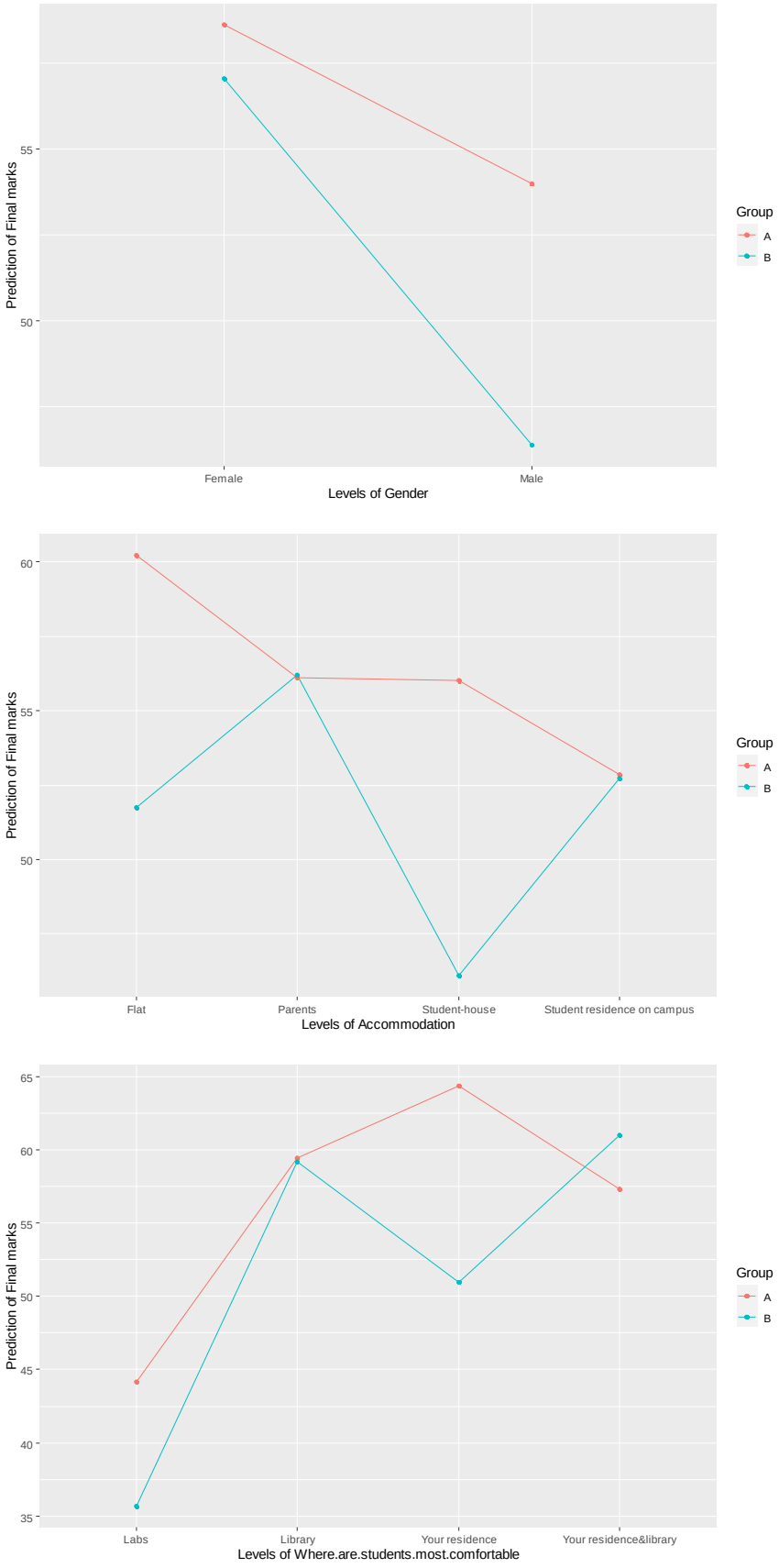


Figure 5.7: Regression slopes of the model fitted in Table 5.6

Table 5.7: ANCOVA - Final marks as the post-test score with no interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	989	989.1	4.012	0.0475*
PreTest	1	90	89.9	0.365	0.5471
Gender	1	2509	2509.4	10.180	0.0018**
Study Place Preference	3	3120	1039.8	4.218	0.0072**
Accommodation	3	507	168.9	0.685	0.5629
Residuals	117	28842	246.5		

Significant p – value * 0.001; ** 0.01; * 0.05**

Figure 5.8 illustrates the diagnostic plots for the linear model when using the ANCOVA, as indicated in Table 5.7. The QQ-plot showed that the residuals are approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. Since there was no evident relationship between the residuals and fitted values, it implies a constant variance across the two groups, as was confirmed with Levene's test for homogeneous variances (p-value = 0.1143 > 0.05). Thus, we have some confidence in the ANCOVA results obtained.

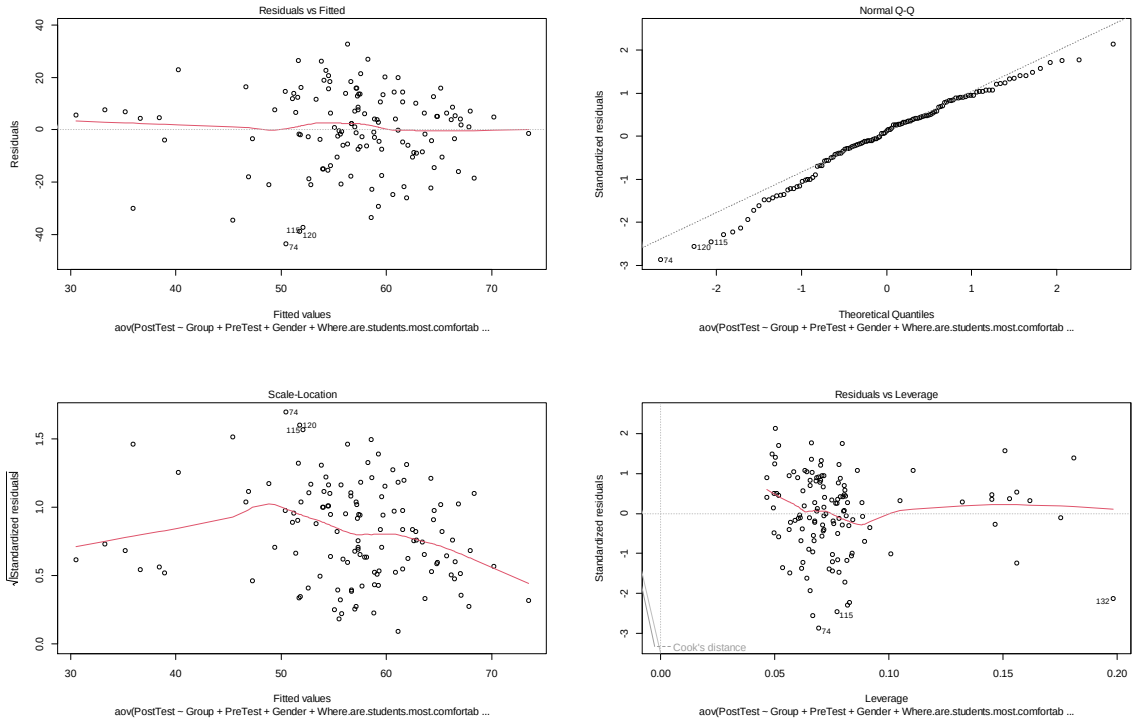


Figure 5.8: Plots of residuals for final marks for the model fitted in Table 5.7

Table 5.8 illustrates the observed and adjusted average means (least-square means) for the significant variables Group, Gender, and Place where students preferred to study used for the ANCOVA indicated in Table 5.7.

Table 5.8: Observed and estimated marginal means for the final marks

	Observed	Adjusted
Group		
A	59.6	57.3
B	53.3	50.8
Gender		
Male	53.2	50.6
Female	61.0	58.3
Study Place Preference		
Their residence	57.1	57.5
Library	58.7	58.7
Computer Labs	40.8	42.3
Their residence & Library	59.8	59.4

Since the ANCOVA showed explanatory effects of importance other than Group, the *potential outcomes approach* can be used to estimate each student's final mark receiving the treatment as if they had no treatment and untreated students as if they received the treatment (Rubin 2005:323). The value of 6.5 was calculated for the average treatment effect. It implies that, on average, a student gained about 7% through the treatment. These results confirmed what will be illustrated in Table 5.9, where the difference in adjusted means showed the same value (6.5) for the Group variable as illustrated in Table 5.8, which is large enough to conclude that the treatment was effective and improved student outcomes after controlling for the effects of gender and the other covariates.

Based on the results illustrated in Table 5.7, it can be concluded that the variable Group reflects a significant difference between the average final marks of the two groups after adjusting for gender and study place preference. The covariate Gender is highly significant, which shows that there is a significant difference between the genders. Furthermore, the average final marks differed significantly based on where students preferred to study. It seems they prefer a quiet place to study. Therefore, we can conclude that these covariates are most likely attributed as causal factors

to students' final scores. Thus, it suggests that gender or study place preference and treatment effect may operate independently on the course outcome. At the very least, the researcher has no evidence to suggest that one gender or study place preference benefitted more from the treatment according to this data set.

Multiple regression was applied to identify possible explanatory factors to isolate the treatment's effect while keeping other factors constant. The multiple regression coefficients, using the students' final scores as the post-test score, are illustrated in Table 5.9.

Table 5.9: Coefficients from multiple regression for final scores

	Estimate	**p-value**
Intercept	39.0090	0.0002***
Group B	-6.5565	0.0213*
PreTest	0.2087	0.2176
Gender – Male	-7.9536	0.0086**
Accommodation – Parents	0.6653	0.8763
Accommodation - Student-House	-4.2296	0.2806
Accommodation - Residence on Campus	-2.9751	0.4788
Study Place – Library	18.1407	0.0040**
Study Place - Their residence	17.6215	0.0025**
Study place - Their residence & Library	19.2426	0.0021**

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.9 showed that Group B performed approximately 7% lower than Group A, significantly different when controlling for the other factors considered. Furthermore, male students performed almost 8% lower than females, which was also a significant difference. It can also be noted that the place where students preferred to study, *e.g.,* the library or their residence, showed significant differences that contributed positively to their average final marks. The place where students stayed while studying did not appear to influence their final scores significantly.

A boxplot in Figure 5.9 illustrates the different accommodations for the two groups.

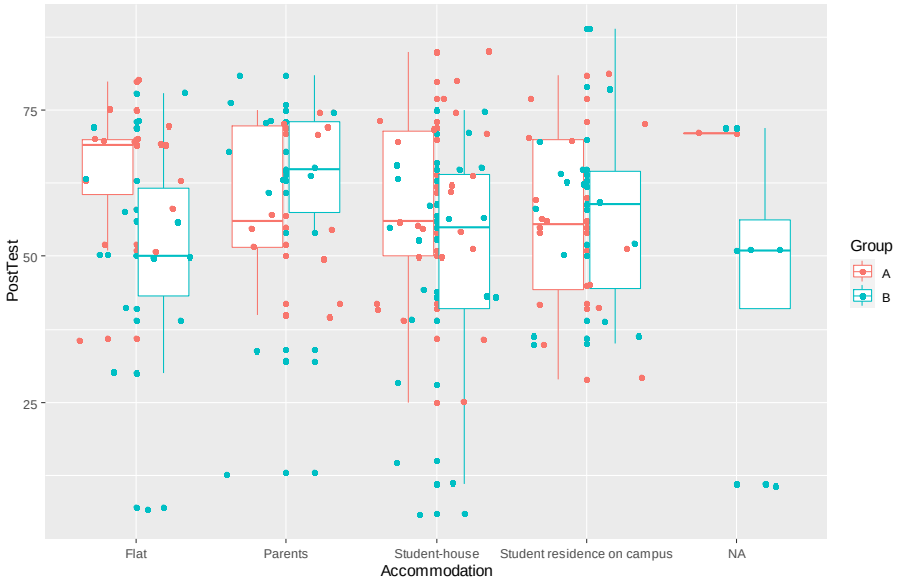


Figure 5.9: Boxplot of accommodation while studying and their final marks for the two groups

Table 5.10 reflects the two groups' average final marks for their respective gender and the place where they prefer to study.

Table 5.10: Average final marks of Groups A and B by group, gender, and place where students prefer to study

	Group A	Group B	p-value
Gender:			
Male	57.41	48.24	0.0412*
Female	62.71	59.61	0.3668
Study Place:			
Library	60.07	57.08	0.5991
Their residence	63.86	50.57	0.0051**
Their residence & Library	56.53	63.47	0.1076
Computer Labs	42.00	39.60	0.8475

An unexpected gender finding from Table 5.10 was that male students from Group A performed about 9% significantly better than males in Group B. A t-test was done to determine whether these differences were significant. It seems that students respond differently to the FC approach. Furthermore, Figure 5.10 confirms that female students performed better than male students, as was stated before. These findings are consistent with international evidence, which finds that it is common for females to outperform male students (Van Broekhuizen *et al.* 2016:38-39).

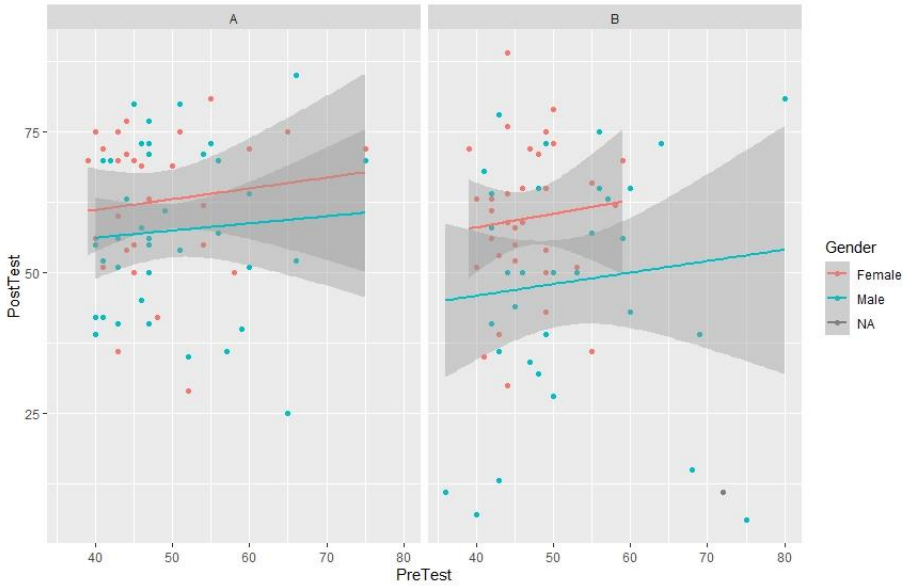


Figure 5.10: Scatterplots of PostTest (y) against Pre-test (x) for the two groups and their respective genders

From Table 5.10, it can furthermore be noted that for the place of study, students studying in the library or in the computer labs performed about the same for both groups, while students in Group A who studied at their residence performed approximately 13% significantly better than students in Group B studying at their residence. Interestingly, when considering the place of study as their residence and library, Group B performed approximately 7% better than Group A, but it was insignificant. These results are furthermore illustrated in Figure 5.11.

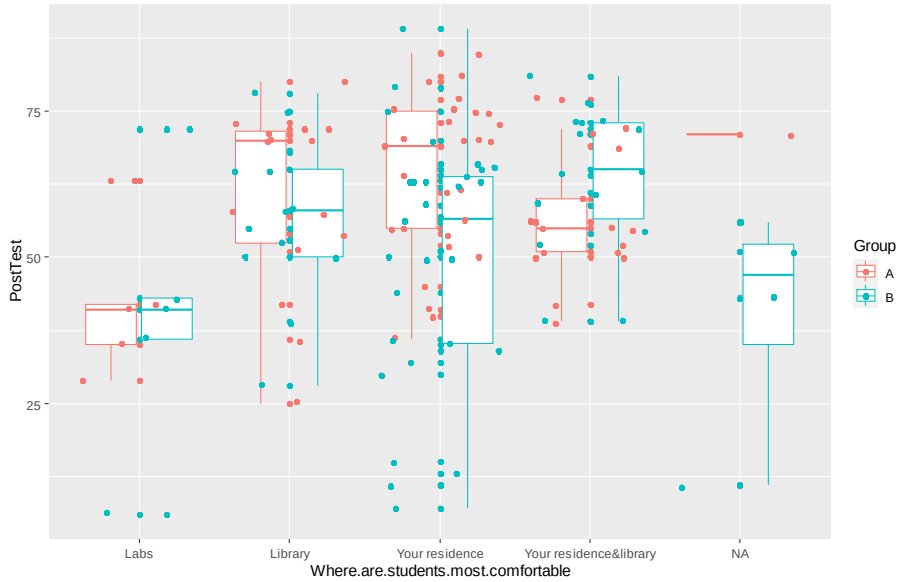


Figure 5.11: Boxplot of the place where students study and their final score for the two groups

Furthermore, a sensitivity analysis was done to determine if the model referred to in Table 5.6 is stable and how well the model fits the data. The Bayesian information criterion (BIC) was calculated to determine which model gave the more parsimonious fit. Table 5.11 summarises the different models fitted with their corresponding Deviance, BICs, AICs, $R^{2,}$, adjusted $R^{2,}$ and the p-value from fitting the different multiple regression models.

Table 5.11: Model fitting for the final scores

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, PreTest, Gender, Accommodation, Study Place preference, Group*Gender, Group*PreTest, Group*Study Place Preference, Group*Accommodation	25907	1074	1128	0.281	0.169	0.0022**

Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Goup*PreTest, Group*Study Place Preference	26537	1071	1116	0.264	0.172	0.0010**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Study Place Preference	26650	1069	1112	0.261	0.176	0.0006***
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	28332	1071	1105	0.214	0.147	0.0013**
Group, Pretest, Gender, Accommodation, Study Place preference	28842	1071	**1103**	0.200	0.139	0.0015**

According to Table 5.11, when using the lowest BIC, the model in Table 5.7 will give the best model fit where the model has a reduced number of explanatory variables. The p-value (0.0015) of the multiple regression model, as applied in Table 5.9 (see Table 5.11), indicates that the model fitted was significant, *i.e.,* at least one of the predictor variables was significantly different from zero. The coefficient of determination (R^2 = 0.2) in Table 5.11 suggests that explanatory variables can explain about 20% of the variation in final scores.

5.7.3 ANCOVA results for the other continuous assessments

The final score comprised of several sub-marks, which will be considered hereafter, with supporting tables and figures given in Appendix G.

5.7.3.1 ANCOVA results for Test 1 as the post-test score

See Tables 15.1 – 15.3 for the different models fitted for test 1. The regression slopes for the model fitted in Table 15.1 are illustrated in Figure 15.2. Figure 15.2 illustrates that gender and the group variable have an interaction.

When using test 1 scores as the post-test score, the multiple regression coefficients were illustrated in Table 15.4. Table 15.4 shows that for test 1, Group B performed about 3% better than Group A, but it was insignificant when controlling for the other factors. Furthermore, male and female students performed similarly. It can be noted that the place where students preferred to study, *e.g.,* the library or their residence, showed significant differences that contributed positively towards their test 1 marks. Students who stayed on campus during their studies also performed about 9% significantly worse than other places of accommodation students who stayed during their studies.

When performing a sensitivity analysis for Test 1 (see Table 15.5), it seems that Table 15.2 gave the best model fit with the lowest BIC. The p-value of the multiple regression model from Table 15.4 generated a value of 0.0002, which shows that the model fitted is significant, *i.e.,* at least one predictor variable is significantly related to test 1 marks. The p-value (=0.0002) is also the lowest, implying that this model is more significant than others.

Figure 15.1 illustrates the diagnostic plots for the linear model using the ANCOVA, as indicated in Table 15.2. The QQ-plot showed that the residuals are approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. Since there was no evident relationship between the residuals and fitted values, it implies a constant variance across the two groups, as was stated with Levene's test for homogeneous variances (p-value = 0.1964 > 0.05). Thus, valid ANCOVA results will be obtained.

It can be concluded that for test 1, there is a significant interaction effect between group and gender, which indicated that the effect of the group was different for the two genders. Furthermore, Table 15.2 illustrated that the covariates of gender and place of the study produced significant differences.

Table 15.6 shows the observed and marginal means for the model fitted in Table 15.2, but it can be misleading due to the interaction involvement.

Table 15.7 showed that the average mark for test 1 of female students was similar irrespective of group, while male students in Group A performed significantly better than male students in Group B. Furthermore, it can be noted that for the place of study, students studying in the library of Group A performed significantly better than their counterparts in Group B, as was also confirmed in Figure 15.2.

5.7.3.2 ANCOVA results for Test 2 as the post-test score

When performing an ANCOVA for Test 2, Table 15.8 showed that only gender was significant, and no significant interaction between the covariates existed. The regression slopes for the model in Table 15.8 are illustrated in Figure 15.3. These plots showed that Group A performed better than Group B when considering their gender, as is also illustrated in Table 15.10.

When doing a sensitivity analysis for Test 2 (see Table 15.12), the model illustrated in Table 15.9 gave the best model fit with the lowest BIC. The p-value of the multiple regression model from Table 15.10 generated a value of 0.0946, which indicates that the model fit is not significant here, *i.e.,* we cannot reject the hypothesis that none of the independent variables have a relationship with the dependent variable.

Figure 15.4 illustrates the diagnostic plots for the linear model using the ANCOVA, as indicated in Table 15.9. The QQ-plot showed that the residuals are approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. Since there was no evident relationship between the residuals and fitted values, it implies a constant variance across the two groups, as was stated with Levene's test for homogeneous variances (p-value = 0.401 > 0.05). Thus, valid ANCOVA results will be obtained.

For Test 2, the *potential outcomes approach* generated a value of about 6% for the average treatment effect, *i.e.,* on average, a student gained about 6% through the treatment of Test 2, but it was not a significant difference when controlling other factors considered, as was confirmed in Table 15.10 & 15.11. Furthermore, Table 15.10 illustrates that male students performed about 8% significantly lower than

female students. Here, it can be noted that the place where students preferred to study in the library or their residence showed significant differences compared to the other places of study that contributed positively to their test 2 marks. Table 15.11 illustrates the observed and adjusted average means for the variable Group and Gender used for the ANCOVA indicated in Table 15.9.

Table 15.13 reflected the average Test 2 marks of the two groups for their respective gender and the place where students preferred to study. It can be concluded from Table 15.13 that the average mark for test 2 of female students increased less than the male students, while they performed better than male students. Male students from Group A performed about 7% better than males in Group B, but the difference was insignificant. Furthermore, it can be noted that for the place of study, students studying in the library, in their residence and library, or the computer labs performed similarly for both groups. Contradictory, students from Group A who studied at their residence performed approximately 11% significantly better than Group B students studying at their residence, as was also illustrated in Figure 15.3.

5.7.3.3 ANCOVA results for Test 3 as the post-test score

Table 15.14 shows the initial ANCOVA results for students' performance on their third test. The regression slopes for the model fitted in Table 15.14, as illustrated in Figure 15.5, showed that the slopes for the regression line for gender are about the same for both groups. Furthermore, no interaction is present for Test 3.

When removing the insignificant interactions, the final results for Test 3 were described in Table 15.15, which showed that only the covariate, gender, differed significantly. Therefore, we can conclude that this covariate most likely influenced the students' test 3 marks. The pre-test scores, the type of accommodation where students stayed while studying, and the place where students preferred to study, on the other hand, were not significant covariates concerning their average test 3 marks.

Figure 15.6 illustrates the diagnostic plots for the linear model using the ANCOVA, as indicated in Table 15.15. The QQ-plot showed that the residuals are approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. For test 3, Levene's test for homogeneous variances (p-value = 0.0365 < 0.05) indicated no homogenous variances across the two groups and, thus, invalid ANCOVA results.

Table 15.16 illustrates the observed and adjusted average means for the variables Group and Gender, as was used for the ANCOVA indicated in Table 15.15.

When doing a sensitivity analysis for Test 3 (see Table 15.17), it seems that Table 15.15 gave the best model fit with the lowest BIC. The p-value of the multiple regression model from Table 15.18 generated a value of 0.0615, which indicates that the model fit is not significant here, *i.e.,* we cannot reject the hypothesis that none of the independent variables have a relationship with the dependent variable.

The *potential outcomes approach* generated a value of about four for the average treatment effect, *i.e.,* on average, a student gained about 4% through the treatment for test 3, but it was not a significant difference when controlling for other factors considered. These results were confirmed in Table 15.18, where the multiple regression coefficients were obtained when using test 3 scores as the post-test score. Table 15.18 showed that female students performed 7% significantly better than male students. It can also be noted that the place where students preferred to study, *e.g.,* the library, their residence, or both, showed significant differences that contributed positively towards their test 3 marks.

Table 15.19 reflected the average test 3 marks of the two groups for their respective gender and the place where students prefer to study. From Table 15.19, it can be concluded that for the average test 3 marks, female students performed better than male students in both groups, although the difference between the two groups for the two genders was approximately similar. Furthermore, it can be noted that students studying in the library performed similarly for both groups regarding their Test 3. Contradictory students from Group A who studied at their residence

performed about 11% significantly better than Group B students. Group B performed about 9% better than Group A when considering the study place as their residence and library, although it was insignificant.

5.7.3.4 ANCOVA results for Tutorials as the post-test score

Tables 15.20 & 15.21 showed the ANCOVA results for the students' performance regarding their tutorial marks. Table 15.21 gives the best model fit (see Table 15.22) for tutorials and reflects a significant difference between the tutorial marks of both the covariate, gender, and the variable group. On the other hand, the pre-test scores, the place they stayed when studying, and where they studied were not significant covariates of their average tutorial marks. The regression slopes for the model in Table 15.20, as illustrated in Figure 15.7, showed no interaction between the group and the other covariates.

Figure 15.8 illustrates the diagnostic plots for the linear model when using the ANCOVA, as indicated in Table 15.21. The QQ-plot showed that the residuals are approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. Since there was no evident relationship between the residuals and fitted values, it implies a constant variance across the two groups, as was stated with Levene's test for homogeneous variances (p-value = 0.2322 > 0.05). Thus, valid ANCOVA results will be obtained.

When doing a sensitivity analysis for tutorials (see Table 15.22), it seems that Table 15.21 gave the best model fit with the lowest BIC. The p-value of the multiple regression model from Table 15.19 generated a value of 0.0172, which indicates that the model fit is significant here, *i.e.,* at least one of the predictor variables has a coefficient different from zero.

Here, the *potential outcomes approach* generated a value of 10.7% for the average treatment effect, *i.e.,* on average, a student gained about 11% through the treatment. These results were confirmed in Tables 15.24 & 15.25. Table 15.23 illustrates the observed and adjusted average means from the model illustrated in

Table 15.21. Looking at Table 15.24 for multiple regression, Group A performed about 11% significantly better than Group B. Furthermore, females also performed about 7% better than male students, but there was no significant difference. It can also be noted that only the library, where students preferred to study, had a significant difference, contributing positively to their tutorial marks.

Table 15.25 reflects the average tutorial marks of the two groups for their respective gender and the place where students prefer to study. Table 15.25 shows that Group A's male students performed about 15% significantly better than males in Group B. The female students in Group A performed about 4% better than the females in Group B. Furthermore, it can be noted that students studying in the library performed about the same for both groups for the place of study. Contradictory, students from Group A who studied at their residence performed about 18% significantly better than Group B students studying at their residence. Both groups performed about the same when considering the place of study as their residence and library, and when studying in the computer labs, it also did not produce significant differences.

5.7.3.5 ANCOVA results for Practicals as the post-test score

Tables 15.26 & 15.27 showed the ANCOVA results for the students' performance regarding their practical marks. Table 15.27 gives the best model fit (see Table 15.28) for practicals and reflects a significant difference between the practical marks of both the covariate, gender, and the variable group. It can thus be concluded that the effect of the group depends on their gender. On the other hand, the pre-test scores, the place they stayed when studying, and where they studied were not significant covariates of their average practical marks. The regression slopes for the model in Table 15.26, as illustrated in Figure 15.10, showed no interaction between the group and the other covariates.

Initially, there was a significant interaction between group and gender. When doing a sensitivity analysis for the practical scores (see Table 15.28), it seems that Table 15.27 gave the best model fit with the lowest BIC. The p-value of the multiple

regression model from Table 15.31 generated a value of 0.0133, which indicates that the model fit is significant here, *i.e.,* at least one of the predictor variables is significantly related to their practical marks.

Figure 15.9 illustrates the diagnostic plots for the linear model when using the ANCOVA, as indicated in Table 15.27. The QQ-plot showed that the residuals approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. Since there was no evident relationship between the residuals and fitted values, it implies a constant variance across the two groups, as was stated with Levene's test for homogeneous variances (p-value = 0.0755 > 0.05). Thus, valid ANCOVA results will be obtained.

Table 15.29 reflects the two groups' average practical marks for their respective gender and the place where students prefer to study. Table 15.29 shows that male students from Group A performed about 17% significantly better than males in Group B, although female students performed about the same for the two groups. Furthermore, it can be noted that for the place of study, students studying at their residence performed 17% significantly better than Group B students studying at their residence compared to the other places students preferred to study.

The multiple regression coefficients were illustrated in Table 15.31 using students' practical scores as the post-test score. From Table 15.31, it can be derived that for their practical scores, Group B performed about 12% lower than Group A, which was a significant difference when controlling for the other factors considered. Furthermore, male students performed 9% significantly lower than female students. It can also be noted that the place where students preferred to study, *e.g.,* the library or their residence and library, also showed significant differences that contributed positively to their practical marks.

5.7.3.6 ANCOVA results for Assignments as the post-test score

Tables 15.32 & 15.33 showed the ANCOVA results for the students' performance regarding their assignments marks. Table 15.33 gives the best model fit (see Table

15.34) for assignments and reflects a significant difference between the assignment marks of both the covariate, gender, and the variable group. It can thus be concluded that the effect of the group depends on their gender. On the other hand, the pre-test scores, the place they stayed when studying, and where they studied were not significant covariates of their average assignment marks. The regression slopes for the model in Table 15.32, as illustrated in Figure 15.11, showed no interaction between the group and the other covariates.

From Table 15.33, a highly significant difference for the group is reflected, and therefore, we can conclude that gender most likely influenced the students' average assignment marks.

Figure 15.12 illustrates the diagnostic plots for the linear model using the ANCOVA, as indicated in Table 15.33. The QQ-plot showed that the residuals are approximately normally distributed. The other plots showed no apparent patterns in the residuals, *i.e.*, an acceptable linearity assumption. Levene's test for homogeneity of variance produced a p-value = 0.0081 < 0.05, which indicated no homogenous variances across the two groups and, thus, invalid ANCOVA results.

Here, the *potential outcomes approach* generated a value of 12.8550 for the average treatment effect, *i.e.,* on average, a student gained about 13% through the treatment. These results were confirmed in Table 15.36. From Table 15.36, it can be derived that for their assignment scores, Group B performed about 13% lower than Group A, which was a significant difference when controlling for the other factors considered. Furthermore, male students performed 8% lower than female students, which was also a significant difference.

Table 15.35 illustrates the observed and adjusted average means for the significant variables Group, Gender, and Study Place Preference, as was used for the ANCOVA indicated in Table 15.33.

When doing a sensitivity analysis for Assignments (see Table 15.34), it seems that Table 15.33 gave the best model fit with the lowest BIC. The p-value of the multiple

regression model from Table 15.36 generated a value of 0.0111, which indicates that the model fit is significant here, *i.e.,* at least one of the predictor variables is significantly related to assignment marks.

Table 15.37 reflects the two groups' average assignment marks for their respective genders. Their place of study preferred as their residence once again differed significantly compared to studying at the computer labs or the library.

5.8 Measuring student engagement

5.8.1 Student engagement measurements with BUSSE

Table 5.12 provides the aggregated average values of the nine BUSSE scales for the students who completed the survey and were part of this research. These scales give the expectations of the students of this research. These scales are calculated to provide insight into first-year students' competencies and expected experiences. Important information is reflected regarding high school engagement and effective learning strategies in high school (Quantitative Reasoning and Learning Strategies), and the other scales are about expected first-year academic engagement and academic performance.

From Group A, only 28 students completed the BUSSE questionnaire, and 25 from Group B.

Scoring the benchmarks is done by expressing the scales on a 60-point scale (*e.g.,* Never = 0, Sometimes = 20, Often = 40, and Very Often = 60), then averaged together to calculate a scale for each engagement indicator.

Table 5.12: BUSSE measurements

	Average Scale (out of 60)		**p-values (t-test)**
	Group A (n=28)	**Group B** (n=25)	
High School Engagement			
Quantitative Reasoning	30	27	0.3212

Learning Strategies	35	37	0.5592
First-year			
Collaborative Learning	39	37	0.5298
Student-Staff Interaction	24	20	0.1979
Discussions with Diverse others	**42**	**41**	0.7569
Academic Perseverance	**43**	38	0.1166
Academic Difficulty	29	27	0.6492
Academic Preparation	**46**	**43**	0.4015
Importance of Campus Environment	**43**	**40**	0.3950

Significant p – value * 0.001; ** 0.01; * 0.05**

An overview from Table 5.12 showed that looking at their first year of study, Group A seems very confident about four subscales, Academic Preparation (M = 46), Academic Perseverance (M = 43), Importance of Campus Environment (M = 43), and Discussions with Diverse Others (M = 42) with mean scores above 40. For Group B, the subscales, Discussions with Diverse Others, Academic Preparation, and Importance of Campus Environment, had relatively high mean scores (values above 40). It shows that first-year students expect to interact with people with different views independently (scores of 42 and 41, respectively). They are also confident in persevering in their studies when things are tough (Academic Perseverance). There is a wide gap between how difficult students think university study will be and how well-prepared students believe they are (SASSE 2015:36).

In contrast, a much lower average of 30 or less for both groups indicates that students are not as confident in their Quantitative Reasoning abilities developed in high school. It may become a cause of concern inside HE and for many stakeholders outside HE. Student-Staff interaction is the lowest scale for both groups. Students generally do not expect to interact much with lecturers during their first year of study (Strydom *et al*. 2017:63).

The Academic Difficulty scale consists of items like how difficult students think learning subject material is, managing their time, paying university expenses, getting help with academic work, and making new friends (Strydom *et al*. 2017:65). In this research, both groups are not confident in their perception of academic difficulty during their first year, indicated by their scores, 29 and 27.

There is a wide gap between how difficult students think university is (Academic Difficulty) and how well-prepared students believe they are (Academic Preparation). These findings emphasise the importance of possible interventions to help students become more realistic about their expectations and abilities without demoralising them (SASSE 2015:37).

Students seem very confident about their academic preparation for both groups (M = 46 and M = 43, respectively, for the two groups). Questions for this scale consisted of how prepared students are to write clearly and effectively, speak clearly and effectively, think critically and analytically, analyse numerical and statistical information, work productively with others, use computing and information technology, and learn effectively on their own. Strydom *et al.* (2017:63) showed that all students, irrespective of gender or race, believed they were well prepared to master their first year of study, as this was the case for this scale.

It can also be noted that Group A, the experimental group, has higher scores than the other group, but none of the measurements differed significantly when performing a t-test, as illustrated in Table 5.12.

An ANCOVA compared their final marks to the above variables, Quantitative Reasoning, Learning Strategies, Collaborative Learning, Student-Staff Interaction, Discussions with Diverse others, Academic Perseverance, Academic Difficulty, Academic Preparation, and Importance of Campus Environment. The results are given in Table 5.13.

Table 5.13: ANCOVA - Final marks as the dependent variable in comparison to BUSSE measurements

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	78	78.1	0.408	0.5264
Gender	1	2	2.5	0.013	0.9103
Quantitative Reasoning	1	831	830.7	4.343	0.0434 *
Learning Strategies	1	8	8.0	0.042	0.8393
Collaborative Learning	1	624	624.0	3.262	0.0782
Student-Staff Interaction	1	434	433.7	2.267	0.1398

Discussions with Diverse others	1	110	110.4	0.577	0.4517
Academic Perseverance	1	7	7.1	0.037	0.8485
Academic Difficulty	1	30	30.4	0.159	0.6921
Academic Preparation	1	17	17.1	0.089	0.7664
Importance of Campus Environment	1	44	43.6	0.228	0.6355

Significant p – value * 0.001; ** 0.01; * 0.05**

From Table 5.13, it can be concluded that only Quantitative Reasoning significantly impacts students' final marks.

5.8.2 Student engagement measurements with the researcher's questionnaire

The researcher used the following themes based on SASSE, but only specific questions related to her research were used to evaluate the student engagement for the students of the two respective groups:

5.8.2.1 Theme 1: Active and collaborative learning

Table 5.14 summarises the participants' responses for each group regarding this theme.

Table 5.14: Number of participants in active and collaborative learning

		Group A	Group B	p-value
How often did you ask questions to fellow students during your class?	Never	12	11	0.87
	Weekly	18	18	
	Daily	24	19	
	Multiple times per class	7	9	
	Did not respond	6	10	
	Total	**67**	**67**	

How did you communicate with fellow students when you did not understand certain concepts?	E-mail Face-to-face in class Outside class WhatsApp (phone) Never	5 17 25 36 2	5 30 18 44 0	0.15
Did you tutor fellow students?	Yes No Did not respond	24 37 6	19 39 9	0.57
	Total	**67**	**67**	
Communicate with fellow students outside of class	Hinder your learning Improve your learning No effect on your learning Did not respond	1 48 8 10	2 43 10 12	0.63
	Total	**67**	**67**	
Interaction with fellow students during class	Hinder your learning Improve your learning No effect on your learning Did not respond	13 34 10 10	14 32 10 11	0.97
	Total	**67**	**67**	
Tutoring fellow students	Hinder your learning Improve your learning No effect on your learning Did not respond	4 32 18 13	3 29 18 17	0.95
	Total	**67**	**67**	
How often did you use technology to communicate with fellow students when you did not understand certain concepts?	Never Sometimes Often Always Did not respond	3 12 22 25 5	1 17 17 21 11	0.47
	Total	**67**	**67**	

Significant p – value * 0.001; ** 0.01; * 0.05**

Close inspection of Table 5.14 reveals that the p-values did not show significant differences regarding the variables considered for this theme. Thus, it serves as evidence that students' profiles regarding active and collaborative learning in the

two groups were similar and were thus comparable; therefore, it could be concluded that there was no evidence that randomisation was not done successfully.

Furthermore, it can be noted that 53.7% (36 of 67 students) in Group A and 66.7% (44 of 67 students) in Group B used WhatsApp to communicate with fellow students when they did not understand certain concepts. The vast majority of Group A students (84.2%) also revealed that communicating with fellow students outside class improved their learning, while 78.2% of Group B indicated that communicating outside class improved their learning. Most students in both groups indicated that tutoring fellow students improved their learning in both groups.

The researcher then investigated whether the treatment affected the outcomes while controlling for key covariates defined in Table 5.14. The results of fitting an ANCOVA for this theme are given in Table 5.15.

Table 5.15: ANCOVA - Average final mark as the post-test score when considering active learning

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	365	365	2.007	0.1606
Gender	1	2540	2540	13.981	0.00035***
How often do students ask questions during class to fellow students	3	1377	459	2.526	0.0636
Students communicate via e-mail with fellow students when they do not understand certain concepts	1	256	256	1.410	0.2387
Students communicate face-to-face in class with fellow students when they do not understand certain concepts	1	104	104	0.573	0.4514
Students communicate outside class with fellow students when they do not understand certain concepts	1	268	268	1.473	0.2286

Students communicate via WhatsApp with fellow students when they do not understand certain concepts	1	285	285	1.566	0.2146
Students never communicate with fellow students when they do not understand certain concepts	1	285	285	1.566	0.2145
Communication with fellow students outside class influenced their learning	2	618	309	1.700	0.1895
Interaction with fellow students during class influenced their learning	2	503	251	1.383	0.2569
Tutoring fellow students	1	3873	3873	21.315	0.00002***
How tutoring fellow students influenced their learning	2	370	185	1.019	0.3658
Students use technology to communicate with fellow students when they do not understand certain concepts	3	265	88	0.487	0.6924
Group*Gender	1	725	725	3.992	0.0492*
Residuals	77	13990	182		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.15 shows significant p-values for gender, tutoring fellow students, and the interaction between group and gender, which will be explored below.

Multiple regression was applied to identify possible explanatory factors for active learning to isolate the treatment's effect while keeping other factors constant. The results of the multiple regression coefficients, using the students' final scores as the post-test score, are illustrated in Table 5.16.

Table 5.16: Coefficients from multiple regression for the final mark as the post-test score when considering active learning

	Estimate	**p-value**
Intercept	75.2316	0.0000***
Group B	2.5576	0.5352
Gender – Male	-3.4460	0.4192
Students ask questions multiple times during class to their fellow students	-9.6702	0.0334*

Students never ask questions during class to fellow students	3.2007	0.5813
Students weekly ask questions during class to fellow students	-2.1898	0.5507
Students communicate by e-mail with fellow students when they do not understand concepts	6.4844	0.3256
Students communicate face-to-face in class with fellow students when they do not understand certain concepts	-2.3495	0.4630
Students communicate outside class with fellow students when they do not understand certain concepts	3.9608	0.2305
Students communicate via WhatsApp with fellow students when they do not understand certain concepts	-4.1908	0.2316
Students never communicate with fellow students when they do not understand certain concepts	-14.3473	0.3477
Communication with fellow students outside class improved their learning	-14.5797	0.1898
Communication with fellow students outside class did not affect their learning	-19.8741	0.0894
Interaction with fellow students during class improved their learning	6.7808	0.0611
Interaction with fellow students during class did not affect their learning	4.6071	0.3339
Students tutored fellow students	12.0839	0.0014**
Tutoring fellow students improved students' learning	-1.5840	0.8045
Tutoring fellow students did not affect students' learning	-5.7405	0.3663
Students never use technology to communicate with fellow students when they do not understand certain concepts	-2.7414	0.8017
Students often use technology to communicate with fellow students when they do not understand certain concepts	-3.5869	0.3142
Students sometimes use technology to communicate with fellow students when they do not understand certain concepts	0.9755	0.8178
Group B*Male students	-11.8108	0.0492*

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.16 showed similar results to Table 5.15. By removing variables with insignificant p-values, the results for the final ANCOVA are shown in Table 5.17, as determined with the lowest BIC illustrated in Table 5.19. The model resulted from fitting multiple regression with the same variables as Table 5.17 is given in Table 5.18.

Table 5.17: ANCOVA - Average final mark as the post-test score when considering final variables for active learning

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	365	365	1.903	0.1711
Gender	1	2540	2540	13.257	0.0005***
How did communication with fellow students outside class influence their learning	2	838	419	2.187	0.1181
Tutoring fellow students	1	4358	4358	22.744	<0.000***
Tutoring fellow students influences their learning	2	363	181	0.946	0.3920
Did students communicate with WhatsApp with fellow students when they did not understand concepts	1	115	115	0.601	0.4402
Residuals	90	17244	192		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.18: Coefficients from multiple regression for the final mark as the post-test score when considering final variables for active learning

	Estimate	p-value
Intercept	74.1651	<0.000***
Group B	-4.1073	0.1547
Gender – Male	-9.2471	0.0035**
How did communication with fellow students outside class improve their learning	-8.7453	0.4106
How did communication with fellow students outside class have no effect on their learning	14.6479	0.1800
Tutor students - Yes	11.6964	0.0007***
Tutoring fellow students improved their learning	-0.9143	0.8794
Tutoring fellow students had no effect on their learning	-5.2647	0.3812
Students did communicate with WhatsApp with fellow students when they did not understand concepts	-2.4036	0.4402

Significant p – value * 0.001; ** 0.01; * 0.05**

The ANCOVA for the final model, as illustrated in Table 5.17, illustrates significant differences between gender and tutoring fellow students. As illustrated in Table 5.18, the results from multiple regression show similar results where tutoring fellow students' significantly improved their final marks by about 12%. Furthermore, female

students performed about 9% significantly better than male students when controlling for the other covariates.

Table 5.19: Model fitting for the final scores when considering active learning

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Gender, Students communicate via WhatsApp with fellow students when they do not understand certain concepts, Communication with fellow students outside class influenced their learning, Students tutor peers, Tutoring fellow students influenced their learning.	17244	812	**838**	0.332	0.273	<0.000***
Group, Gender, Students communicate via WhatsApp with fellow students when they do not understand certain concepts, Communication with fellow students outside class influenced their learning, Students tutor peers, Tutoring fellow students influenced their learning, Communication with fellow students f2f in class when they do not understand concepts, Did the students use technology to communicate with fellow students when they did not understand certain concepts.	16890	818	854	0.346	0.255	0.0001***
The initial model, as illustrated in Table 5.16	13990	817	877	0.458	0.310	0.0001***

In Table 5.20, cross-tabulation for students' average final scores was done between the two groups when tutoring their fellow students.

Table 5.20: Post-test marks for the two groups when tutoring fellow students

Tutoring students	Group A	Group B	p-value (t-test)
Yes	69.83 (n=24)	63.42 (n=19)	0.0774
No	51.81 (n=37)	51.77 (n=39)	0.9911
Total (n)	61	58	
p-value (t-test)	<0.000***	0.0085**	

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.20 shows that the two groups' average post-test marks did not significantly differ whether tutoring their fellow peers or not. However, the average post-test scores when tutoring fellow peers for each group were significantly higher than when not tutoring fellow students. When tutoring fellow students, their average final score seems to increase irrespective of the group, but strong students are more likely to tutor less able students. They are not strong because they tutor, they tutor because they are strong.

A two-way ANOVA with variables Group and Tutoring students is illustrated in Tables 5.21 & 5.22, with its model fitting illustrated in Table 5.23 to establish any evidence of the effects of these two variables. Table 5.24 illustrates the results of fitting multiple regression to Group and Tutoring with their final marks as post-test scores.

Table 5.21: ANOVA for Post-test marks of the two groups when tutoring fellow students regarding group and interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	327	327	1.515	0.221
Tutoring fellow students	1	6187	6187	28.674	<0.000***
Group*Tutoring fellow students	1	276	276	1.280	0.260
Residuals	115	24813	216		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.22: ANOVA for Post-test marks of the two groups when tutoring fellow students regarding group without interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	327	327	1.511	0.221
Tutoring fellow students	1	6187	6187	28.605	<0.000***
Residuals	116	25089	216		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.23: Model fitting for the final scores when tutoring fellow students regarding group

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Tutoring fellow students, Group*Tutoring fellow students	24813	983	997	0.2148	0.1944	<0.000***
Group, Tutoring fellow students	25089	982	**994**	0.2061	0.1924	<0.000***

From Table 5.23, it is clear that Table 5.22 will be the best model fitted where the lowest BIC was generated. Table 5.22 confirms that the group does not differ significantly like was previously established. When looking at Table 5.24, it is possible that tutoring fellow students improved final scores significantly, but group does not play a role.

Table 5.24: Coefficients from multiple regression for the final mark as the post-test score when considering tutoring fellow students according to group

	Estimate	p-value
Intercept	52.982	<0.000***
Group B	-2.325	0.392
Tutoring fellow students - Yes	15.045	<0.000***

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 5.25 illustrates the average final scores of participants gender according to whether they tutored fellow students.

Table 5.25: Post-test marks for gender when tutoring fellow students

Tutoring students	Female	Male	p-value (t-test)
Yes	68.62 (n=21)	65.45 (n=22)	0.3665
No	56.97 (n=35)	47.37 (n=41)	0.0080**
Total (n)	56	63	
p-value (t-test)	0.0002***	0.00003***	

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.25 shows that students' average post-test scores were similar when tutoring their fellow students regardless of gender. Interestingly, female students' average scores who did not tutor their peers were significantly higher than male students who did not tutor. Furthermore, students, irrespective of gender, who tutored their fellow students have a significantly higher average final mark than students who did not tutor their fellow students.

A two-way ANOVA with variables Gender and Tutoring students will be illustrated in Tables 5.26 & 5.27, with its model fitting illustrated in Table 5.28 to establish any evidence of the effects of these variables mentioned. Table 5.29 illustrates the results of fitting multiple regression to Group and Tutoring with their final marks as post-test scores.

Table 5.26: ANOVA for Post-test marks of Gender when tutoring fellow students

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Gender	1	1738	1738	8.542	0.00418**
Tutoring fellow students	1	6181	6181	30.379	<0.000***
Gender*Tutoring fellow students	1	284	284	1.396	0.2398
Residuals	115	23399	203		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.27: ANOVA for Post-test marks of Gender when tutoring fellow students without interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Gender	1	1738	1738	8.513	0.0042**
Tutoring fellow students	1	6181	6181	30.276	<0.000***

Residuals	116	23683	204		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.28: Model fitting for the final scores when tutoring fellow students for gender

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Gender, Tutoring fellow students, Gender*Tutoring fellow students	23399	976	990	0.2596	0.2403	<0.000***
Gender, Tutoring fellow students	23683	976	**987**	0.251	0.238	<0.000***

The results from Tables 5.27 and 5.29 show that gender and tutoring fellow students show significant differences, but it seems that group is not different when students tutor their peers. The p-value of the multiple regression model from Table 5.27 indicates that the model fitted is significant, *i.e.,* at least one of the predictor variables is significantly related to final scores.

Table 5.29: Coefficients from multiple regression for the final mark as the post-test score when considering tutoring fellow students

	Estimate	p-value
Intercept	55.711	<0.000***
Gender Male	-7.270	0.0065**
Tutoring fellow students - Yes	15.008	<0.000***

Significant p-value * 0.001; ** 0.01; * 0.05**

It can be argued that the impact of student learning is through engagement with peers for both groups (peer tutoring), as is evident here. They are thus learning by teaching, although it can result in “the blind leading the blind” at its worst. It can be concluded that collaboration between students occurred when they learned from each other. The lecturer created a learning community. It is aligned with the literature on the value of peer learning as a contributor to student success.

5.8.2.2 Theme 2: Student-Staff interaction

Table 5.30 gives the participants' responses regarding student-staff interaction for this study.

Table 5.30: Number of participants interacting with the lecturer inside and outside of the classroom

		Group A	Group B	p-value
How often did you ask questions to your lecturer during your class?	Never	44	36	0.42
	Weekly	15	17	
	Daily	1	3	
	Multiple times per class	1	3	
	Did not respond	6	8	
	Total	**67**	**67**	
How did you communicate with your lecturer when you did not understand certain concepts?	E-mail	12	10	0.40
	Face-to-face in class	12	15	
	WhatsApp	42	33	
	Never	6	11	
Your lecturer	Hinder your learning	1	2	0.50
	Improve your learning	48	49	
	No effect on your learning	7	3	
	Did not respond	11	13	
	Total	**67**	**67**	
Did you receive prompt feedback regarding your academic performance from the lecturer?	Yes	46	42	1.00
	No	14	14	
	Did not respond	7	11	
	Total	**67**	**67**	
How did you communicate with your lecturer when discussing marks on assessments?	E-mail	5	6	0.24
	Face-to-face in class	17	23	
	Outside class	1	0	
	WhatsApp	19	13	
	Email & WhatsApp	1	3	
	Face-to-face & WhatsApp	1	3	
	Email & Face-to-face	1	0	
	Never	17	9	

How often did you use technology to communicate with your lecturer when you did not understand certain concepts?	Never Sometimes Often Always Did not respond	7 24 23 8 5	13 25 16 4 9	0.24
	Total	**67**	**67**	

Significant p – value * 0.001; ** 0.01; * 0.05**

Multiple regression was applied to identify possible explanatory factors for student-staff interaction to isolate the treatment's effect while keeping other factors constant. The results of the multiple regression coefficients, using the students' final scores as the post-test score, are illustrated in Table 5.31.

Table 5.31: Coefficients from multiple regression for the final mark as the post-test score concerning the interaction with the lecturer

	Estimate	**p-value**
Intercept	40.6699	0.0106*
Group B	-6.8439	0.0348*
Gender – Male	-10.6990	0.00066***
Students ask questions multiple times during class to the lecturer	-1.9568	0.8622
Students never ask questions during class to the lecturer	2.0402	0.8211
Students weekly ask questions during class to the lecturer	2.3917	0.7911
Students communicate via e-mail with the lecturer when they do not understand certain concepts	8.5909	0.1797
Students communicate face-to-face in class with the lecturer when they do not understand certain concepts	11.3667	0.0252*
Students communicate via WhatsApp with the lecturer when they do not understand certain concepts	8.6811	0.1470
Students never communicate with the lecturer when they do not understand certain concepts	14.6504	0.0649
Students received prompt feedback from the lecturer	2.9264	0.4161
Students communicate face-to-face and by e-mail when discussing marks on their assessments with the lecturer	-17.4210	0.2951
Students communicate via WhatsApp and e-mail when discussing marks on their assessments with the lecturer	-12.6001	0.1679
Students communicate with WhatsApp and face-to-face when discussing marks on their assessments with the lecturer	5.0623	0.6024

Students communicate face-to-face when discussing marks on their assessments with the lecturer	-5.3001	0.3806
Students never communicate with the lecturer when discussing marks on their assessments	-6.4425	0.2952
Students communicate with WhatsApp when discussing marks on their assessments with the lecturer	-11.6133	0.0767
The lecturer influenced learning by improving learning	22.9882	0.0163*
The lecturer did not influence the learning	9.7311	0.3263
Students never used technology to communicate with the lecturer when they did not understand certain concepts	-11.5682	0.0923
Students often use technology to communicate with the lecturer when they do not understand certain concepts	-0.5556	0.9137
Students sometimes use technology to communicate with the lecturer when they do not understand certain concepts	-3.9009	0.4348

Significant p – value * 0.001; ** 0.01; * 0.05**

From Table 5.31, Group A performed significantly better (6.84%) than Group B regarding student-staff interaction. Furthermore, female students, students communicating with the lecturer face-to-face in class when not understanding concepts, and students' perception of whether the lecturer improved their learning also showed significant improvements in the student-staff interaction theme.

Table 5.32 gives ANCOVA results where final scores were used with the different variables regarding interacting with the lecturer.

Table 5.32: ANCOVA - Average final mark as the post-test score considering interaction with the lecturer

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	663	663.4	3.541	0.0636
Gender	1	2738	2738.4	14.615	0.0003***
How often do students ask questions during class to the lecturer?	3	1021	340.4	1.817	0.1510
Students communicate via e-mail with the lecturer when they do not understand certain concepts	1	2	1.5	0.008	0.9286

Students communicate face-to-face in class with the lecturer when they do not understand certain concepts	1	601	600.5	3.205	0.0773
Students communicate via WhatsApp with the lecturer when they do not understand certain concepts	1	1187	1186.7	6.334	0.0139*
Students never communicate with the lecturer when they do not understand certain concepts	1	72	71.8	0.383	0.5377
Receiving prompt feedback from the lecturer	1	929	929.2	4.959	0.0409*
How students communicate with the lecturer when discussing marks on assessments	6	1148	191.3	1.021	0.3598
How did the lecturer influence students' learning?	2	1751	875.7	4.674	0.0091**
Students use technology to communicate with the lecturer when they do not understand certain concepts	3	707	235.6	1.257	0.3716

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.32 shows that the significant variables for this theme were:

- Gender,
- students communicating via WhatsApp with the lecturer,
- receiving prompt feedback from the lecturer, and
- students' perception of how the lecturer influenced students' learning.

When removing variables with insignificant p-values, the final results are shown in Tables 5.33 & 5.34, showing the best model fitting described in Table 5.35.

Table 5.33: Final ANCOVA - Average final mark as the post-test score with interaction with the lecturer (BIC=848)

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	682	682.3	3.648	0.0592
Gender	1	2691	2691.0	14.388	0.0003***
Students communicate face-to-face in class with the lecturer when they do not understand certain concepts.	1	766	766.2	4.097	0.0458*
Students communicate via WhatsApp with the lecturer when they do not understand certain concepts.	1	1260	1260.2	6.738	0.0110*
Receiving prompt feedback from the lecturer	1	1180	1180.4	6.311	0.0137*
How did the lecturer influence students' learning?	2	1486	742.9	3.972	0.0221*
Residuals	93	17394	187.0		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.34: Final ANCOVA: Average final mark as the post-test score with interaction with the lecturer (BIC=844)

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	682	682.3	3.664	0.0586
Gender	1	2691	2691.0	14.451	0.0003***
Students communicate face-to-face in class with the lecturer when they do not understand certain concepts.	1	766	766.2	4.115	0.0453*
Receiving prompt feedback from the lecturer	1	1485	1485	7.975	0.0058**
How did the lecturer influence students' learning?	2	2332	1165.8	6.261	0.0028**
Residuals	94	17504	186.2		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.35: Model fitting for interaction with the lecturer

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Gender, Students communicate via WhatsApp with the lecturer when they do not understand certain concepts, Receiving prompt feedback from the lecturer, How did the lecturer influence students' learning?	18345	828	849	0.279	0.233	<0.000***
Group, Gender, Students communicate face-to-face in class with the lecturer when they do not understand certain concepts, students communicate via WhatsApp with the lecturer when they do not understand certain concepts, receiving prompt feedback from the lecturer, how did the lecturer influence students' learning?	17394	825	848	0.317	0.265	<0.000***
Group, Gender, Students communicate face-to-face in class with the lecturer when they do not understand certain concepts, Receiving prompt feedback from the lecturer, How did the lecturer influence students' learning?	17504	823	**844**	0.312	0.269	<0.000***

When including interaction, the BIC increased and was therefore not included in Table 5.35. The p-value of the multiple regression model from Table 5.35 generated a value of <0.000, which indicates that the model fitted is significant, *i.e.,* at least one of the predictor variables is significantly related to final marks.

The results of the multiple regression coefficients for the final model fitted, using the students' final scores as the post-test score, are illustrated in Table 5.36.

Table 5.36: Coefficients from multiple regression for the final mark as the post-test score concerning the interaction with the lecturer

	Estimate	**p-value**
Intercept	42.915	<0.000***
Group B	-6.770	0.0161*
Gender - Male	-10.411	0.0004***
Students communicate face-to-face in class with the lecturer when they do not understand certain concepts	7.445	0.0325*
Students received prompt feedback from the lecturer	5.618	0.0900
The lecturer influenced learning by improving learning	19.712	0.0186*
The lecturer did not influence the learning	6.317	0.4924

Significant p – value * 0.001; ** 0.01; * 0.05**

From Table 5.36, Group A performed about 7% significantly better than Group B regarding student-staff interaction. Therefore, it can be illustrated that the FC approach is an effective teaching practice as student engagement increases regarding the student-staff theme. Furthermore, Table 5.35 shows that female students, students communicating with the lecturer face-to-face in class when not understanding concepts, and students indicating that the lecturer improved their learning also significantly improved their final marks for this theme.

In Table 5.37, the average final marks were considered for the two groups where students indicated that they used WhatsApp to interact with the lecture when they did not understand certain concepts.

Table 5.37: Post-test marks when students use WhatsApp to interact with the lecturer of the two groups

Using WhatsApp to interact with the lecturer	**Group A**	**Group B**	**p-value (t-test)**
Yes	60.48 (n = 42)	59.45 (n = 33)	0.7660
No	56.14 (n = 21)	48.96 (n = 25)	0.1858
p-value (t-test)	0.281	0.0401*	

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 5.37 shows no significant difference between Groups A and B, whether they used WhatsApp or not to communicate with their lecturer. However, Group B showed a significantly higher difference in their average final scores when using WhatsApp than students not using WhatsApp to communicate with their lecturer. It is clear that the use of technology is also present in the traditional class approach. Group A also had a higher average final score, but it differed insignificantly from students not using WhatsApp to communicate with the lecturer.

A two-way ANOVA for the variables from Table 5.37 is given below in Table 5.38, and the multiple regression results are summarised in Table 5.39. These tables confirm the results as indicated in Table 5.37. Table 5.40 confirms that the interaction between the two variables did not improve the model fit.

Table 5.38: Final ANOVA: Average final mark as the post-test score with interaction when communicating with WhatsApp with the lecturer regarding group

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	508	507.8	1.954	0.1648
Students communicate with WhatsApp with the lecturer when they do not understand certain concepts	1	1562	1561.6	6.010	0.0157*
Residuals	118	30662	259.8		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.39: Coefficients from multiple regression for the final mark as the post-test score when communicating with WhatsApp with the lecturer regarding group

	Estimate	p-value
Intercept	54.073	<0.000***
Group B	-3.374	0.2548
Students communicate with WhatsApp with the lecturer when they do not understand certain concepts -Yes	7.438	0.0157*

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.40: Model fitting for interaction with the lecturer via WhatsApp regarding group

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Students communicate via WhatsApp with the lecturer when they do not understand certain concepts*Group	30394	1022	1036	0.0714	0.0476	0.0335*
Group, Students communicate via WhatsApp with the lecturer when they do not understand certain concepts	30662	1021	**1032**	0.0632	0.0473	0.0212*

Table 5.41 showed the average final scores when students communicated via WhatsApp according to gender.

Table 5.41: Post-test marks of students when communicating via WhatsApp with the lecturer according to gender

	Female	Male	p-value (t-test)
Yes	63.9 (n = 40)	55.6 (n = 27)	0.0140*
No	55.5 (n = 16)	50.5 (n = 22)	0.3556
p-value (t-test)	0.0623	0.2713	

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.41 indicates that female students using WhatsApp to communicate with their lecturer performed significantly higher than male students using WhatsApp. Female and male students not using WhatsApp to communicate with their lecturer performed similarly. Tables 5.42 and 5.43 confirmed similar results.

Table 5.42: Final ANOVA: Average final mark as the post-test score when communicating with WhatsApp with the lecturer regarding gender

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Gender	1	2049	2049.4	8.19	0.00499**
Students communicate with WhatsApp with the lecturer when they do not understand certain concepts	1	1154	1153.7	4.61	0.0338*
Residuals	118	29528	250.2		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.43: Coefficients from multiple regression for the final mark as the post-test score when communicating with WhatsApp with the lecturer regarding gender

	Estimate	p-value
Intercept	56.880	<0.000***
Gender - Male	-7.117	0.0167*
Students communicate with WhatsApp with the lecturer when they do not understand certain concepts - Yes	6.467	0.0338*

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.44: Model fitting for interaction with the lecturer via WhatsApp regarding gender

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Gender, Students communicate via WhatsApp with the lecturer when they do not understand certain concepts*Group	29455	1018	1032	0.1	0.0770	0.0062*
Gender, Students communicate via WhatsApp with the lecturer when they do not understand certain concepts	29528	1017	**1028**	0.0979	0.0826	0.0023*

Table 5.45 shows the two groups' average final scores, where students perceived that their lecturer improved their learning according to their gender and group.

Table 5.45: Post-test marks of students indicating their learning improved from the lecturer according to the two groups and gender

	Group A	Group B	p-value (t-test)
Female	66.82 (n = 22)	63.33 (n = 27)	0.2124
Male	59.08 (n = 26)	51.18 (n = 22)	0.1369
p-value (t-test)	0.0297*	0.0162*	

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.45 indicated that female and male students for both groups had similar average final marks regarding their perception that the lecturer improved their learning. Female students from Group A differed significantly from male students in Group A. Similar results were derived for Group B. The two-way ANOVA results in Table 5.46 confirmed the above results. The results from fitting multiple regression for these variables are given in Table 5.47, where Group A performed about 6% better than Group B regarding these variables. Furthermore, female students performed about 9% better than male students, and lastly, students indicating the lecturer improved their learning also differed significantly.

Table 5.46: ANCOVA for Post-test marks of Gender and Group where students indicated that the lecturer improved their learning

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
Group	1	727	726.5	3.549	0.0624
Gender	1	3037	3036.6	14.833	0.0002***
How did the lecturer influence your learning	2	3246	1623.2	7.929	0.0006***
Residuals	105	21496	204.7		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.47: Coefficients from multiple regression for the final mark as the post-test score concerning if the lecturer improved their learning regarding group and gender

	Estimate	p-value
Intercept	43.711	<0.000***
Group B	-6.309	0.0242*
Gender - Male	-9.257	0.0011**
The lecturer influenced learning by improving learning	24.284	0.0047**
The lecturer did not influence the learning	10.362	0.2765

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.48: Model fitting for the final scores if the lecturer influenced students learning

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Gender, How did your lecturer influence your learning	21496	904	**921**	0.246	0.217	<0.000***
Group, Gender, How did your lecturer influence your learning, Group*How did your lecturer influence your learning, Gender*How did your lecturer influence your learning	20779	909	936	0.213	0.271	<0.000***

The p-value of the multiple regression model from Table 5.48 indicates that the model fitted is significant, *i.e.,* at least one of the predictor variables is significantly related to final scores.

To summarise, the respective groups did differ for theme 2 (Student-Staff interaction).

5.8.2.3 Theme 3: Enriching educational experiences

5.8.2.3.1 Perceptions of the FC approach

The intervention was discussed in section 5.6 (the FC approach). Furthermore, the students' perceptions using the FC approach were explored, as illustrated in Table 5.49.

Table 5.49: Participant's perceptions of the FC approach

	Disagree	Neutral	Agree	N
I would recommend the flipped classroom to a friend	12 (18.5%)	12 (18.5%)	41 (63.1%)	65
I like watching lectures with videos	3 (4.6%)	15 (23.1%)	47 (72.3%)	65
I like watching videos at my own pace	1 (1.6%)	5 (7.8%)	58 (90.6%)	64
I prefer flipped classroom to traditional teaching	8 (12.5%)	28 (43.8%)	28 (43.8%)	64
I am more motivated to learn during flipped classroom	7 (10.8%)	26 (40%)	32 (49.2%)	65

A flipped classroom makes it easier to understand course content	5 (7.7%)	22 (33.8%)	38 (58.5)	65
Fellow students distract my attention in a traditional class	10 (15.4%)	18 (27.7%)	37 (56.9)	65
The videos held my attention	3 (4.8)	20 (31.7%)	40 (63.5%)	63

Note N is the number of participants who responded.

From Table 5.49, results show that 90.6% of participants agreed that they liked watching video-lectures at their own pace (58 from 64 students). Furthermore, 72.3% of the students (47 from 65 students) indicated that they liked watching the video-lectures. 63.1% of the students indicated that they would recommend the FC approach to a friend and 63.5% of students indicated that the videos kept their attention.

Reliability analysis was performed on the eight items given in Table 5.49 Cronbach's α showed these items to reach acceptable reliability, α = 0.61 with a 95% confidence interval of [0.48;0.75]. Most items appeared to be worthy of retention**.**

5.8.2.3.2 Relationship of the different perceptions of the FC approach

Table 5.50 illustrates the relationship between the variables as defined in Table 5.49.

Table 5.50: Correlation matrix between variables defined in Table 5.49 with the corresponding p-values within brackets.

	I like watching lectures with videos	**I like watching videos at my own pace**	**I prefer flipped classroom to traditional teaching**	**I am more motivated to learn during flipped classroom**	**A flipped classroom makes it easier to understand course content**	**Fellow students distract my attention in a traditional class**	**The videos held my attention**
I would recommend the flipped classroom to a friend	0.2823 **(0.0731)**	0.0879 **(0.5692)**	0.2952 **(0.0406*)**	0.3617 **(0.0103*)**	0.1662 **(0.1952)**	0.0875 **(0.4078)**	0.1462 **(0.3514)**

I like watching lectures with videos		0.2058 **(0.0957)**	0.2256 **(0.0707)**	0.1173 **(0.3163)**	0.0817 **(0.5680)**	-0.0855 **(0.5026)**	0.0583 **(0.6147)**
I like watching videos at my own pace			0.0740 **(0.5513)**	-0.0264 **(0.8490)**	-0.0268 **(0.7886)**	-0.0039 **(0.9428)**	0.1569 **(0.2234)**
I prefer flipped classroom to traditional teaching				0.4841 **(0.00013***)**	0.2271 **(0.0869)**	0.1619 **(0.3476)**	0.2405 **(0.0597)**
I am more motivated to learn during flipped - classroom					0.4503 **(0.0002***)**	0.0441 **(0.5230)**	0.3120 **(0.0108*)**
A flipped classroom makes it easier to understand course content						0.0544 **(0.5537)**	0.1906 **(0.1208)**
Fellow students distract my attention in a traditional class							0.2612 **(0.0338*)**

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.50 illustrated that the correlations between the various variables are not very strong, but significant p-values from Table 5.50 illustrated that there was a correlation between:

- students would recommend the FC approach to a friend, and they preferred the FC approach to traditional teaching,

- they would recommend the FC approach and were more motivated to learn with the FC approach,
- students preferred the FC approach to traditional teaching, and were more motivated to learn with the FC approach,
- they were more motivated to learn with the FC approach and the FC approach made it easier to understand course content,
- they were motivated to learn during the FC approach and the videos held their attention, and
- students indicated that videos held their attention and fellow students distracted them in a traditional class.

From this study, it seems that the FC approach was welcomed by the students and had a positive effect on student motivation and understanding. Students can self-regulate their learning because they watch videos. This flexibility of the FC approach allows students to resort to self-paced learning according to their own needs.

5.8.2.3.3 Other factors that influence students learning

Table 5.51 indicates other factors the participants indicated influenced their learning of the two groups.

Table 5.51: Number of participants indicating other factors influencing learning

		Group A	Group B	p-value
Studying independently	Hinder learning	4	8	0.46
	Improve learning	47	43	
	No effect	6	4	
The use of technology	Hinder learning	-	6	0.043*
	Improve learning	54	47	
	No effect	3	4	
A large class	Hinder learning	34	34	0.92
	Improve learning	6	5	
	No effect	15	17	

Significant p – value * 0.001; ** 0.01; * 0.05**

Tables 5.52 and 5.53 give the correlations for other factors that influenced students' learning for the two groups.

Table 5.52: Pearson correlation matrix between variables influencing the students' learning (Group A) with corresponding p-values within brackets

	Interaction with fellow students during class	Tutoring fellow students	Your lecturer	Studying independently	The use of technology	A large class
Communication with fellow students outside of class	0.2325 (0.3990)	0.0443 (0.7550)	0.2639 (0.1780)	0.1441 (0.6796)	-0.0789 (0.5833)	-0.1219 (0.7584)
Interaction with fellow students during class		-0.0365 (0.8618)	-0.1260 (0.2877)	0.1351 (0.5545)	0.2040 (0.4386)	0.1672 (0.1877)
Tutoring fellow students			0.2948 (0.0679)	0.2796 (0.0395*)	0.3147 (0.1572)	0.0436 (0.7022)
Your lecturer				0.2729 (0.0599)	-0.0749 (0.4659)	-0.0675 (0.4631)
Studying independently					0.4690 (0.0183*)	-0.1025 (0.4412)
The use of technology						-0.1442 (0.1917)

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.52 shows that the correlations between the various variables are not very strong. It shows a significant correlation between studying independently and using technology for Group A. There is also a significant relationship between studying independently and tutoring fellow students.

Table 5.53: Pearson correlation matrix between variables influencing the students' learning (Group B) and the corresponding p-values

	Interaction with fellow students during class	Tutoring fellow students	Your lecturer	Studying independently	The use of technology	A large class
Communication with fellow students outside of class	0.3821 (0.0045**)	0.0778 (0.0879)	0.2576 (0.1175)	0.0441 (0.6544)	0.4787 (0.00008***)	-0.2211 (0.0916)
Interaction with fellow students during class		0.0859 (0.3952)	0.2381 (0.0806)	-0.1467 (0.8194)	0.2317 (0.0129*)	0.1634 (0.1786)
Tutoring fellow students			0.0743 (0.3556)	-0.0288 (0.4055)	0.1237 (0.0143*)	-0.0541 (0.3384)
Your lecturer				-0.0351 (0.6041)	0.1372 (0.0504)	-0.0659 (0.4659)
Studying independently					0.1930 (0.0239*)	-0.0869 (0.4653)
The use of technology						-0.4251 (0.0083**)

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.53 shows that the correlations between the various variables are not very strong but show significant correlations for Group B influencing their learning:

- between interacting with students inside and outside of class;
- between communicating with fellow students outside of class and the use of technology;
- between interacting with fellow students during class and the use of technology;
- tutoring fellow students and the use of technology;
- between studying independently and the use of technology, and

- negative correlation (-0.4251) between the use of technology and being in a large class.

As seen from the above correlations, collaborative learning also occurs in the traditional classroom setting. The greatest relationship indicates that students in the traditional approach also use technology when collaborating with peers.

5.8.3 Self-reported student engagement index

Here, a data-driven self-reported engagement score was derived from the survey questions identified as pertaining to such engagement. First, the researcher visualised the engagement for the two groups to see whether creating such a score is feasible and the directions make sense, as illustrated in Figure 5.12 through a bi-plot created from principal components analysis.

In Figure 5.12, the left indicates positively reported engagement, and the top reflects a technological tendency towards engagement (versus F2F engagement lower down). Interestingly, email is seen as a negative engagement - it might suggest that the student sometimes wishes to distance themselves from the lecturer by disengaging in the moment and instead writing an email later.

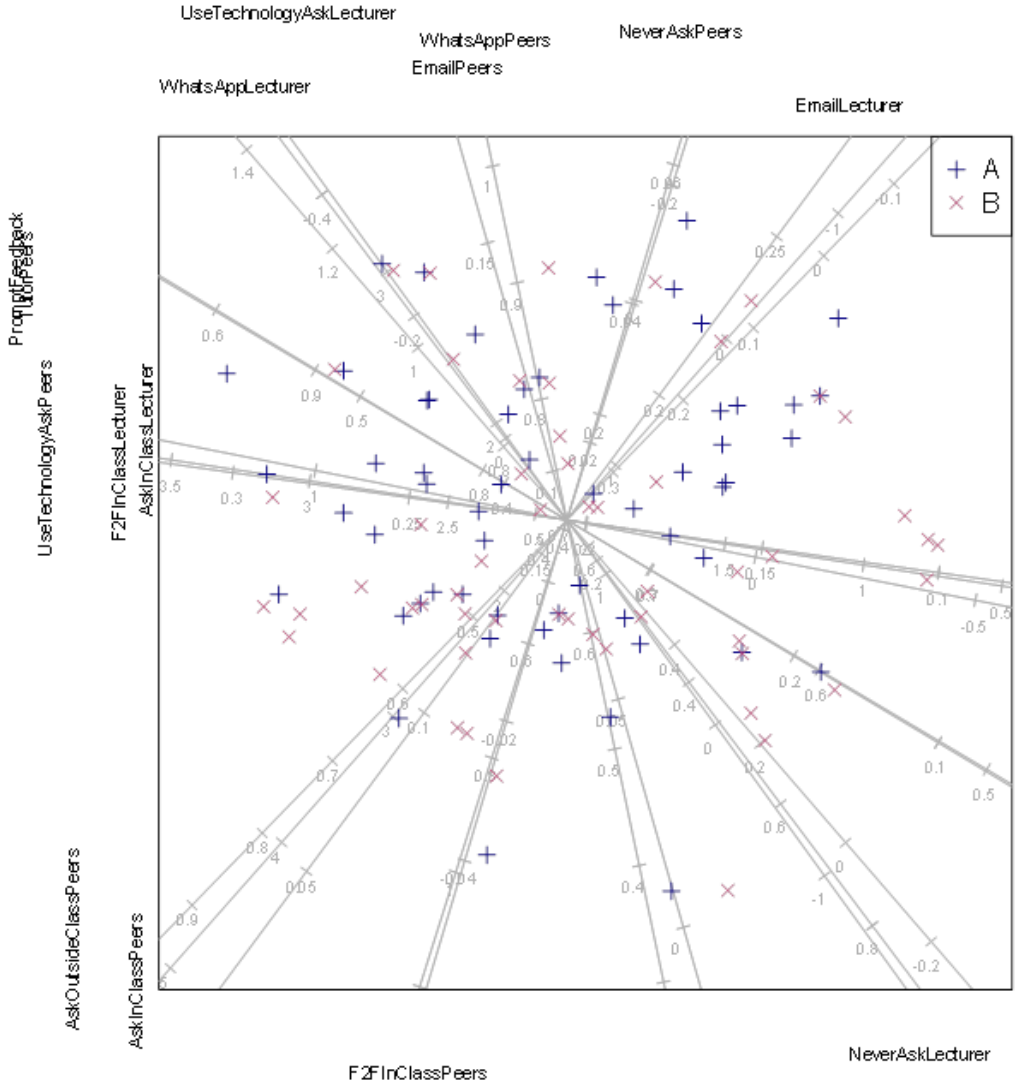


Figure 5.12: Bi-plot for self-reported engagement scores of the two groups

For this section, the researcher combined the questions using the following weights, which capture about 26% of the variation:

Variable	Weight
AskInClassLecturer	0.141
AskInClassPeers	0.255
EmailLecturer	-0.010
F2FInClassLecturer	0.018
WhatsAppLecturer	0.065
NeverAskLecturer	-0.051
EmailPeers	0.004
F2FInClassPeers	0.032

AskOutsideClassPeers	0.045
WhatsAppPeers	0.011
NeverAskPeers	-0.003
UseTechnologyAskPeers	0.228
UseTechnologyAskLecturer	0.203
TutorPeers	0.033
PromptFeedback	0.028

Now, consider the correlation with the marks as illustrated in Figure 5.13.

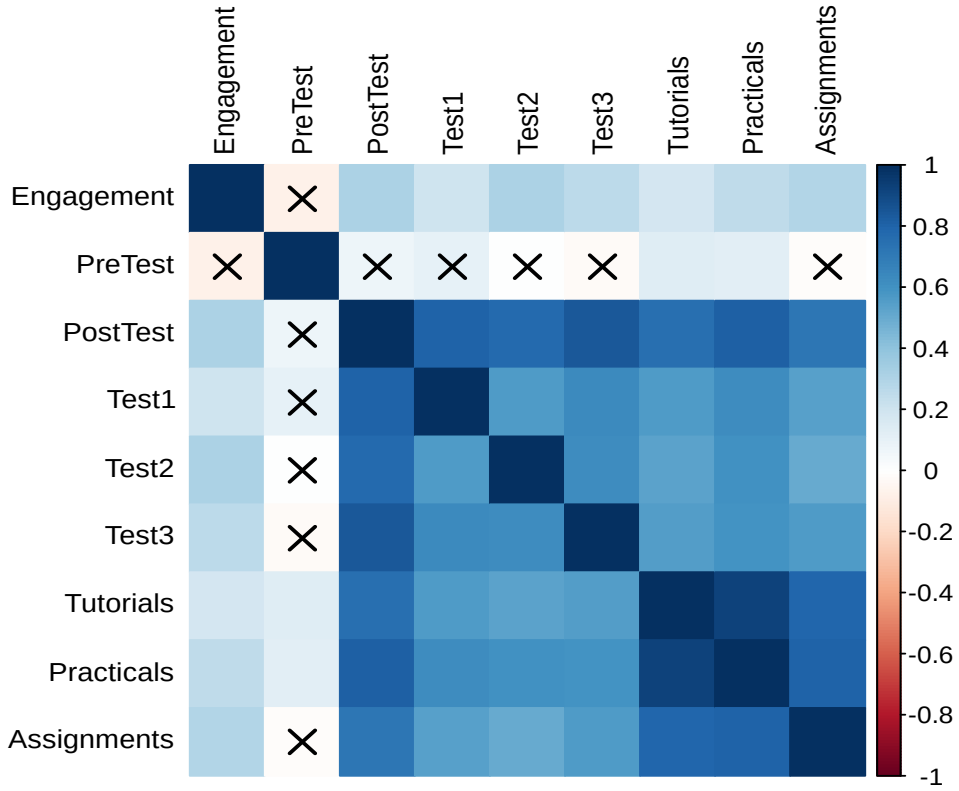


Figure 5.13: Correlation matrix of Engagement score and the various assessments

From Figure 5.13, it was derived that the self-reported engagement score was positively correlated to all assessments other than the PreTest, as expected. It should be noted that the correlation is of a medium intensity, meaning it only partly explains the variation in marks. We can also look at it with a regression by regressing the improvement from pre-test to post-test on the score, as is illustrated in Table 5.54.

Table 5.54: Coefficients from regression for the final mark as the post-test score concerning the engagement score

	Estimate	p-value
Intercept	-6.744	0.132
Engagement	11.860	<0.000***

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.55: Coefficients from regression for the final mark as the post-test score concerning the engagement score with an interaction with group

	Estimate	p-value
Intercept	-6.306	0.361
Engagement	12.551	0.012*
Group B	-0.709	0.938
Engagement*Group B	-1.640	0.804

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.56: Coefficients from regression for the final mark as the post-test score regarding group

	Estimate	p-value
Intercept	10.259	<0.000***
Engagement	-3.722	0.264

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.57: Coefficients from regression for the final mark as the post-test score regarding group

	Estimate	p-value
Intercept	1.320	<0.000***
Group B	-0.078	0.402

Significant p – value * 0.001; ** 0.01; * 0.05**

It appears the effect of engagement is consistent across groups, with a mark change of about 12 marks per unit of self-reported engagement. To understand what such a unit represents, we look at the spread in Figure 5.14.

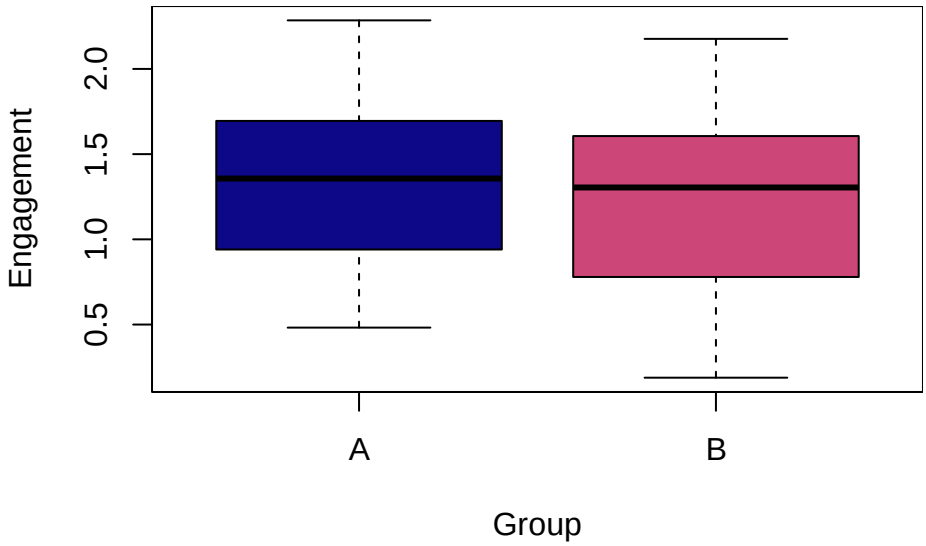


Figure 5.14: Boxplot of the engagement score regarding the respective groups

Looking at the boxplots, we see that a unit of self-reported engagement could be seen as “some” engagement roughly equivalent to the interquartile range. An effort to engage might result in an engagement score change of 1, and thus about 12 marks extra, which is a lot.

5.8.4 Participation Score

Engagement can also be measured by the proportion of assessments (tutorials, quizzes, assignments, tests, and examinations) completed by the participants. In Figure 5.15, a boxplot comparing the two groups’ participation scores, illustrates that Group A has a higher participation score than Group B for the lower quantiles. This implies that Group A completed more of their assessments than Group B and can indicate why Group A performed better than Group B. Linear regression was performed to determine whether there was a relationship between participation scores and the groups. The results are summarised in Table 5.58, which illustrates that Group B participated significantly less than Group A. When comparing the PostTest and participation scores, Table 5.59 is generated, which shows the attendance scores differ significantly with respect to PostTest scores.

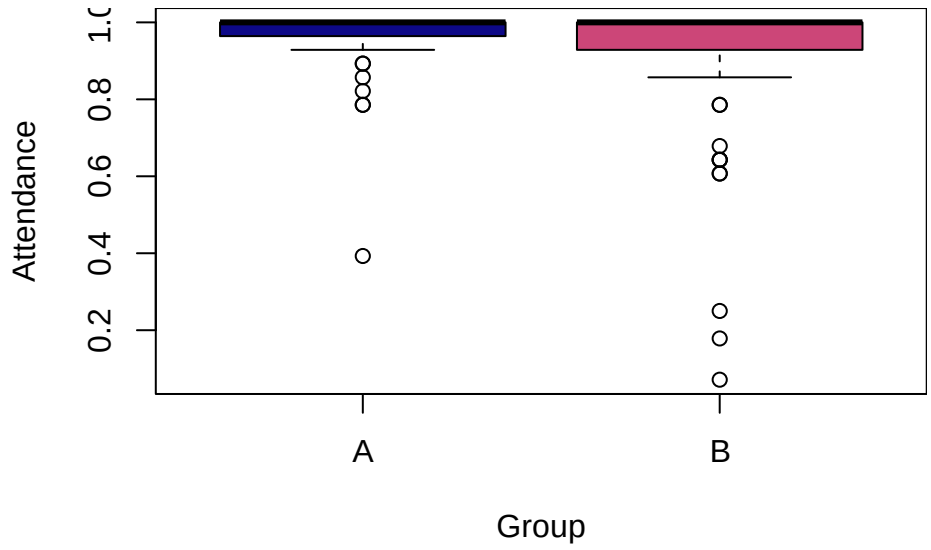


Figure 5.15: Boxplot of participation score of the two groups

Table 5.58: Coefficients from regression for the participation score regarding group

	Estimate	p-value
Intercept	0.964	<0.000***
Group B	-0.071	0.022*

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.59: Coefficients from regression for the result regarding participation score

	Estimate	p-value
Intercept	-47.412	<0.000***
Participation	60.092	<0.000*

Significant p – value * 0.001; ** 0.01; * 0.05**

In Table 5.60, the PostTest was compared to attendance scores, group and the interaction between group and attendance scores. Here, the group and the interaction were insignificant, but attendance scores produced significant results regarding PostTest. In Table 5.61, PostTest was compared regarding the participant scores and the self-reported engagement score of Section 5.8.3. The participation and engagement (see section 5.8.3) were significant for explaining their PostTest scores.

Table 5.60: Coefficients from regression for the result regarding interaction between participation score and group

	Estimate	p-value
Intercept	-48.638	0.018*
Participation	61.078	0.004**
Group B	1.280	0.954
Participation*GroupB	-0.716	0.975

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 5.61: Coefficients from regression for the result regarding interaction between participation score and group

	Estimate	p-value
Intercept	-55.768	<0.000***
Participation	56.362	<0.000***
Engagement	9.221	0.001**

Significant p – value * 0.001; ** 0.01; * 0.05**

5.9 Experiences & perceptions of students using the videoed-lectures in this study

The results from the questionnaire that the students completed and the interviews done with students will be discussed in this section. The interviews were audio-recorded to ensure internal validity. Some of the student comments concurred with the research referred to in previous chapters.

5.9.1 Students' description of a flipped classroom to future EFBC 2524 students

The students used the following comments to describe video-lecturing:

- *It feels like you are being taught alone, with no distractions or disruptions in the comfort of your own home;*
- *it is so convenient*;
- *just like a traditional class, but with the convenience of doing it at any time and never miss a lecture;*

- *it is an innovative way of learning but requires discipline and commitment;*
- *it is the future;*
- *it is a virtual classroom in your own time, own space at your own pace;*
- *a portable class where you could take Statistics everywhere where you are going;*
- *having class without having class, and*
- *your videos are by far the greatest invention to me.*

5.9.2 The experiences and perceptions of students who participated in this study

Furthermore, students were asked how they experienced the flipped classroom. They answered that they preferred the FC approach as it is "*flexible, and I can follow my own schedule at my own pace, regulate my study time, and control my own learning, not according to a timetable*. *I can repeatedly repeat what I do not understand day or night without annoying the lecturer to explain again. You get to practice with the voice of the lecturer until you understand."* Most students (90.63%) responded in the questionnaire that they like watching videos at their own pace. This indicates that the FC approach supported students in their learning process as they could adjust the learning pace to their needs. All students are subjected to the same pace as the lecturer during a traditional class. It is, therefore, convenient to *slow learners.* It is "*easier to do work at my place considering the distance I have to travel to campus. It saves time and money for transport."*

Many of the respondents (73.9%) of Group A confirmed in the questionnaire that video-lecturing was a convenient and useful learning tool, and they "*would prefer to study other subjects*" with video-lecturing as "*some of the lecturers anyway read from slides, and it is a waste of time to attend class*".

Another benefit students' experienced was that they *could finish a chapter within one day, i.e., finish large loads of work quicker.* Some students also referred to the videos as *very helpful for visual and auditory learners.*

5.9.3 The challenges of videoed-lectures

The main themes identified as a drawback of video-lecturing were:

- *One-way communication.*

According to most of the students in this research, the biggest drawback of the flipped classroom was that they could not immediately ask the lecturer for assistance when they did not grasp certain concepts while viewing the videos. One of the students said: "*It is one-way communication because you cannot engage with the lecturer right away when you do not understand something like in a class, which can lead to procrastination. It feels like I am teaching myself."*

- *Lack of motivation and responsibility by students.*

Students declared that they did not manage their time productively and, as a result, fell behind in their learning. One student reported that "*it involves a lot of self-discipline to take time to watch videos"* to be successful. Students also said that they "*feel isolated and get distracted easily at home like being hungry, television, music playing, etc., and don't feel a sense of obligation until it is too late."* Some students expressed concerns about something *discussed in class that is not mentioned in the videos.*

- *Resource constraints*

Another problem identified by the students was that they could not actively engage due to network challenges *to access the videos as not everyone has access to a computer off-campus* and the *lack of an internet connection (data) or Wi-Fi to obtain videos as it takes a lot of data to download videos. Load-shedding* was also considered an impairment of the learning process in the FC approach.

5.10 Other factors enhancing students' learning for EFBC 2524 (2017)

- *Collaborative learning*

The main factor the respondents perceived that contributed to their learning for this subject was discussions with peers (study buddy) and their lecturer using the instant

messaging tool on WhatsApp. This faceless environment must be set for certain "working hours" as this is not sustainable when available 24 hours daily, and students expect an immediate response to their questions.

- *Technology*

An overwhelming 94.7% of Group A indicated that technology (video-lectures, Blackboard, or WhatsApp) was pivotal in their learning. In comparison, 82.5% of Group B showed that the use of technology improved their learning. These results align with those of Zweekhorst and Maas (2015:14), who stated that higher usage of ICT tools positively affects students' perceptions of their level of engagement.

- *Independent studying*

Another contributing factor to their learning was studying independently, as 82.5% of Group A said that improved their learning, while 78.2% of Group B said studying independently enhanced their learning.

5.11 Other factors hindering students learning for EFBC 2524 (2017)

- *Large classes*

About 61% of the participants mentioned their learning was hindered as they were "*distracted by fellow students and by the noise from a large class."*

It is quite a mission to lecture when most students make more noise than your voice can endure, and there is a lack of cooperation. A deaf student complained that his interpreters did not listen to the lecturer when students made noise in class, and then he missed important information during a lecture. Recent research reported that the physical environment influences students' cognitive load. Therefore, noise in a classroom negatively impacts learners and lowers learning outcomes (Choi *et al.* 2014:233). Video lecturing substantially provides a solution to this problem.

Other factors that hindered their learning were social media, finances, or friends being a distraction.

6. Discussion of results

6.1 Summary of results

6.1.1 Conclusions from the comparison of the experimental and control group

Background demographic information suggested that students in the two groups were quite similar. It was confirmed with a Chi-square test, which indicated no significant differences between the two groups regarding gender, race, age, home language, type of accommodation when studying, where they were most comfortable when studying, and their pre-test scores. It can thus be deduced that there was no evidence that randomisation was not done successfully.

The results of this study showed no correlation between the pre- and post-test scores of the respective groups. However, the paired t-test showed a significant difference between the pre-and post-test scores of Group A. This supports the idea that the academic capabilities of diverse students when starting HE show no evidence of influencing their outcomes in this course, according to this study. Possible reasons for this notion are that students realised that they are responsible for their own successes, and with proper guidance and effective interventions, students can transition from school to university and succeed.

The researcher believes that the medium effect size finding could possibly indicate that the higher average of the experimental group can be attributed to an increased understanding of course material and concepts. This may aid the student to understand better future courses and/or maximise time to learn in other courses. In the long run, this could increase the likelihood that a student will graduate, secure a job and/or successfully enter the workforce with superior knowledge.

These findings emphasise the importance of the quality of first-year educational experiences as a contributor to student success and highlight that regardless of students' pre-university characteristics, institutions can design first-year programs

that meet the needs of diverse students (Reason *et al.* 2006:156, Strydom *et al.* 2017:57).

The researcher then applied an ANCOVA to determine the effect of the group on the different assessment marks while controlling demographic variables. Student characteristics, in the form of gender, pre-university qualifications and general living arrangements were chosen as covariates. Literature suggests that these measures influence student engagement.

6.1.1.1 Results: Post-test – Final marks:

It can be concluded that the variable Group reflects a significant difference between the average final marks of the two groups after adjusting for gender and study place preference. The covariate gender is highly significant. Furthermore, the average final marks differed significantly based on where students preferred to study. Therefore, we can conclude that these covariates are most likely attributed as causal factors to students' final scores. Thus, it suggests that gender or study place preference and treatment effect may operate independently on the course outcome. At the very least, the researcher has no evidence to suggest that one gender or study place preference benefitted more from the treatment according to this data set.

When analysing the final marks of females compared to males, it was proven in this study that females significantly outperformed males. When comparing the final marks of males between the two groups, an unexpected gender finding was that male students from Group A performed significantly better than males in Group B.

It can further be noted that the place where students preferred to study, *e.g.,* the library or their residence, showed significant differences that contributed positively to their average final marks. However, the place where students stayed while studying did not appear to influence their final scores significantly.

When analysing the place of study, students studying in the library or computer labs performed about the same for both groups, while students in Group A who studied at their residence performed significantly better than students in Group B studying at their residence.

6.1.1.2 Results: Post-test – Test 1:

It can be concluded that for test 1, there is a significant interaction effect between group and gender, which indicated that the effect of the group was different for the two genders. The average mark for test 1 of female students was similar irrespective of group, while male students in Group A performed significantly better than male students in Group B. Furthermore, it can be noted that for the place of study, students studying in the library of Group A performed significantly better than their counterparts in Group B.

6.1.1.3 Results: Post-test – Test 2:

Only gender was significant, and no significant interaction between the covariates existed. Students from Group A who studied at their residence performed significantly better than Group B students studying at their residence.

6.1.1.4 Results: Post-test – Test 3:

Only gender was significant. However, where the multiple regression coefficients were obtained, it can be noted that the place where students preferred to study, showed significant differences that contributed positively towards their test 3 marks.

6.1.1.5 Results: Post-test – Tutorials:

A significant difference exists between the tutorial marks of both the covariate, gender, and the variable group. However, where the multiple regression coefficients were obtained, Group A performed significantly better than Group B, however there was no significant difference in gender.

When simply comparing the two groups, Group A's male students performed significantly better than males in Group B. Students from Group A who studied at their residence performed significantly better than Group B students studying at their residence.

6.1.1.6 Results: Post-test – Practicals:

Significant difference between the practical marks of both the covariate, gender, and the variable group were found. It can thus be concluded that the effect of the group depends on their gender.

When simply comparing the two groups, Group A's male students performed significantly better than males in Group B. Students from Group A who studied at their residence performed significantly better than Group B students studying at their residence.

Where the multiple regression coefficients were obtained, Group A students performed significantly better than Group B students and female students performed significantly better than male students. It can also be noted that the place where students preferred to study, the library or their residence and library, also showed significant differences that contributed positively to their practical marks.

6.1.1.7 Results: Post-test – Assignments:

Significant differences between the assignment marks of both the covariate, gender, and the variable group were found.

Where the multiple regression coefficients were obtained, Group A students performed significantly better than Group B students and female students performed significantly better than male students.

When simply comparing the two groups, Group A students performed significantly better than Group B students. Their place of study preferred as their residence once again differed significantly compared to studying at the computer labs or the library.

6.1.1.8 When measuring student engagement by using BUSSE scales:

When attempting to measure student engagement using the BUSSE scales, there was no significant difference between the groups in any engagement indicators.

An ANOVA was done comparing the students' final marks to the BUSSE scales and it was concluded that only quantitative reasoning significantly impacted students' final marks.

The BUSSE engagement indicators' findings were not significant; thus, the researchers could not base her findings on such results.

6.1.2 Student engagement measurements based on the researcher's questionnaire:

Several questions were posed to the students of both groups and their answers were compared to determine if there was a significant difference between the student engagement experienced in the traditional group as opposed to the FC approach.

The results were categorised according to themes of student engagement.

6.1.2.1 Theme 1 – Active and collaborative learning:

The variables considered under this theme were mainly how the students interacted with their peers inside and outside of class regarding the course material. There were no significant differences regarding the variables considered between the two groups. However, most students in both groups indicated that communicating with fellow students and tutoring their peers improved their learning.

This research found that students who tutored their fellow peers performed significantly better than students who did not tutor their peers, regardless of group. It should be kept in mind that there is a possibility that students are not strong

because they tutor, and the inverse could be true in that the tutor because they are strong.

It is clear that the FC approach did not significantly enhance collaborative learning in this study. However, what can be concluded from this study is that collaborative learning has a positive effect on student success.

The findings show insignificant differences between all the learning variables for the respective groups when interacting with fellow students during or outside class, except for gender, tutoring fellow students, and the interaction between group and gender.

6.1.2.2 Theme 2 – Student-staff Interaction:

The variables that were considered under this theme were mainly how the students interacted with the lecturer regarding course material during and outside of class and prompt feedback.

Group A performed significantly better than Group B regarding student-staff interaction. Therefore, it can be illustrated that the FC approach is an effective teaching practice as student engagement increases regarding the student-staff theme.

Furthermore, female students, students communicating with the lecturer face-to-face in class when not understanding concepts, and students' perception of whether the lecturer improved their learning also showed significant improvements in the student-staff interaction theme.

6.1.2.3 Theme 3 – Enriching educational experiences:

From the survey, 63% of students indicated they had a favourable perception of the FC approach. There was a correlation between students who would recommend the FC approach to a friend and students who prefer this approach to traditional teaching. There was a further correlation between students recommending the FC

approach and students who are motivated to learn with the FC approach. Furthermore, there was a correlation between students who preferred the FC approach over traditional teaching and students who were more motivated to learn with the FC approach. Another important correlation to be noted is one between students who are more motivated to learn with the FC approach and a flipped classroom, which makes it easier to understand course content. Another noteworthy correlation is between students who are motivated to learn with the FC approach and the videos that hold students' attention. Lastly, there was also a correlation between videos holding students' attention and fellow students distracting them in a traditional class.

A significant correlation was noted for Group A between studying independently and using technology. There is also a significant correlation between studying independently and tutoring fellow students.

From this study, it seems the students welcomed the FC approach, positively affecting student motivation and understanding.

The following correlations are worth noting for Group B

- between interacting with students inside and outside of class (0.3821);
- between communicating with fellow students outside of class and the use of technology (0.4787) – highest relationship;
- between interacting with fellow students during class and the use of technology;
- tutoring fellow students and the use of technology (HIPs);
- between studying independently and the use of technology, and
- negative correlation (-0.4251) between the use of technology and being in a large class.

As can be seen from the above correlations, collaborative learning also takes place in the traditional classroom setting. The greatest relationship indicates that students in the traditional approach also use technology when collaborating with peers.

6.1.3 Conclusions from the questionnaire survey

Reflecting on student voices, it can be concluded that students had positive attitudes towards the FC approach and enjoyed the format. Many of the students reported that the video lectures are indispensable to their learning and some would even prefer to take a course using the flipped pedagogy in the future.

The open-ended questions also revealed that the FC approach's effectiveness depends on diligent and disciplined students because some students admitted to being lazy and procrastinating until the last minute before watching the videos. They were not willing to enhance their learning outcomes. Therefore, there will always be a place for traditional lecturing, as some students do not want to be independent learners. A total of 26.2% of respondents still preferred traditional teaching.

Most respondents reported that one of the drawbacks to introducing the FC approach is one-way communication, as they could not immediately ask when not understanding certain concepts when viewing the videos. However, they could use the WhatsApp group to ask the lecturer questions immediately.

The findings and literature indicate that, with guidance and interventions, students can transition from school to university and succeed. These results are relevant for those educators and policy planners interested in increasing retention, diminishing drop-out rates, and closing the "articulation" gap. However, student engagement research has not yet yielded a single "silver bullet" that solves the engagement riddle (Strydom *et al*. 2017:145). Some factors affect success in the first year, but it is impossible to find a "one size fits all" solution to increase student throughput rates (Zewotir *et al*. 2011:1243).

The next chapter will discuss the researcher's conclusions, implications, recommendations, strengths and limitations of the study, and suggestions for further research.

7. Conclusions, implications, recommendations, and limitations

7.1 Introduction

Significant focus has been placed on teaching and learning aspects to improve student learning. This study was aimed at adding to the literature regarding ways to enhance academic performance. A variant of the FC approach was implemented and were the effects of such treatment studied by the researcher. The aim of this study was primarily to determine to what extent the FC approach improves student engagement in first-year statistics education.

The researcher undertook an extensive literature review regarding learning approaches, different perspectives on student engagement, technology and flipping the classroom in HE.

From the findings of this study, there were a few prominent conclusions that are to be highlighted. The experimental group significantly outperformed the traditional teaching group. There were two significant covariates being gender and the place where students prefer to study.

Interestingly, it was found that male students in the experimental group performed significantly better than the male students in the traditional teaching group. It can thus be deduced from this study that the FC approach has a greater impact on male engagement. However, generally, female students outperformed male students.

Students in the experimental group who studied at their place of residence performed significantly better than the students in the traditional teaching group who studied at their place of residence. This finding clearly exhibits the usefulness of the FC approach in enhancing student engagement. This proves that students do not have to reside on campus to be more engaged. It seems to show from the study that the FC approach is useful to combat socio-economic challenges. Should

students not be able to travel to campus, the FC approach will still allow them to succeed. Thus, the researcher can conclude that the FC approach is highly beneficial for enhancing student outcomes.

The FC approach was proved to have no effect on active and collaborative learning. There was no difference regarding the impact of collaborative learning between the two groups. However, it was found that collaborative learning significantly increased student success. This study therefore confirmed that collaborative learning is a HIP.

It can be regarded that this intervention was successful as an enriching educational experience.

Another noteworthy finding was that the experimental group performed significantly better than traditional group regarding student-staff interaction. Therefore, it can be illustrated that the FC approach is an effective teaching practice as student engagement increases regarding the student-staff theme.

Although it is time-consuming, with careful planning, the FC approach can be implemented for any discipline for the future HE. This chapter commences with improvements recommended for implementing the new variant of the flipped classroom. Following these elements, a discussion of the limitations of this study is provided and recommendations for future research. The chapter concludes with the significance of the study.

7.2 Improvements recommended for the flipped classroom

- *PowerPoint videos could not be paused. So, whenever the researcher had a distraction in the middle of a slide, she had to redo the whole slide.* This was overcome by opening the generated PowerPoint slides in the screen-casting program, Camtasia Studio, edited and saved as a video file in MP-4 format. Students can now pause the videos and watch them on their cell phones.

- *The videos needed subtitles for differently enabled students.* Subtitles were generated in Camtasia, which was a substantial effort taking many hours. Therefore, videos must be designed to be an inclusive learning space for an increasingly diverse learning population like deaf students.

- *Lack of internet connection (data) to obtain videos takes a lot of data to download videos.* To obtain free access without using data, all the videos can be transferred onto an SD card, which students can then just put in their phones, tablet, laptops, or any other electronic device to access the information without needing any data. A password can even be placed on the card to be used by only one user to prevent students from passing the Secure Digital (SD)-card to other students. Videos can be compressed to reduce data costs, but the quality of videos becomes inferior. Furthermore, a YouTube channel could be used where only registered students have access. Another measure to combat this challenge was discovered by the researcher after this study took place. The videos can be uploaded to the LMS (Blackboard) in the following manner. The video-lectures can be uploaded using the MEDIAL Blackboard Video Block which allows students to download or view the videos without requiring data to do same.

Those new to the FC approach should expect some technology glitches, especially when creating videos for the first time, and where to post the videos, *e.g.,* Blackboard or YouTube, etc. However, when initial technical and logistical problems were resolved and a complete set of videos are completed, future preparation time will be reduced significantly.

7.3 Limitations

It is important to point out the limitations of this study. First, the small number of students in certain categories of this research could influence the outcome of the statistical analyses. The conclusions drawn should consider that this small sample might have benefitted certain conclusions. Secondly, not all students in the experimental group responded to the questionnaire. This non-response could have

influenced the results of the questionnaire survey. Thirdly, generating videos' the first time around did have its limitations. It seems that PowerPoint does not have a function to generate subtitles, and the researcher had to revert to Camtasia for that function. Fourthly, this study was only done at one South African University.

7.4 Recommendations for future research

Bearing in mind the research findings, as well as the limitations mentioned, the following recommendations for future research are made:

- From the researcher's experience, the ECP first-year statistics students, the step-child of the family, performed better in 2021 than the main campus students. Interestingly, it is supposed to be the other way around because these students have lower AP scores. It would be interesting to determine which factors (like students being more motivated to succeed, bridging courses, etc.) led to the average of the ECP students being higher than main campus students.
- From researcher's further consideration of literature, it was picked up that there is a correlation between a student's final mark for the first semester and their grade 12 marks, however the same is not true for the second semester marks. It would be interesting to investigate this fact in further detail.

Van der Merwe (2012:270-271) indicated that findings need to be disseminated as widely as possible to advance the scholarship of teaching and learning in general, and scholarship in statistics education in particular. The following is recommended in this regard:

- The findings should be shared on departmental, faculty, and institutional levels, possibly using presentations at the researcher's own institution, the UFS.
- The findings should be shared nationally at conferences and using publications in scholarly journals that potentially reach the statistics education population in the country. This process could enhance teaching and learning in the sciences in the country and stimulate further research and scholarship.

- The findings should be shared internationally at conferences and in scholarly publications (one such article has already been published). In this way, the study can contribute internationally to advancing the scholarship of teaching and learning on a disciplinary level, an important emphasis in current literature.

7.5 Conclusion

This study implemented a variant of the FC approach in a first-year Statistics module whereby students had to take responsibility for their own learning by viewing video-lectures at their own pace. The students had to collaborate with the lecturer when they did not understand certain sections or concepts of the study material and was technology intended to be used as a tool to increase collaboration. This study was primarily aimed at the behavioural perspective of student engagement, focusing on respecting diverse talents and ways of learning.

In this study, students applied different learning activities such as inquiring about information, watching video-lectures, and practically applying the knowledge studied when completing weekly online assessments. Students collaborated with the lecturer and their peers via e-mail or WhatsApp to thoroughly understand the subject. Therefore, active learning, which fosters deep learning, was encouraged. This finding is consistent with the constructivist pedagogical theory, which emphasises the importance of interaction with others in knowledge construction and develops a deeper understanding of subject matter. These findings align with other studies that report positive student perceptions of blended learning in first-year statistics.

This research found that the FC intervention, as applied by the researcher, resulted in a significant increase in student performance on their final marks, which indicates that the FC approach is an important pedagogical approach to increase student achievement. Further the results did indeed confirm that the FC approach improved student engagement. One factor which significantly enhanced student engagement was the students' preferred place of study. Students from the experimental group studying at their place of residence significantly outperformed the student from the

traditional group who studied at their place of residence. Another factor which indicated that student engagement was enhanced was the fact that student-staff interaction significantly increased in the experimental group.

This study confirmed that the FC approach did not significantly enhance collaborative learning. However, it was confirmed that collaborative learning is a very effective method to promote student success regardless of group.

This study could not confirm that the students in the FC approach showcased better independent learning. Although flipping is a student-centred approach, students are still heavily dependent on their lecturer to increase their success.

Another element this study was aimed at investigating was the impact technology has on HE Statistics. The study found that technology does not have a greater impact in the FC approach than in the traditional approach. It was evident that students from both groups used technology in collaborative learning.

Self-reported engagement scores also correlate to higher marks, but not a difference by group on average. However, if we consider minimum engagement minimum participation scores, we see more completely disengaged students in Group B.

This research led to a more contemporary delivery of the original FC approach, which can be used when protests or pandemic outbreaks like COVID-19 disrupt classes. This blended approach could be implemented or used as a framework for future students in any discipline who would prefer to abstain from classes. As such, the study will make a significant contribution to teaching, learning, and course design in HE.

The results of this study cannot be generalised to a broader spectrum.

8. References

Abaido, G. & El-Messiry, H. 2016. Efficiency of WhatsApp as a means of disseminating educational information. *ST-5: IT & Knowledge Excellence*, Paper#: 5.2, 1-4.

Abdullah, M.C., Teoh, H.C., Roslan, S. & Uli, J. 2015. Student engagement: Concepts, Development and Application in Malaysian Universities. *Journal of Educational and Social Research MCSER Publishing, Rome-Italy,* 5(2): 275-283.

Abeysekera, L. & Dawson, P. 2014. Motivation and Cognitive Load in the Flipped Classroom: Definition, Rationale and a Call for Research. *Higher Education Research & Development*, 34(1):1-14.

Adams Becker, S., Cummins, M., Davis, A., Freeman, A., Hall Giesenger, C. & Ananthanarayanan, V. 2017. *NMC Horizon Report: 2017 Higher Education*. Austin: Texas: The New Media Consortium.

Akimov, A., Malin, M., Sargsyan, Y., Suyunov, G. & Turdaliev, S. 2023. Student success in a University first-year statistics course: Do students' characteristics affect their academic performance? *Journal of Statistics and Data Science Education,* 00 (0):1-12.

Alshwiah, A.A. 2016. The effect of Applying Laurillard's Conversational Framework (LCF) on the Development of Writing Skills: Perceptions and Engagement of Students in a Middle East Context. *A thesis submitted for Doctor of Philosophy,* University of Leicester.

Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C. & Norman, M.K. 2010. *How learning works: 7 Research-based principles for smart teaching*. San Fransisco: Jossey-Bass.

Anderson, H.M. 2011. Dale's Cone of Experience.
(http://www.queensu.ca/teachingandlearning/modules/active/documents/Dales_Coneof_Experience_summary.pdf)
(Retrieved December 2018).

Anderson, T. & Dron, J. 2012. Learning technology through three generations of technology enhanced distance education pedagogy. European Journal of Open, Distance and E-learning.
(https://files.eric.ed.gov/fulltext/EJ992485.pdf)

Anderson, L.W. & Krathwohl, D. 2001. *A taxonomy for learning, teaching and assessing: a revision of Bloom's taxonomy of educational objectives.* New York: Longman.

Annamalai, N. 2019. Using WhatsApp to extend learning in a blended classroom environment. *Teaching English with Technology*, 19(1): 3-20.

Ashwin, P & McVitty. 2015. The meanings of student engagement: Implications for policies and practices. In Curaj, A., Matei, L., Pricopie, R. Salmi, J. & Scott, P. (Eds.) *The European Higher Education Area Between Critical Reflections and Future Policies*. Switserland: SpringerLink.com.

Astin, A.W. 1993. *What Matters in College? Four critical years revisited.* San Francisco: Jossey-Bass.

Astin, A.W. 1999. Student involvement: A Developmental Theory for Higher Education. *Journal of College Student Development,* 40(5):518-529.

Ausburn, L.J. & Ausburn, F.B. 2008. Effects of desktop virtual reality on learner performance and confidence in environment mastery: Opening a line of inquiry. *Journal of Industrial Teacher Education*, 45(1), 54-87.

Axelson, R.D. & Flick, A. 2010. Defining student engagement. *Change: The Magazine of Higher Learning*. 43:1, 38-43.
(http://dx.doi.org/10.1080/00091383.2011.533096)
(Retrieved June 2017).

Bae, Y. & Han, S. 2019. Academic Engagement and Learning Outcomes of the Student Experience in the Research University: Construct Validation of the Instrument. *Educational Sciences: Theory & Practice,* 19(3), 49-64.

Baker, J.W. 2000. *The "classroom flip": Using web course management tools to become a guide by the side.* Paper presented at the 11th International Conference on College Teaching and Learning. Jacksonville, FL.

Bandura, A. 1971. *Social Learning Theory*. New York: General Learning Press. (http://www.asecib.ase.ro/mps/Bandura_SocialLearningTheory.pdf)

Barkley, E. 2010. *Student Engagement Techniques – A Handbook for College Faculty*. San Francisco: Jossey-Bass.

Baukal, C.E., Ausburn, F.B. & Ausburn, L.J. 2013. A proposed multimedia cone of abstraction: updating a classic instructional design Theory. *I-manager's Journal of Educational Technology*, 9(4), 15-24.

Bean, J.C., 2011. *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom* (2nd ed.) San Francisco, CA: Jossey-Bass.

Bekker, J.H., Naicker, S.A. & Olivier, S.P. 1976. *A Basic Philosophy of Education*. Johannesburg: Perskor Book Printers.

Bergman, J. & Sams, A. 2012. *Flip your classroom: Reach every student in every class every day,* Washington D.C.: International Society for Technology in Education/American Society of Continuing Education.

Berrett, D. 2012. A guide to the flipped classroom, *The Chronicle of Higher Education,* Inc.
(http://www.chronicle.com/article/How "Flipping" the Classroom can improve the Traditional Lecture/130857/, 2-6:18-19)
(Retrieved July 2015).

Biggs, J. & Tang, C. 1999. *Teaching for Quality Learning at University – What the student does*. 3rd ed. Society for Research into Higher Education & Open University Press, England: McGraw-Hill Education.

Blalock, H.M. 1987. Some general goals in teaching statistics. *Teaching Sociology,* 15, 164-172.

Bliuc, A.M., Goodyear, P. & Ellis, R.A. 2007. Research focus and methodological choices in studies into students' experiences of blended learning in higher education. *Internet and Higher Education*, 10:231-244.

Bloom, B.S. 1978. New views of the learner: Implications for instruction and curriculum, *Educational Leadership,* 35(7), 563-576.

Bond, M. & Bedenlier, S. 2019. Facilitating student engagement through educational technology: Towards a conceptual framework, *Journal of Interactive Media in Education*, 11: 1-14.

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O. & Kerres, M. 2020. Mapping research in student engagement and educational technology in higher education: a systematic evidence map. *International Journal of Educational Technology in Higher Education*, 17:2.

Bonk, C.J. 2008. YouTube anchors and enders: The use of shared video content as a macro context for learning. Paper presented at the *American Educational Research (AERA) 2008 Annual Meeting,* New York, NY.

Bonner, S.E. 1999. Choosing teaching methods based on learning objectives: An integrative framework. *Issues in Accounting Education*, 14(1).

Boyce, G. 1999. Computer-assisted teaching and learning in accounting: Pedagogy or Product? *Journal of Accounting Education,* 17, 191-220.

Brame, C.J. 2015. *Flipped the Classroom*. Centre for Teaching. Vanderbilt University, Nashville.
(http://cft.vanderbilt.edu/guides-sub-pages/flipping-the-classroom/)
(Retrieved 2015).

Brandt, D.A. 1997. Constructivism: teaching for an understanding of the Internet, *Communications of the ACM,* 40(10), 112-117.

Briggs, A., Anderson, T., Gebrekristos, S., Simon, A., & Mei, A. 2019. Evaluation of Adaptive Learning in Statistics (ALiS) , Urban Institute, available at

https://www/urban.org/research/publication/evaluation-adaptive-learning-statistics-alis.

Brownell, J.E. & Swaner, L.E. 2009. High-Impact Practices: Applying the learning outcomes literature to the development of successful campus programs, *AAC&U Peer Review*, 11(2): 26-30.
(https://www.aacu.org/publications-research/periodicals/high-impact-practices-applying-learning-outcomes-literature)
(Retrieved June 2015).

Brush, T. & Saye, J. 2000. Implementation and evaluation of a student-centred learning unit: A case study. *Educational Technology Research and Development,* 48(3):79-100.
(http://dx.doi.org/10.1007/BF02319859)
(Retrieved November 2017).

Bryson, C. & Hardy, C. 2011. Clarifying the concept of student engagement: A fruitful approach to underpin policy and practice. Paper presented at the HEA Conference, 5 - 6 July, at Nottingham University.

Bryson, C. & Hand, L. 2008. An introduction to student engagement. In *SEDA special 22: Aspects of student engagement*, 5–13. Nottingham: Staff and Educational Development Association.

Buerck, J.P., Malmstrom, T. & Peppers, E. 2003. Learning environments and learning styles: Non-traditional student enrollment and success in an Internet-based versus a lecture-based computer science course. *Learning Environments Research*, 6:137-155.

Burger, D.A. and Schall, R., 2018. Robust fit of Bayesian mixed effects regression models with application to colony forming unit count in tuberculosis research. Statistics in medicine, 37(4): 544-556.

Burke, A. S. & Fedorek, B. 2017. Does “flipping” promote engagement?: A comparison of a traditional, online, and flipped class. *Active Learning in Higher Education*, 18(1): 11-24.

Burns, R.B. 2000. *Introduction to research methods*. London: Sage.

Calik, M. Ebenezer, J. Özsevgec, T. Kücük, Z. & Artun, H. 2015. Improving science student teachers' self-perception of fluency with innovative technologies and scientific inquiry abilities. *J Sci Educ Technol*, 24:448-460.

Cates, W.M. 1992. Fifteen principles for designing more effective instructional hypermedia products. *Educational Technology,* 32(12), 5-11.

CCCSE *see* Centre for Community College Student Engagement.

Centre for Community College Student Engagement (CCCSE). 2013. *A matter of degrees: Engaging Practices, Engaging Students (High-Impact Practices for Community College Student Engagement).* Austin, TX: The University of Texas at Austin, Community College Leadership Program.

Centre for Teaching and Learning (CTL). 2018. Where is the rest of the class? *A study of class attendance at the University Of The Free State.* Bloemfontein, South Africa: University of the Free State.

Chaffee, J. 2006. *Thinking Critically*. 8th Ed. Boston: Houghton Mifflin.

Chance, B., Ben-Zvi, D., Garfield, J. & Medina, E. 2007. The Role of Technology in Improving Student Learning of Statistics, *Technology Innovations in Statistics Education:* 1(1). (http://repositories.cdlib.org/uclastat/cts/tise/vol1/iss1/art2)

CHE *see* Council on Higher Education.

Cheah, S. & Sale, D. 2017. Pedagogy for evidence-based flipped classroom – Part 3: Evaluation, *Proceedings of the 13th International CDIO Conference, University of Calgary, Calgary, Canada.*

Cheng, G. & Chau, J. 2011. A comparative study of using blogs and wikis for collaborative knowledge construction. *International Journal of Instructional Media,* 38:71-78.

Chickering, A.W. & Gamson, Z.F. 1987. Seven Principles for good practice in undergraduate education. *AAHE Bulletin*, 39(7).

Chickering, A.W. & Ehrmann, S.C. 1996. Implementing the seven principles: Technology as a lever. *AAHE Bulletin,* 49(2).

Choi, H.H., Van Merriënboer, J.J. & Paas, F. 2014. Effects of the physical environment on cognitive load and learning: Towards a new model of cognitive load. *Educational Psychology Review,* 26(2), 225-244.

Churches, A. 2008. Bloom's Digital Taxonomy. (http://www.ccconline.org/wp-content/uploads/2013/11/Churches_2008_DigitalBloomsTaxonomyGuide.pdf) (Retrieved November 2018).

Clark, J. 2008. PowerPoint and pedagogy: Maintaining student interest in university lectures. *College Teaching*, 56, 39-45.

Cloete, M. & Joynt, C. 2019. The road less travelled – hybrid learning and blended teaching, *Keynote speakers from UP at the Blended Learning Colloquium hosted by CTL, UFS.*

Cobb, G.W. 1992. Teaching Statistics. *1992 CUPM_Report_1992_Mathematical Association of America*. (https://www.maa.org/sites/default/files/pdf/CUPM/first_40years/1992Cobb.pdf) (Retrieved November 2018).

Cobb, G.W. 2007. The introductory statistics course: A ptolemaic curriculum. *Technology Innovations in Statistics Education*, 1(1).

Cobcroft, R.S. Towers, S.J., Smith, J.E. & Bruns, A. 2006. Mobile learning in review: Opportunities and challenges for learners, teachers, and institutions. In *Proceedings Online Learning and Teaching (OLT) Conference 2006*, Queensland University of Technology, Brisbane, 21-30.

Cohen, J. 1988. *Statistical power analysis for behavioural sciences*, 2nd ed. Hillsdale, NJ: Erlbaum.

Congos, D.H. & Schoeps, N. 1998. Inside Supplemental Instruction Sessions: One Model of What Happens that Improves Grades and Retention. *Research and Teaching Developmental Education,* 15: 47-61.

Council on Higher Education (CHE). 2013. A proposal for undergraduate curriculum reform in South Africa: The case for a flexible curriculum structure. In *Report of the Task Team on Undergraduate Curriculum Structure Discussion Document.* Pretoria: CHE.

Creswell, J.W. & Plano Clark, V.L. 2011. Designing and Conducting Mixed Methods Research, SAGE

CTL *see* Centre for Teaching and Learning.

Cummins, J. 2000. Negotiating Intercultural Identities in the Multilingual Classroom. *The Catesol Journal*, 12(1), 163-178.

Czerniewicz, L. & Brown, C. 2005. Information and Communication Technology (ICT) use in teaching and learning practices in Western Cape higher education institutions. *Perspectives in Education*, 23 (4), 1-18.

Czerniewicz, L. & Brown, C. 2012. The habitus of digital "strangers" in higher education. *British Journal of Educational Technology*, 44(1):44-53.
(DOI: 10.1111/j.1467-8535.2012.01281.x)

Czerniewicz, L., Trotter, H. & Haupt, G. 2019. Online teaching in response to student protests and campus shutdowns: academics' perspectives. *Int J Educ Technol High Educ* 16**,** 43.
(https://doi.org/10.1186/s41239-019-0170-1)

Dale, E. 1969. *Audio-Visual Methods in Teaching,* 3rd ed., Holt, Rinehart & Winston, New York.

Dalstrom, E. & Bischel, J. 2014. *ECAR Study of Undergraduate Students and Information Technology,* Research report. Louisville, CO: ECAR.
(http://www.educause.edu/ecar)
(Retrieved May 2016).

Da Silva, L. 2020. Employing video-based lectures to enhance the learning of ECP students in large first-year statistics classes. In Rollnick, M. & Lubben, F. (Eds.) *Proceedings of the 2019 Colloquium on Extended Curriculum Programmes*. University of Pretoria.
(https://www.up.ac.za/colloquium2019)

Davis, B.G. 1993. *Tools for Teaching*. San Francisco: Jossey-Bass Publishers.

Debevec, K. Shih, Mei-Yau & Kashyap, V. 2006. Learning strategies and performance in a technology-integrated classroom. *Journal of Research on Technology in Education,* 38, 293-307.

De Jong, T. 2010. Cognitive load theory, educational research, and instructional design: some food for thought, *Instructional Science,* 38(2):105-134.

Department of Higher Education and Training (DHET). 2014. *Policy for the Provision of Distance Education in South African Universities in the Context of an Integrated Post-school System.* Department of Higher Education and Training (DHET).

Department of Higher Education and Training (DHET). 2019. *2000 to 2016 First Time entering undergraduate cohort studies for public higher education institutions.* Pretoria: DHET.

Department of Higher Education & Training (DHET). 2020. Students' Access to and Use of Learning Materials (SAULM). *Survey Report 2020*.
(https://usaf.ac.az/wp-content/uploads/2021/02/DHET_SAULM-Report-2020.pdf)

Dewey, J. 1916. *Democracy and Education*. New York: The Macmillan Company.

Dewey, J. 1938. *Experience & Education*. New York: Kappa Delta Pi.

Dimitrov, D.M. & Rumrill, Jr. P.D. 2003. Pretest -Posttest designs and measurement of change. *Speaking of Research*. Work 20: 159-165.

Dixson, M.D. 2010. Creating effective student engagement in online courses: What do students find engaging? *Journal of the Scholarship of Teaching and Learning,* 10(2): 1-13.

Doering, A., Lewis, C., Veletsianos, G. & Nichols-Besel, K. 2008. Preservice teachers' perceptions of instant messaging in two educational contexts. *Journal of Computing in Teacher Education*, 25(1), 5-12.
(http://files.eric.ed.gov/fulltext/EJ834086.pdf)
(Retrieved February 2019).

DHET *see* Department of Higher Education and Training.

Donnelly, R. 2010. Harmonizing technology with interaction in blended problem-based learning. *Computers & Education*, 54:350-359.

Dube, B. 2020. Rural online learning in the context of COVID-19 in South Africa: Evoking an inclusive education approach. *REMIE – Multidisciplinary Journal of Educational Research*, 10(2): 136-157.

Durrheim, K. & Wassenaar, D. 2002. Putting design into practice: writing and evaluating research proposals. In Terre Blanche, M. & Durrheim, K. (Eds.). *Research in Practice: Applied methods for the social sciences.* Cape Town: University of Cape Town Press.

Educause Learning Initiative. 2012. 7 things you should know about flipped classrooms.
(https://library.educause.edu/-/media/file/library/2012/2/eli7081-pdf.pdf)
(Retrieved February 2012).

Eichler, J. & Peeples, J. 2016. Flipped classroom modules for large enrollment general chemistry courses: a low barrier approach to increase active learning and improve student grades. *Chemistry Education Research and Practice,* 17(1):197-208.
(DOI:10.1039/C5RP00159E)

Elen, J. & Clarebout, G. 2001. An invasion in the classroom: Influence of an ill-structured innovation on instructional and epistemological beliefs. *Learning Environments Research*, 4:87-105.

Ellis, S.M. & Steyn, H.S. 2003. Practical significance (effect sizes) versus or in combination with statistical significance (p-values), *Management Dynamics*, 12(4): 51-53.

Estrada, A.C.M., Vera, J.G., Ruiz, G.R. & Arrebola, I.A. 2019. Flipped classroom to improve university student centered learning and academic performance, *Social Sciences*, 8, 315, 1-14.

Farmus, L., Cribbie, R.A. & Rotondi, M.A. 2020. The flipped classroom in introductory statistics: Early evidence from a systematic review and meta-analysis, *Journal of Statistics Education*, 28(3), 316-325.
(DOI: 10.1080/10691898.2020.1834475)

Ferrandino, J.A. 2016. Student achievement in undergraduate statistics: The potential value of allowing failure. *Journal of the Scholarship of Teaching and Learning*, 16(6):1-18.

Forte, J.A. 1995. Teaching statistics without sadistics. *Journal of Social Work Education*, 31(2):204-218.

Fraenkel, J.R. & Wallen, N.E. 2008. *How to Design and Evaluate Research in Education*. New York: McGraw-Hill.

Fredericks, J.A., Blumenfeld, P.C. & Paris, A. 2004. School engagement: Potential of the concept state of the evidence. *Review of Educational Research,* 74:59-119. (DOI:10.3102/00346543074001059)

Freeman, S., O'Connor, E., Parks, J.W., Cunningham, M., Hurley, D., Haak, D., Dirks, C. & Wenderoth, M.P. 2007. Prescribed active learning increases performance in introductory biology. *OBE Life Science Education,* 6:132-139.

Fulgham, C. & Roberts, S. 2017. Online teaching boot camp. Magna Teaching with Technology conference 2017. The best of teaching with technology. *Magna Publications*.
(www.TeachingWithTechnology2017.com)
(Retrieved April 2017).

GAISE College Report ASA Revision Committee. 2016. *Guidelines for Assessment and Instruction in Statistics Education College Report 2016*.
(https://www.amstat.org/education/gaise)
(Retrieved November 2018)

Garfield, J. 1995. How Students Learn Statistics. *International Statistical Review,* 63(1):25-34.

Garfield, J. & Ben-Zvi, D. 2007. *Developing students' statistical reasoning: connecting research and teaching practice.* Emeryville, CA: Key College Publishing.

Gazit, T., Bronstein, J., Amichai-Hamburger, Y., Aharony, N., Bar-Ilan, J. & Perez, O. 2018. Active participants and lurkers in online discussion groups: an exploratory analysis of focus group interviews and observation. *Information Research*, 23(2): paper 791.
(http://InformationR.net/ir/23-2/paper791.html)

Gilakjani, A.P. 2012. Visual, Auditory, Kinaesthetic Learning Styles and Their impacts on English Language Teaching. *Journal of Studies in Education*, 2(1):104-113.

Gillispie, V. 2016. Using the flipped classroom to bridge the gap to Generation Y. *Ochsner Journal*, 16(1):32-36.
(http://www.ochsnerjournal.org/toc/ochs/16/1)
Retrieved (November 2017).

Ginns, P. & Ellis, R. 2007. Quality in blended learning: Exploring the relationships between online and face-to-face teaching and learning. *Internet and Higher Education*, 10(1):53-64.

Glaser, B.G. & Strauss, A.L. 1967. *The Discovery of Grounded Research: Strategies for Qualitative Research.* New York: Aldine De Gruyter.
Glazer, F.S. 2012. *Blended learning: Across the disciplines, across the academy.* Stylus Publishing: Virginia.

Goodwin, B. & Miller, K. 2013. Research Says / Evidence on Flipped Classrooms Is Still Coming In, *Technology-Rich Learning,* 70(6), 78-80.

Gosper, M., Malfroy, J. & McKenzie, J. 2013. Students' experiences and expectations of technologies: An Australian Study designed to inform planning and development decisions. *Australian Journal of Educational Technology*, 29(2):268-282.

Graham, C.R., Tripp, T.R., Seawright, L. & Joeckel, G.L. 2007. Empowering or Compelling Reluctant Participators Using Audience Response Systems. *Active Learning in Higher Education,* 8(3):233-258.

Griffiths, D.S., Winstanley, D. & Gabriel, Y. 2005. *Learning shock – The Trauma of Return to Formal Learning,* London: Sage Publications, 36(3): 275-297.

Groccia, J.E. & Hunter, M.S. 2012. *The First-Year Seminar: Designing, Implementing, and Assessing Courses to Support Student Learning and Success: Volume II – Instructor Training and Development.* Columbia, SC: The National Resource Centre.

Groccia, J.E. 2018. What is Student Engagement? *New Directions for Teaching and Learning in Student engagement: A Multidimensional Perspective*, 154, Wiley Online Library (wileyonlinelibrary.com).
(DOI: 10.1002/tl.20287)
(Retrieved April 2019).

Hake, R. 1998. Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 16:64-74.

Hallinger, P. & Lu, J. 2013. Learner-centred higher education in East Asia: Assessing the effects on student engagement. *International Journal of Educational Management*, 27(6): 594-612.

Halverson, L.R., Graham, C.R., Spring, K.J., Drysdale, J.S. & Henrie, C.R. 2014. A thematic analysis of the most highly cited scholarship in the first decade of blended learning research. *The Internet and Higher Education,* 20, 20-34. (http://dx.doi.org/10.1016/j.iheduc.2013.09.004)

Hamdan, N., McKnight, P., McKnight, K. & Arfstrom, K. M. 2013. *A whitepaper based on the literature review titled: A review of flipped learning.* Flipped Learning Network.
(www.flippedlearning.org)
(Retrieved November 2016).

Herrmann, K.J. 2013. The impact of cooperative learning on student engagement: Results from an intervention, *Active Learning in Higher Education*, 14(3): 175-187.

Hertzog, P.E. & Swart, A.J. 2018. Student perceptions of audio feedback in a design-based module for distance education. *Global Journal of Engineering Education*, 20(2): 100-106.

Hinkle, D.C., Wiersma, W. & Jurs, S.G. 1988. *Applied Statistics for the Behavioral Sciences*. Boston, Boston: Houghton Mifflin Company.

Holley, D. & Oliver, M. 2010. Student engagement and blended learning: Portraits of risk, *Computers & Education*, 54(3): 693-700.

Holmberg, J. 2016. Applying a conceptual design framework to study teachers' use of educational technology, *Educ Inf Technol*, Sweden: Springer.
(DOI 10.1007/s10639-016-9536-3)
(Retrieved December 2018).

Hoover, D.S. 2006. Popular culture in the classroom: Using audio and video clips to enhance survey courses. *The History Teacher*, 39, 467-478.

Hornsby, D.J., Osman, R. & De Matos-Ala, J. 2013. *Large-class pedagogy, Interdisciplinary perspectives for quality higher education*, Stellenbosch: Sunpress.

Hu, S. & Kuh, G.D. 2001. Computing experience and good practices in undergraduate education: Does the degree of campus wiredness matter? Paper

presented at the Annual Meeting of the American Educational Research Association. Seattle: ERIC database: ED 452775.
(http://files.eric.ed.gov/fulltext/ED452775.pdf)
(Retrieved May 2017).

Huitema, B.E. 1980. *The Analysis of Covariance and Alternatives*, New York: John Wiley & Sons.

Hung, H.T. 2015. Flipping the classroom for English language learners to foster active learning. *Computer Assisted Language Learning*, 28(1): 81-96.

Jaffer, S.D., Ng'ambi, D. & Czerniewicz, L. 2007. The role of ICTs in higher education in South Africa: One strategy for addressing teaching and learning challenges. *International Journal of Education and Development Using ICT, 3(4).*

Januszewski, A. & Molenda, M. eds., 2013. *Educational technology: A definition with commentary*. Routledge.

Jarvis, W., Halvorson, W., Sadeque, S. & Johnston, S. 2014. A large class engagement (LCE) Model based on the service-dominant logic (SDL) and flipped classrooms. *Educational Research and Perspectives,* 41, 1-24.

Jensen, J., Kummer, T. & Godoy, P. 2014. Improvements from a flipped classroom may simply be the fruits of active learning. *CBE - Life Sciences Education*, 14(1): 1-12.
(DOI:10.1187/cbe.14-08-0129)

Jimerson, S., Campos, E. & Greif, J. 2003. Toward an understanding of definitions and measures of school engagement and related terms. *The California School Psychologist 8*: 7-27.

Johnson, L. & Adams, S. 2011. *Technology outlook for UK tertiary education 2011–2016: An NMC Horizon Report regional analysis.* Austin, TX: The New Media Consortium.

Johnson, S. 2014. Applying the seven principles of good practice: Technology as a lever – in an online research course. *Journal of Interactive Online Learning*, 13(2), 41-50.

Johnston, K.A. 2013. A guide to educating different generations in South Africa. *Issues in Informing Science and Information Technology,* 10, 261-273. (http://www.informingscience.org/Publications/1810)
(Retrieved November 2017).

K-12 Teachers Alliance, Teach Hub.Com, accessed 2015, weblog, Pros and Cons of flipping.

Kahu, E.R. 2013. Framing student engagement in higher education. *Studies in Higher Education*, 38:5, 758-773.
(http://dx.doi.org/10.1080/03075079.2011.598505)
(Retrieved June 2017).

Kahu, E.R. & Nelson, K. 2018. Student engagement in the educational interface: understanding the mechanisms of student success. *Higher Education Research & Development,* 37(1): 58-71.

Kahu, E.R., Picton, C. & Nelson, K. 2019. Pathways to engagement: a longitudinal study of the first-year student experience in the educational interface. *Higher Education*, 79: 657-673.

Kaliisa, R. & Picard, M.Y. 2017. A systematic review on mobile learning in higher education: The African perspective. *The Turkish Online Journal of Educational Technology*, 16(1), 1-18.

Kamau, G.N. 2022. ICT4D Research in developing countries: A call for pragmatism approach. *International Journal of Computer and Information System,* 3(2), 51-55.

Kaushik, V. & Walsh, C.A. 2019. Pragmatism as a research paradigm and its implications for social work research. *Social Sciences*, 8(9), 255.

Kezar, A. & Kinzie, J. 2006. Examining the ways institutions create student engagement: The role of mission. *Journal of College Student Development,* 47(2): 149-172.

Killen, R. 2004. Teaching portfolios. In Gravett, S & Geyser, H. (Eds.). *Teaching and learning in higher education.* Pretoria: Van Schaik Publishers.

King, A. 1993. From sage to stage to guide on the side. *College Teaching*, 41(1):30-35.
(http://www.edweek.org/ew/articles/2012/10/03/06khan_ep.h32.html)
(Retrieved July 2015).

Kinzie, J. 2012. Fostering student learning and success: The value of high-impact practices.
(www.d.umn.edu/vcaa/sem/k/kinzieH02012%283%29.pdf)
(Retrieved May 2017).

Kirstein, M. & Kunz, R. 2015. Student-centred approach to teaching large classes: friend or foe? Research Paper, University of Pretoria.

Knight, J.K. & Wood, W.B. 2005. Teaching more by lecturing less. *Cell Biology Education*, 4:298-310.

Koekeritz, J., Malkiewicz, J. & Henderson, A. 2002. The seven principles of good practice: Applications for online education in nursing. Nurse Educator, 27, 283-287.

Krathwohl, D.R. 2002. A revision of Bloom's taxonomy: An overview. *Theory into Practice,* 41(4), 212-218.

Krause, K. 2005. *Understanding and Promoting Student Engagement in University Learning Communities*. Paper presented as keynote address: Engaged, Inert or Otherwise Occupied? Deconstructing the 21st Century Undergraduate Student at the James Cook University Symposium 'Sharing Scholarship in Learning and Teaching: Engaging Students' James Cook University, Townsville / Cairns, Queensland, Australia, 21-22 September.

Kuh, G.D., Hayek, J.C., Carini, R.M., Ouimet, J.A. & Kennedy, J. 2001. *NSSE technical and norms report.* National Survey of Student Engagement. (http://cpr.iub.edu/uploads/Norms!%20i-44.pdf) (Retrieved January 2018).

Kuh, G.D. & Vesper, N. 2001. Do computers enhance or detract from student learning? *Research in Higher Education*, 42(1):87-102.

Kuh, G.D. 2003. What we are learning about student engagement from the NSSE. *Change,* 35(2):24-35.

Kuh, G.D., Kinze, J., Shuh, J.H. & Whitt, E.J. 2005. *Student success in college: Creating conditions that matter.* San Francisco: Jossey-Bass.

Kuh, G.D. 2008. High-Impact Educational Practices: What they are, who has access to them, and why they matter. Association of American Colleges & Universities. (https://www.aacu.org/leap/hips) (Retrieved July 2016).

Kuh, G.D. 2009a. What student affairs professionals need to know about student engagement. *Journal of College Student Development*, 50(6): 683-706.

Kuh, G.D. 2009b. The National Survey of Student Engagement: Conceptual and Empirical Foundations. (http://nsse.indiana.edu/pdf/NSSEConceptualandEmpiricalFoundations.pdf) Retrieved August 2018).

Kuh, G.D. & Gonyea, R.M. 2015. The role of the academic library in promoting student engagement in learning. *College & Research Libraries*, 76(3): 359-385.

Kumar, R. 1999. *Research Methodology: A step-by-step guide for beginners.* London: SAGE.

Lage, M., Platt, G. & Treglia, M. 2000. Inverting the classroom: A gateway to creating an inclusive learning environment, *Journal of Economic Education,* 31(1), 30-43.

Laird, T., Shoup, R., Kuh, G. & Schwarz, M. 2008. The effects of discipline on deep approaches to student learning and college outcomes. *Research in Higher education*, 49:469-494.

Lape, N.K., Levy, R., Yong, D.K., Haushalter, K.A., Eddy, R. & Hankel, N. 2014. Probing the Inverted Classroom: A Controlled Study of Teaching and Learning Outcomes in Undergraduate Engineering and Mathematics, *121st ASEE Annual Conference and Exposition,* June 15-18; Indianapolis, IN

Laurillard, D. 1999. A Conversational Framework for Individual Learning Applied to the 'Learning Organisation' and the 'Learning Society', *Systems Research and Behavioral Science, Special Issue: Applying Systems Thinking to Higher Education,* 16(2), 113-122.

Laurillard, D. 2008. *Digital technologies and their role in achieving our ambitions for education*. London: Institute of Education.

Laurillard, D. 2012. *Teaching as a Design Science – Building Pedagogical Patterns for Learning and Technology*, New York: Routledge.

Lawson, T. & Comber, C. 2014. Videoconferencing and learning in the classroom: the effects of being an Orphan Technology? *The International Journal of Technologies in Learning,* 20(1):69-79.

Lea, M.R. & Jones, S. 2011. Digital literacies in higher education: exploring textual and technological practice. *Studies in Higher Education,* 36(4), 377-393.

Lee, M. 2018. Flipped classroom as an alternative future class model?: implications of South Korea's social experiment. *Education Tech Research Dev,* 66: 837-857.

Lim, C.P. & Wang, T. 2015. *Blended learning for quality higher education: Selected case studies on implementation from Asia-Pacific.* Bangkok: UNESCO, 39-65.

Lincoln, Y.S. & Guba, E.G. 1985. *Naturalistic inquiry.* Newbury Park, CA: Sage.

Lloyd, S.A. & Robertson, C.L. 2012. Screencast tutorials enhance student learning of statistics. *Teaching of Psychology,* 39(1), 67-71.

Logan, B. 2015. Deep exploration of the flipped classroom before implementing it. *Journal of Instructional Pedagogies,* 16:1-12.

Long, T., Logan, J. & Waugh, M. 2016. Students' perceptions of the value of using videos as a pre-class learning experience in the flipped classroom. *Tech Trends*. (DOI: 10.1007/s11528-016-0045-4)

Lumpkin, A., Achen, R.M. & Dodd, R.K. 2015. Using technology-nested instructional strategies to enhance student learning. *Insight: A Journal of Scholarly Teaching*, 10:114-125.

Maarouf, H. 2019. Pragmatism as a supportive paradigm for the mixed research approach: conceptualizing the ontological, epistemological, and axiological stances of pragmatism. *International Business Research,* 12(9), 1-10.

Madani, R. 2019. Analysis of educational quality, a goal of education for all policy. *Higher Education Studies*, 9(1), 100-109.

Madge, C., Breines, M.R., Dalu, M.T.B., Gunter, A., Mittelmeier, J., Prinsloo, P. & Raghuram, P. 2019. WhatsApp use among African international distance education (IDE) students: transferring, translating and transforming educational experiences. *Learning, Media and Technology,* 44(3): 267-282.

Malm, E. & Defranco, J.F. 2011-2012. Toward a student-centred measure of learning management system utilization. *Journal of Educational Technology Systems,* 40(4), 401-413.

Mangan, K. 2013. A guide to the flipped classroom. *The Chronicle of Higher Education*, Inc.
(http://www.Chronicle.com/article/Inside-the-Flipped-classroom/141891/)
(Retrieved 2013).

Maphosa, V., Dube, B. & Jita, T. 2020. A UTAUT Evaluation of WhatsApp as a tool for lecture delivery during the COVID-19 lockdown at a Zimbabwean University. *International Journal of Higher Education*, 9(5): 84-93.

Maree, K. 2014. *First steps in Research.* Pretoria: Van Schaik Publishers.

Maree, K. 2017. *First steps in Research.* Pretoria: Van Schaik Publishers.

Mason, G.S., Shuman, T.R. & Cook, K.E. 2013. Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education.* 56(4):430-435. (http://doi.org/10.1109/TE.2013.2249066)
(Retrieved November 2017).

Mayer, R. E. 2001. *Multimedia learning*. New York: Cambridge University Press.

Mayer, R.E. 2003. The Promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction*, 13(2):125-139.

Mayer, R.E. 2009. *Multimedia learning*. 2nd ed. New York: Cambridge University Press.

Mayet, R. 2016. Supporting at-risk learners at a comprehensive university in South-Africa. *Journal of Student Affairs in Africa*, 4(2):1-12.

Mayhew, M.J., Rockenbach, A.N., Bowman, N.A., Seifert, T.A., Wolniak, G.C., Pascarella, E.T. & Terenzini, P.T. 2016. *How college affects: 21st – century evidence that higher education works,* Vol.3. San Francisco: Jossey-Bass.

McGill, I. & Warner Weis, S. (Eds.) 1989. *Making Sense of Experiential Learning, Continuing the dialogue: new possibilities for experiential learning,* The Society for Research into Higher Education and Open University Press, Milton Keynes.

McGivney-Burelle, J. & Xue, F. 2013. Flipping Calculus, *Primus,* 23(5): 477-486. (http://doi.org/10.1080/10511970.2012.757571)

McLaughlin, J.E., Gharkholonarehe, N., Khanova, J., Deyo, Z.M. & Rodgers, J.E. 2015. INSTRUCTIONAL DESIGN AND ASSESSMENT, The Impact of Blended Learning on Student Performance in a Cardiovascular Pharmacotherapy Course. *American Journal of Pharmaceutical Education,* 79(2) Article 24.

McLean, D. & White, E.R. 2009. Two approaches to podcasting use in the classroom. *Merlot Journal of Online Teaching and Learning,* 5(2):336-347.

McMillan, J. H., & Schumacher, S. 2001. *Research in Education. A Conceptual Introduction* (5th ed.). New York: Longman.

McMillan, J.H. & Schumacher, S. 2006. *Research education Evidence-Based Inquiry.* 6th ed. Boston: Pearson.

McRae, K., Odeh, S., Diap, M. & Mcneill, M. 2017. "Institutional wide curriculum change in higher education", 40th Annual Conference of the Higher Education Research and Development Society Australia (HERDSA).

Meletiou-Mavrotheris, M., Lee, C. & Fouladi, R.T. 2007. Introductory statistics, college student attitudes and knowledge – a qualitative analysis of the impact of technology-based instruction. *International Journal of Mathematical Education in Science and Technology,* 38(1): 65-83.

Mentimeter. 2019. (https://www.mentimeter.com/powerpoint) (Retrieved March 2019)

Michael, J. 2006. Where's the evidence that active learning works? *Advances Physiology Education*, 30:159-167.

Miles, C.A. & Foggett, K. 2016. Supporting Our Students to Achieve Academic Success in the Unfamiliar World of Flipped and Blended Classrooms. *Journal of University Teaching & Learning Practice*, 13(4):1-14.

Milliard, E. 2012. *Five reasons flipped classrooms work: turning lectures into homework to boost student engagement and increase technology-fuelled creativity*. The University of Business. (https://www.universitybusiness.com/article/5-reasons-flipped-classrooms-work) (Retrieved 2015).

Mishra, S. 2020. Social networks, social capital, social support and academic success in higher education: A systematic review with a special focus on 'underrepresented' students. *Educational Research Review,* 29: 12-13.

Mortagy, Y. & Boghikian-Whitby, S. 2010. A longitudinal comparative study of student perceptions in online education. *Interdisciplinary Journal of E-Learning and Learning Objects,* 6, 23-44.

Neshyba, S. 2013. A guide to the flipped classroom. *The chronicle of Higher Education*, Inc.
(http://www.chronicle.com/article/It's a Flipping Revolution/138259)
(Retrieved July 2015).

Ng'ambi, D. & Lombe, A. 2012. Using Podcasting to Facilitate Student Learning: A Constructivist Perspective. *Educational Technology & Society*, 15(4), 181-192.

Ng'ambi, D., Brown, C., Bozalek, V., Gachago, D. & Wood, D. 2016. Technology enhanced teaching and learning in South African higher education – A rearview of a 20 year journey. *British Journal of Educational Technology*, 47(5): 843 – 858.
(http://dx.doi.org/10.1111/bjet.12485)

Nwosisi, C., Ferreira, A. Rosenberg, W. & Walsh, K. 2016. A study of the flipped classroom and its effectiveness in flipping thirty percent of the course content. *International Journal of Information and Education Technology*, 6(5): 348 -351.

Oblinger, D.G. & Oblinger, J.L. 2005. *Educating the net generation*. Educause. Boulder. North Carolina State University.
(www.educause.edu/educatingthenetgen/)

O'Dowd, D.K. & Aguilar-Roca, N. 2009. Garage demos: using physical models to illustrate dynamic aspects of microscopic biological processes. *CBE Life Science Education*, 8:118-122.

OECD. 2015. *Students, computers and learning.* PISA: OECD Publishing
(http://www.oecd-ilibrary.org/education/students-computers-and-learning_978926439555-en.)

Olivier, E. 2017. Gamification as a transformative assessment in higher education. *HTS Teologiese Studies / Theological Studies*, 73(3), a4527.
(https://doi.org/10.4102/hts.v73i3.4527)

(Retrieved October 2018)

Ouda, H. & Ahmed, K. 2016. Flipped Learning As A New Educational Paradigm: An Analytical Critical Study. *European Scientific Journal*, 12, 417 – 444.
(DOI: 10.19044/esj.2016.v12n10)
(Retrieved April 2019).

Owston, R.D., Garrison, D.R. & Cook, K. 2006. *Blended learning at Canadian universities: issues and practices. In Bonk, C.J. & Graham, C.R. (Eds). The Handbook of Blended Learning: Global Perspectives, Local Designs,* Pfeiffer, San Fransisco, C.A.

Pace, C.R. 1998. Recollection and Reflection. In *J.C. Smart (ed.), Higher Education: Handbook of Theory and Research (pp. 1-34).* London: Kluwer Academic Publisher.

Parvaiz, G.S., Mufti, O. & Wahab, M. 2016. Pragmatism for Mixed Method research at Higher Education Level. *Business & Economic Review.* 8(2), 67-79.

Pascarella, E.T. & Terenzini, P.T. 2005. *How college affects students: A third decade of research.* San Francisco: Jossey-Bass.

Pask, G. 1976. Conversational techniques in the study and practice of education. *British Journal of Educational Psychology,* 46(1), 12-25.

Pike, G.R. & Kuh, G.D. 2005. First- and Second-Generation College Students:P A Comparison of their engagement and intellectual development. *The Journal of Higher of Education*. 76(3), 276-300.
(http://www.jstor.org/stable/3838799)

Plana, M.G.C., Escofet, M.I.G., Figueras, I.T., Gimeno, A., Appel, C. & Hopkins, J. 2013. *Improving learners' reading skills through instant short messages: A sample study using WhatsApp*. 4th World-CALL Conference, Glasgow.
(https://www.researhgate.net/publication/255718202)
(Retrieved February 2019).

Prensky, M.(ed). 2001. *Digital game-based learning*, McGraw-Hill, New York.

Ramsden, P. 2003. *Learning to Teach in Higher Education,* 2nd ed, London: Routledge Falmer.

R Development Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0.

Reason, R.D., Terenzini, P.T. & Domingo, R. 2006. First things first: Developing academic competence in the first year of college. *Research in Higher Education*, 47(2):149-175.
(https://doi.org/10.1007/s11162-005-8884-4)

Reddy, P. & Sharma, B. 2020. Digital Literarcy: A Review of literature, *International Journal of Technoethics*, 11(2): 65-94.

Reddy, V., Isdale, K., Juan, A., Visser, M., Winnaar, L., & Arends, F. 2016. TIMSS 2015: Highlights of Mathematics Achievement of Grade 5 South African Learners. Human Sciences Research Council.

Rego, R. 2017. New media technologies in teaching and learning in higher education, *Media Watch*, 8(1): 75-88.

Richardson, J. 2005. Instruments for obtaining student feedback: A review of the literature, *Assessment and Evaluation in Higher Education,* 30(4): 387-415.

Richey, R., Klein, J.D. & Tracey, M.W. 2011. The instructional design knowledge base: *Theory, research, and practice.* New York: Routledge.

Roehl, A., Reddy, L.S. & Shannon, G.J. 2013. The flipped classroom: An opportunity to engage millennial students through active learning strategies. *Journal of Family and Consumer Sciences*, 105(2), 44-49.

Roseth, C., Garfield, J. & Ben-Zvi, D. 2008. Collaboration in Learning and Teaching Statistics, *Journal of Statistics Education,* 16(1).
(www.amstat.org/publications/jse/v16n1/roseth.html)
(Retrieved November 2016).

Rubin, D.B. 2005. Causal inference using potential outcomes: Design, Modeling, Decisions. *Journal of the American Statistical Association, 100*(469), 322-331.

Ruggiero, D. & Mong, C. 2015. The teacher technology integration experience: Practice and reflection in the classroom. *Journal of Information Technology Education: Research*, 14, 161-178.
(http://www.informingscience.org/Publications/2227)
(Retrieved December 2017).

SASSE *see* South African Surveys of Student Engagement

Schau, C. 2003. Students' attitudes: The 'other' important outcome in statistics education. *Joint Statistical Meetings* (Section on Statistical Education), 3673-3683.

Schindler, L.A., Burkholder, G.J., Morad, O.A. & Marsh, C. 2017. Computer-based technology and student engagement: a critical review of the literature. *International Journal of Educational Technology in Higher Education*, 14(25), 1-28.

Schnotz, W. 2013. Integrated Model of Text and Picture Comprehension. In R.E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning.* Cambridge: Cambridge University Press. 2nd Edition.

Schreiber, B. & Yu, D. 2016. Exploring student engagement practices at a South African university: student engagement as a reliable predictor of academic performance. *South African Journal of Higher Education*, 30(5):157-175.

Seels, B. 1997. *The relationship of media and ISD theory: The unrealized promise of Dale's Cone of Experience* (ERIC Document Reproduction Service No. ED 409 869).
(http://eric.ed.gov/ERICWebPortal/Home.portal)
(Retrieved January 2019).

Seltman, H.J. 2018. *Experimental Design and Analysis.*
(http://www.stat.cmu.edu/~hseltman/309/Book/Book.pdf)
(Retrieved August 2018).

Sevian, H. & Robinson, W.E. 2011. Clickers promote learning in all kinds of classes – Small and large, graduate and undergraduate, lecture and lab. *Journal of College Science Teaching*, 40(3), 14-18.

Sharples, M., Taylor, J., & Vavoula, G. 2007. A Theory of Learning for the Mobile Age. In R. Andrews and C. Haythornthwaite (eds.) The Sage Handbook of Elearning Research. London: Sage, pp. 221-47.

Shulman, L. 2005. Making Differences: A Table of Learning. *Change,* 34(6): 36-44.

Siegle, D. 2014. Technology: Differentiating instruction by flipping the classroom. *Gifted Child Today*, 37(1):51-55.

Siemens, G. 2008. *Learning and knowing in networks: Changing roles for educators and designers.* Paper 105: University of Georgia IT Forum. (http://it.coe.uga.edu/itforum/Paper105/Siemens.pdf)

Simpson, D.B. & Burnett, D. 2017. Commuters versus residents: The effects of living arrangement and student engagement on academic performance. *Journal of College Student Retention: Research, Theory & Practice*, 0(0), 1-19.

Smallhorn, M. 2017. The flipped classroom: A learning model to increase student engagement, not academic achievement. *Student Success,* 8(2), 43-53. (DOI: 10.5204/ssj.v8i2.381).

Smit, I. & Du Plessis, L. 2013. WhatsApp in Social Networking, MXit with BB Messaging: Can social networking sites be used to enhance learning? In Steyn, J. & Kirlidog, M. (eds). 2012. *Alleviating Digital poverty with ICT innovation in emerging economies, Will ICT Rights make a difference? IDIA2012 Conference Proceedings Beykent University, Istanbul, Turkey*.

Smith, D. & Smith, K. 2014. The case for 'passive' learning – The 'silent' community of online learners. *European Journal of open and Distance Learning.* (http://www.eurodl.org/materials/contrib/2014/Smith_Smith.pdf) (Retrieved December 2017).

Smith, J. 2017. Wake them up! Ten ways to enliven your college classroom. Magna Teaching with Technology conference 2017. The best of teaching with technology. *Magna Publications*.
(www.TeachingWithTechnology2017.com)
(Retrieved April 2017).

Sol, K. & Heng, K. 2022. Understanding epistemology and its key approaches in research. *Cambodian Journal of Educational Research*, 2(2), 80-99.

Sorden, S.D. 2012. The cognitive theory of multimedia learning.
(Sorden.com/portfolio/sorden_draft_multimedia2012.pdf)
(Retrieved May 2017).

South African Surveys of Student Engagement (SASSE). 2015. Promoting access with success for all students through engagement. Annual Report 2015. University of the Free State (UFS).
(http://sasse.ufs.ac.za)
(Retrieved February 2017).

Sowa, L. & Thorsen, D. 2015. An assessment of student learning, perceptions and social capital development in undergraduate, lower-division STEM courses employing a flipped classroom pedagogy. Paper presented at the 122nd ASEE Annual Conference and Exposition, Seattle, WA.

Spaull, N. 2019. Priorities for education reform in South Africa. Input document for Treasury's Economic Colloquium. A report to President Ramaphosa & Minister Mboweni. Stellenbosch University.
(https://nicspaull.files.wordpress.com/2019/01/v2-spaull-priorities-fo-educ-reform-treasury-19-jan-2019.pdf)
(Retrieved April 2019).

Speller, L. 2018. Clickers: TurningPoint Mobile (Previously ResponseWare) for students.
(https://tips.uark.edu/responseware-for-students/)
(Retrieved September 2019).

Steen-Utheim, A.T. & Foldnes, N. 2017. A qualitative investigation of student engagement in a flipped classroom. *Teaching in Higher Education.*
(DOI: 10.1080/13562517.2017.1379481)
(Retrieved November 2017).

Stillings, N.A., Weisler, S.E., Chase, C.H., Feinstein, M.H., Garfield, J.L. & Rissland, E.L. 1995. *Cognitive science: An introduction.* 2nd ed. Cambridge, Ma: MIT Press.

Strayer, J. 2012. How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environ Res*, 15(2): 171-193.

Strelan, P., Osborn, A. & Palmer, E. 2020. The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review*, 30, 100314.

Strydom, J.F., Mentz, M. & Kuh, G.D. 2010. Enhancing success in higher education by measuring student engagement in South Africa. *Acta Academica*, 42(1):259-278.

Strydom, F., Kuh, G. & Loots, S. 2017. *Engaging Students: Using Evidence to Promote Student Success*. Bloemfontein: Sun Press.

Subramony, D., Molenda, M., Betrus, A. & Thalheimer, W. 2014. The mythical retention chart and the corruption of Dale's Cone of Experience. *Educational Technology,* 54(6), 6-16.

Sweller, J. 2005. Implications of cognitive load theory for multimedia learning. In R.E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning.* New York: Cambridge University Press.

Talbert, R. 2014a. Toward a Common Definition of "Flipped Learning", A Guide to the flipped classroom. *The Chronicle of Higher Education*.
(http://www.chronicle.com/blognetwork/cgoutnines/2014/04/01/toward-a-common-definition-of-flipped-learning/)
(Retrieved July 2015)

Talbert, R. 2014b. Flipped Learning Skepticism: Do Students Want to Have Lecturers? A Guide to the flipped classroom. *The Chronicle of Higher Education*.

(http://www.chronicle.com/blognetwork/castingoutnines/2014/05/05/flipped-learning-skepticism-do-students-want-to-have-lectures/)
(Retrieved July 2015).

Tani, M., Gheith, M.H. & Papaluca, O. 2021. Drivers of student engagement in higher education: a behavioral reasoning theory perspective. *Higher Education*, 82:499-518.

Tashakkori, A. & Teddlie, C. 1998. *Mixed methodology: Combining qualitative and quantitative approaches.* Thousand Oaks: Sage Publications.

Teng, Y. & Wang, X. 2021. The effect of two educational technology tools on student engagement in Chinese EFL courses. *International Journal of Educational Technology in Higher Education*, 18:27.

Thomas, L. 2002. Student retention in higher education: The role of institutional habitus. *Journal of Educational Policy*, 17, 423-442.

Tight, M. 2012. *Researching Higher Education*. 2nd ed. Open University Press.
Tight, M. 2014. Discipline and theory in higher education research, *Research Papers in Education*. 26(1), 93-110
(https://doi.org/10.1080/02671522.2012.729080)
(Retrieved October 2020).

Toohey, S (1999) Designing Courses for Higher Education. Buckingham, Open University Press.

Topping, K.J. 2005. Trends in peer learning. *Educational Psychology,* 25(6): 631-645.

Triantafyllou, E. & Timcenko, O. 2014. Introducing a flipped classroom for a statistics course: a Case study. *Conference: 2014 25th EAEEIE Annual Conference (EAEEIE).*
(https://www/researchgate.net/publication/268196355)

Trowler, V. 2010. *Student engagement literature review,* Department of Educational Research. Lancaster University. The Higher Education Academy.

Trowler, V., Allan, R.A., Bryk, J. & Din, R.R. 2021. Pathways to student engagement: beyond triggers and mechanisms at the engagement interface. *Higher Education*, 84: 761-777.

Truschel, Ed. D. 2015. What tutors can do to enhance critical thinking skills through the use of Bloom's Taxonomy. *The Association for the Tutoring Profession.* (https://www.myatp.org/wp-content/uploads/2015/04/Synergy-Vol-2-Truschel1.pdf) (Retrieved November 2018).

Tucker, C.T., Wycoff, T. & Green, J.T. 2017. *Blended learning in action – A practical guide toward sustainable change.* California: Corwin.

Turnbull, D., Chugh, R. & Luck, J. 2021. Learning management systems: a review of the research methodology literature in Australia and China. *International Journal of Research & Method in Education*, 44(2): 164-178.

Ujakpa, M. M., Heukelman, D., Lazarus, V.K., Neiss, P. & Rukanda, G.D. 2018. Using WhatsApp to support communication in teaching and learning. *IST-Africa 2018 Conference Proceedings*, 1-6.

Van Broekhuizen, H. 2016. Graduate Unemployment, Higher Education Access and Success, and Teacher Production in South Africa. PhD thesis, Faculty of Economic and Management Sciences, Stellenbosch University.

Van Broekhuizen, H., Van der Berg, S. & Hofmeyer, H. 2016. Higher Education Access and Outcomes for the 2008 National Grade 12 Cohort. Stellenbosch Economic Working Papers: 16/16 (Online). (http://resep.sun.ac.za/wp-content/uploads/2018/07/wp-16-2016_1.pdf) (Retrieved April 2019).

Van der Merwe, A. & Mouton, J. 2005. Integrating ICTs into the teaching and learning environment: An investigation of lecturer perceptions of possible barriers and incentives. *Perspectives in Education*, 23(4): 19-37.

Van der Merwe, C.A. & Van der Merwe, S. 2009. Student success: Data mining measures what matters. *Journal for New Generation Sciences*, 7(2): 284-302.

Van der Merwe, L. 2012. An analysis of the field of statistics education research with special reference to computer-assisted teaching and learning. Phd dissertation.

Van Jaarsveldt, D.E. & Ndeya-Ndereya, C.N. 2015. 'It's not my problem': exploring lecturers' distancing behaviour towards students with disabilities. *Disability & Society.*
(DOI: 10.1080/09687599.2014.994701)

Vij, S. 2015. The construction of knowledge. Australian Council for Educational Research, 9(3).
(https://www.acer.org/files/teacher-india-sample1.pdf)
(Retrieved February 2019).

Von Glasersfeld, E. 2008. Learning as Constructive Activity, Originally published in *Proceedings of the 5th Annual Meeting of the North American Group of Psychology in Mathematics Education, Vol. 1 (Montreal: PME-NA, 1983, pp. 41— 101), edited by J.C. Bergeron & N. Herscovics. AntiMatters* 2(3).

Vygotsky, L.S. 1978. *Mind in society: The development of a higher psychological process.* Cambridge, MA: Harvard University Press.

Wallman, K.K. 1993. Enhancing statistical literacy: Enriching our Society, *Journal of the American Statistical Association,* 88(421), 1-8.

Wasserman, N.H., Quint, C., Norris, S.A. & Carr, T. 2017. Exploring flipped classroom instruction in Calculus III. *International Journal of Science and Math Education*, 15: 545-568.

Wedlock, B.C. & Growe, R. 2017. The Technology-driven student: How to apply Bloom's Revised Taxonomy to the digital generations. *Journal of Education & Social Policy*, 7(1): 25-34.

Welman, R.W., Kruger, F. & Mitchell, B. 2005. *Research methodology,* Cape Town: Oxford University Press.

Whillier, S. & Lystad, R.P. 2015. No Difference in Grades or Level of Satisfaction in a Flipped Classroom to Neuroanatomy, *J Chiropr Educ*, 26(2), 127-33.

Wilson, S. G. 2013. The flipped class: A method to address the challenges of an undergraduate statistics course. *Teaching of Psychology*, 40(3): 193-199. (DOI:10.1177/0098628313487461)

Wilson, T. 2017. What's going on behind the blank stare? Magna Teaching with Technology conference 2017. The best of teaching with technology. *Magna Publications*.
(www.TeachingWithTechnology2017.com)
(Retrieved April 2017).

Wilson, C., Broughan, C. & Marselle, M. 2019. A new framework for the design and evaluation of a learning institution's student engagement activities. *Studies in Higher Education,* 44(11), 1931-1944.

Wilson-Strydom, M. 2015. UNIVERSITY ACCESS AND SUCCESS Capabilities, diversity and social justice. Research Brief UFS.
(https://www.ufs.ac.za/docs/librariesprovider34/default-document-library/university-access-and-success-capabilities-diversity-and-social-justice.pdf?sfvrsn=0)
(Retrieved June 2017).

Winquist, J.R. & Carlson, K.A. 2014. Flipped statistics class results: Better performance than lecture over one year later. *Journal of Statistics Education,* 22(3), 1-10.

Xerri, M.J., Radford, K. & Shacklock, K. 2018. Student engagement in academic activities: a social support perspective. *Higher Education*, 75:589-605.

Yeung, H.W. 1997. Critical realism and realist research in human geography: a method or a philosophy in search of a method. *Progress in Human Geography,* 21:51-71.

Yeung, A., Raju, S. & Sharma, M. 2016. Online lecture recordings and lecture attendance: Investigating student preferences in a large first-year psychology course. *Journal of Learning Design,* 9(1):55-71.
(DOI:10.5204/jld.v9i1.243)

Zeleke, A. & Lee, C. 2018. A study of students' attitudes change and performance improvement in a flipped class. In *Sorto, M.A. & White, A. & Guyot, L. (Eds.), Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10, July 2018), Kyoto, Japan.*

Zewotir, T. & North, D. 2011. Opportunities and challenges for statistics education in South Africa. *Pythagoras*, 32(2), Art. #28, 1 – 9.

Zewotir, T., North, D. & Murray, M. 2011. Student success in entry-level modules at the University of Kwazulu-Natal. *SAJHE*, 25(6), 1233-1244.

Zweekhorst, M.B.M. & Maas, J. 2015. ICT in Higher Education: Students perceive increased engagement. *Journal of Applied Research in Higher Education*, 7(1):2-18.
(DOI:10.1108/JARHE-02-2014-0022)

9. Appendix A: Letter of consent

Researcher: Mrs L. da Silva
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Study Leader: Dr S.P. van Tonder
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24 July 2017

Informed Consent:

Dear Participant

I would like to invite you to take part in this research project:

Flipping the classroom to enhance student engagement in first-year Statistics Education.

An average of only 16% of students who enrol in South African universities finish their studies and therefore we are investigating other learning strategies to improve student success. Flipping means replacing traditional face-to-face lecturing by first doing self-study outside the class environment with the help of videos before attending classes. The students that sign this letter on consent will be randomly assigned to two groups, where the one group will do flipping, and the other group will still follow traditional teaching in class. Then we can compare which group outperforms the other group.

We would like you to participate with us in this research because we want to see whether this type of teaching will enhance your learning.

The reason we are doing this study is to improve student success by promoting student engagement in their studies by flipping the classroom.

The possible risks to you in taking part in this study are that your lecturer is in the role of authority, but we assure you that no comments will be used against you or influence your marks in any way. Confidentially will be secured and no mention of student numbers will be made in the research report.

I am sure you will benefit from this study and even students with English as their second language will benefit from this way of teaching. No financial benefits will be given to the participants of this study. UFS can benefit from this study because student throughput rates can be increased if Flipping succeeds.

While I greatly appreciate your participation in this important study and the valuable contribution you can make, your participation is entirely voluntary, and you are under no obligation to take part in this study. If you do choose to take part, and an issue arises which makes you uncomfortable, you may at any time stop your participation with no further repercussions.

If you experience any discomfort or unhappiness with the way the research is being conducted, please feel free to contact me directly to discuss it and note that you are free to contact my study supervisor (indicated above).

Should any difficult personal issues arise during this research, I will endeavour to see that a qualified expert is contacted and able to assist you.

Yours sincerely,

_____

Mrs L. da Silva

Please fill in and return this page. Keep the letter above for future reference.

Study: Flipping the classroom for enhancing student engagement in first-year Statistics Education.

Researcher: Mrs L. da Silva

Name and surname: _____

Student Nr.: _____

Age: _____

E-Mail: _____

- I hereby give free and informed consent to participate in the abovementioned research study.
- I understand what the study is about, why I am participating and what the risks and benefits are.
- I give the researcher permission to make use of the data gathered from my participation, subject to the stipulations he/she has indicated in the above letter.

Signature: _____ **Date:** _____

10. Appendix B: Questionnaire for EFBC 2524 students (2017)

Answer each question by making a cross at the appropriate choice or by writing your opinion in the space provided.

Please take note that the information given will be treated confidentially and will not be used to influence any students' marks.

DEMOGRAPHIC INFORMATION

1. **Student Nr. _____**

2. **Gender**

Male	
Female	

3. **Race**

Black	
Coloured	
Indian	
Asian	
White	
Other – Specify	

4. **Age**

18 – 19	
20 – 21	
Other (specify)	

5. **Home Language**

Afrikaans	
English	
Sotho	
Other (specify)	

6. **Are you an International Student?**

Yes	
No	

7. **What type of accommodation do you have while studying?**

Private: Parents	
Private: flat	
Student House	
Student Residence (On-campus)	
Other (specify)	

8. **How many hours do you study daily?**

None	
0-2	
2-4	
More than 4	

9. **Where are you most comfortable in studying?**

Your residence	
Library	
Labs	
Your residence and Library	
Other (Specify)	

STUDENT PERCEPTIONS ON THE FLIPPED CLASSROOM

10. Choose applicable options below when you watched videos?

Take notes	
Stopped and Rewind	
Re-watched sections when you did not understand a section	
Paid 100% attention with no distractions	
None of the above	

11. How would you describe this flipped classroom to a future student of this class?

_____

_____

12. What did you enjoy of the flipped classroom?

_____

_____

Answer each of the following questions:

	Disagree	Neutral	Agree
13. I would not recommend the flipped classroom to a friend.			
14. I like watching lectures with videos.			
15. I like watching videos at my own pace.			
16. I like watching videos for about 10 minutes.			
17. I like watching videos for about 30 minutes or longer.			
18. I prefer traditional teaching to the flipped classroom.			
19. I am more motivated to learn during the flipped classroom approach.			
20. A flipped classroom makes it easier to understand the course content.			
21. Fellow students distract my attention in a traditional class.			
22. The videos held my attention.			

23. Will you like to study other subjects with Flipping as well?

Yes	
No	

24. If you answered No in question 23, explain why?

_____

_____

25. If you answered Yes in question 23, explain why?

_____

_____

26. In your opinion, what is the disadvantages of a flipped classroom?

_____

_____

27. What improvements would you recommend to a flipped classroom?

_____

_____

STUDENTS' ENGAGEMENT FOR EFBC 2524:

28. What other sources did you use e.g. WhatsApp, Internet, etc. to complete assignments? Specify.

_____

_____

29. How often did you ask questions during class to your lecturer?

Never	
Weekly	
Daily	
Multiple times per class	

30. How often did you ask questions to fellow students during your class?

Never	
Weekly	
Daily	
Multiple times per class	

31. How did you communicate with your lecturer when you did not understand certain concepts?

E-mail	
Face-to-face in class	
WhatsApp (phone)	
Never	

32. How did you communicate with fellow students when you did not understand certain concepts?

E-mail	
Face-to-face in class	
Outside class	
WhatsApp (phone)	
Never	

33. How often did you use technology to communicate with fellow students when you did not understand certain concepts?

Never	
Sometimes	

Often	
Always	

34. How often did you use technology to communicate with your lecturer when you did not understand certain concepts?

Never	
Sometimes	
Often	
Always	

35. Did you tutor fellow students?

Yes	
No	

36. Did you receive prompt feedback regarding your academic performance from the lecturer?

Yes	
No	

37. How did you communicate with your lecturer when discussing marks on assignments or assessments?

E-mail	
Face-to-face in class	
Outside class	
WhatsApp (phone)	
Never	

HOW DID THE FOLLOWING FACTORS INFLUENCE YOUR LEARNING IN THIS COURSE?

	HINDER YOUR LEARNING	IMPROVE YOUR LEARNING	NO EFFECT ON YOUR LEARNING
38. Communicate with fellow students outside of class			
39. Interaction with fellow students during class			
40. Tutoring fellow students			
41. Your lecturer			
42. Studying independently			
43. The use of technology (e.g. Blackboard, Internet, etc.)			
44. A large class			

45. What other factors enhanced your learning? Specify.

_____

46. What other factors hindered your learning? Specify.

_____

Thank you for your cooperation.

11. Appendix C: Interview questions for students (Focus group)

1. How would you describe this flipped classroom (viewing videos) to future students?

2. What did you like about the class with videos?

3. What did you not like about the class with videos?

4. Do you feel the use of technology in this course improved your performance?

5. Would you change how the videos were being sent to you?

6. Did you use your own data to download the videos?

7. Did you watch the videos via PowerPoint, or did you use something else?

8. Do you think the students attending class have better opportunities than the students viewing the lectures?

9. Would you advise students in the traditional class to rather view lectures in their own time with videos? Give a reason.

12. Appendix D: Confirmation from ethics committee

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS·UV
EDUCATION
OPVOEDKUNDE

Faculty of Education

25-Nov-2016

Dear **Mrs. Liza Da Silva**

Ethics Clearance: **Flipping the classroom for enhancing student engagement and deep learning in first-year Statistics Education.**

Principal Investigator: **Mrs. Liza Da Silva**

Department: **School of Higher Education Studies (Bloemfontein Campus)**

APPLICATION APPROVED

With reference to your application for ethical clearance with the Faculty of Education, I am pleased to inform you on behalf of the Ethics Board of the Faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2015/0658**

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance, and we wish you every success with your research.

Yours faithfully

Dr. Juliet Ramohai

Chairperson: Ethics Committee

Education Ethics Committee
Office of the Dean: Education
T: +27 (0)51 401 9683| F: +27 (0)86 546 1113 | E: RamohaiJ@ufs.ac.za
Winkie Direko Building | P.O. Box/Posbus 339 | Bloemfontein 9300 | South Africa
www.ufs.ac.za

13. Appendix E: Approval from UFS authorities for participation of students / staff in research projects

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS UV

SECRETARY
OFFICE OF THE DEAN
STUDENT AFFAIRS
05- 2017
UNIVERSITY OF THE FREE STATE

UNIVERSITY OF THE FREESTATE RESEARCH ETHICS COMMITTEES

APPROVAL FROM UFS AUTHORITIES
FOR PARTICIPATION OF STUDENTS/STAFF IN RESEARCH PROJECTS

Title, Initials, Surname:	Mrs L. da Silva	**Staff/Student number**	036368
Department/Institution:	Education / Math. Statistics		
Phone:	—	**E-mail address:**	dasilval@ufs.ac.za
Supervisor(s):	Dr. S.P. v. Tonder	**Phone:**	0716549348

Protocol Title:	Flipping the classroom to enhance student engagement in first-year Statistics Education.

Who will be involved in the study? (tick ✓)	☑ UFS Personnel	☐ Students

INSTRUCTIONS:

- Please attach the following to this form when requesting approval from the signatories:
  - A short summary of the study protocol;
- Kindly note that it is the responsibility of the researcher(s) to ensure that all relevant signatures are obtained before this signed form is attached to your Ethical Clearance Application's Document Checklist on RIMS.
- Please choose either section A, B **OR** C below.
- *Please note:*
  - *If you are doing research on any students from the UFS you require the permission of the Dean: Student Affairs B (i).*
  - *if you are doing research on students/staff from a non-academic/support service division at the UFS you require the permission of the Director / Snr Director of the Division C (i).*
- Section D is **mandatory** for all research on campus.

A. FOR RESEARCH ON UFS STUDENTS AND/OR STAFF FROM A SPECIFIC FACULTY, BOTH THE FOLLOWING SIGNATURES MUST BE OBTAINED:		
i. HEAD OF DEPARTMENT	☒ Approved	☐ Not Approved
Signature:	Date:	
	26 / 5 / 2017.	
Comments:		
I Approve.		
ii. DEAN OF FACULTY	☐ Approved	☐ Not Approved
Signature:	Date:	
PROF. ED VERHOEVEN DEAN / DEKAAN NATURAL & AGRICULTURAL SCIENCES NATUUR- EN LANDBOUWETENSKAPPE P.O. BOX/BUS 339 (44) BLOEMFONTEIN • ZA 9300	2017-05-29	
Comments:		
Approved		

AND

B. FOR RESEARCH ON INTERFACULTY UFS STUDENTS AND/OR STUDENTS IN UFS RESIDENCES, THE FOLLOWING SIGNATURE MUST BE OBTAINED:		
i. DEAN: STUDENT AFFAIRS	☑ Approved	☐ Not Approved
Signature:	Date:	
	01—06—2017	
Comments:		

OR

C. FOR RESEARCH ON STAFF FROM SUPPORT SERVICES:		
i. DIRECTOR / SNR DIRECTOR OF SUPPORT SERVICE DIVISION	☐ Approved	☐ Not Approved
Signature:	**Date:**	
Comments:		

AND

D. ALL RESEARCH ON STUDENTS AND/OR STAFF TO BE APPROVED BY:		
i. VICE-RECTOR: RESEARCH	☑ Approved	☐ Not Approved
Signature:	**Date:**	
CW. Witthuhn	06/05/2017	
Comments:		

Die Universiteit van die Vrystaat
The University of the Free State
2017 -06- 06
Prof. R.C. Witthuhn
VISEREKTOR: NAVORSING
VICE RECTOR: RESEARCH

Prof. Corli Witthuhn
Viserektor:Navorsing - Vice Rector:Research
Universiteit van die Vrystaat
University of the Free State
Hoofgebou K61 Tel. 051 - 401 2116

14. Appendix F: Examples of assessments

Quizzes, Tutorials and Assignments:

Examples of some of the pools of the tutorials and assignments:


Tutorial 3


Assignment 2_sem2.docx

Semester tests:


test1_sem2_2017_efbc_memo (7).docx


Efbc2524_test2_sem 2_2017_memo (6).do


efbs_test3_sem2_2017_memo (1) (6).odt

Examinations:


EFBC_eks_sem2_2017 (4).docx


EBCS 1524_exam2_sem2_2

15. Appendix G: ANCOVA results for other continuous assessments

Table 15.1: ANCOVA results for Test 1 as the post-test score with interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	324	324.2	1.134	0.2893
Group	1	721	721.2	2.522	0.1152
Gender	1	1567	1566.8	5.479	0.0211*
Accommodation Type	3	756	251.9	0.881	0.4535
Study Place Preference	3	5702	1900.5	6.646	0.0004***
Group*Gender	1	1680	1679.8	5.874	0.0170*
Group*PreTest	1	312	312.1	1.091	0.2985
Group*Accommodation Type	3	1251	416.9	1.458	0.2301
Group*Study Place Preference	3	677	225.7	0.789	0.5023
Residuals	109	31168	285.9		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.2: ANCOVA results for Test 1 as the post-test score as the best model fit

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	324	324.2	1.126	0.2909
Group	1	721	721.2	2.504	0.1163
Gender	1	1567	1566.8	5.440	0.0214*
Accommodation Type	3	756	251.9	0.874	0.4566
Study Place Preference	3	5702	1900.5	6.599	0.0004***
Group*Gender	1	1680	1679.8	5.833	0.0173*
Residuals	116	33408	288.0		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.3: ANCOVA results for Test 1 as the post-test score

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	324	324.2	1.081	0.3006
Group	1	721	721.2	2.405	0.1237
Gender	1	1567	1566.8	5.224	0.0241*
Accommodation Type	3	756	251.9	0.840	0.4747
Study Place Preference	3	5702	1900.5	6.337	0.0005***
Residuals	117	35088	299.9		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.4: Coefficients from multiple regression for Test 1 as the post-test score from Table 15.3

	Estimate	p-value
Intercept	31.5334	0.0055**
PreTest	0.3031	0.0998
Group B	2.6286	0.5622
Gender - Male	0.8243	0.8484
Accommodation - Parents	-3.1916	0.4911
Accommodation - Student-house	-6.4171	0.1350
Accommodation - Student residence on campus	-9.2454	0.0484*
Study Place - Library	24.2104	0.0004***
Study Place - their residence	23.2117	0.0003***
Study place - their residence & Library	26.5184	0.0001***
Group B* Gender Male	-15.0905	0.0173*

Significant p – value * 0.001; ** 0.01; * 0.05**

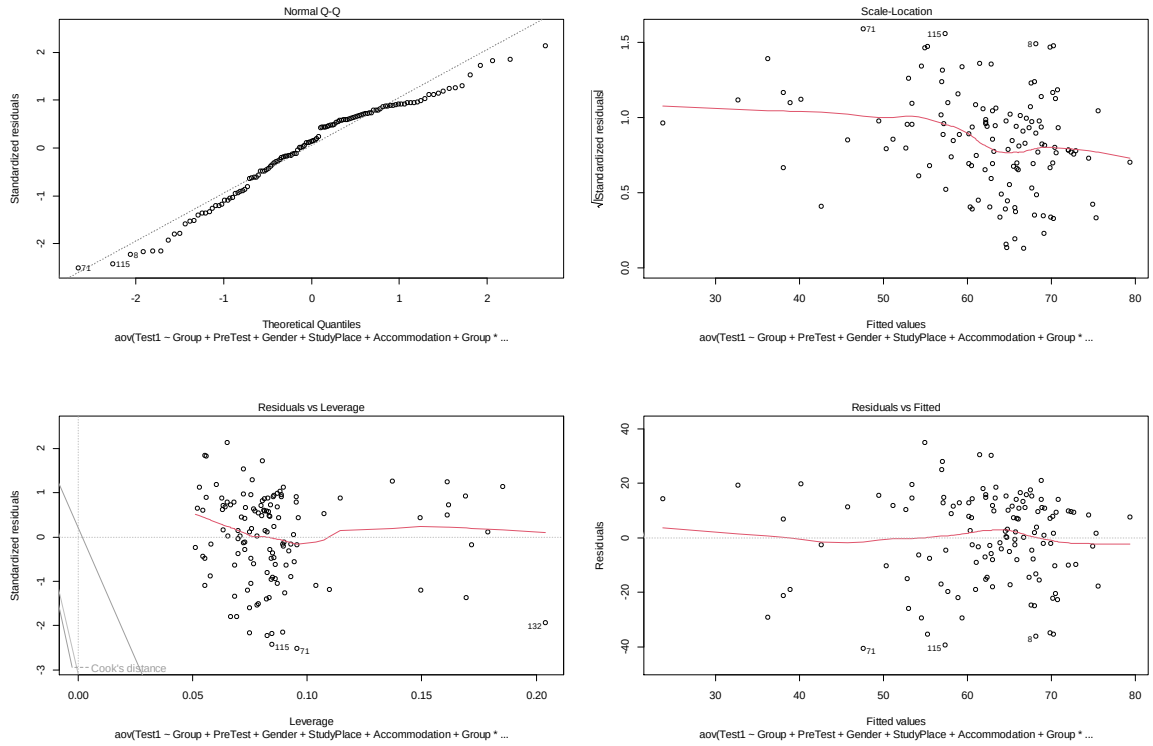
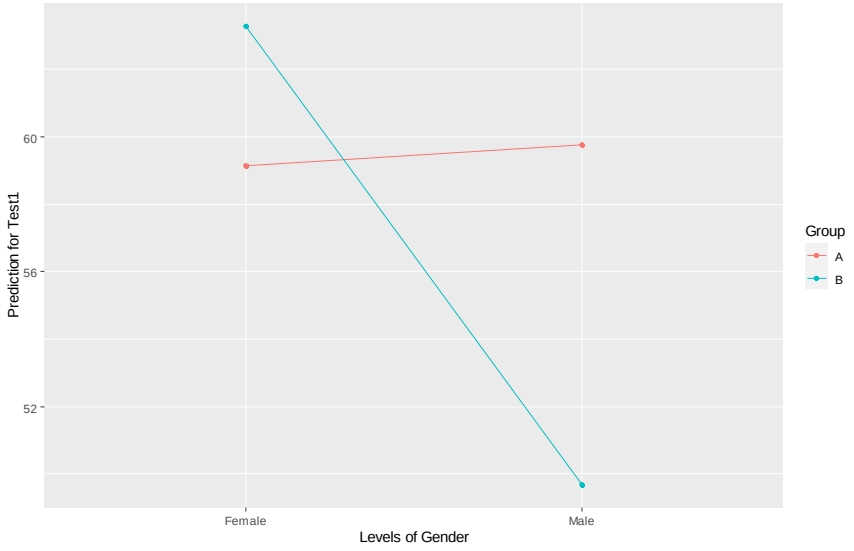


Figure 15.1: Plots of residuals for Test 1

Table 15.5: Model fitting for Test 1

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value

Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference, Group*Accommodation	31168	1097	1151	0.2942	0.1841	0.0011**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Pretest, Group*Study Place Preference	32388	1096	1142	0.2665	0.1749	0.0009***
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Study Place Preference	32671	1095	1138	0.2601	0.175	0.0007***
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	33408	**1092**	**1126**	0.2434	0.1782	0.0002***
Group, Pretest, Gender, Accommodation, Study Place preference	35088	1096	1128	0.2054	0.1443	0.0011**



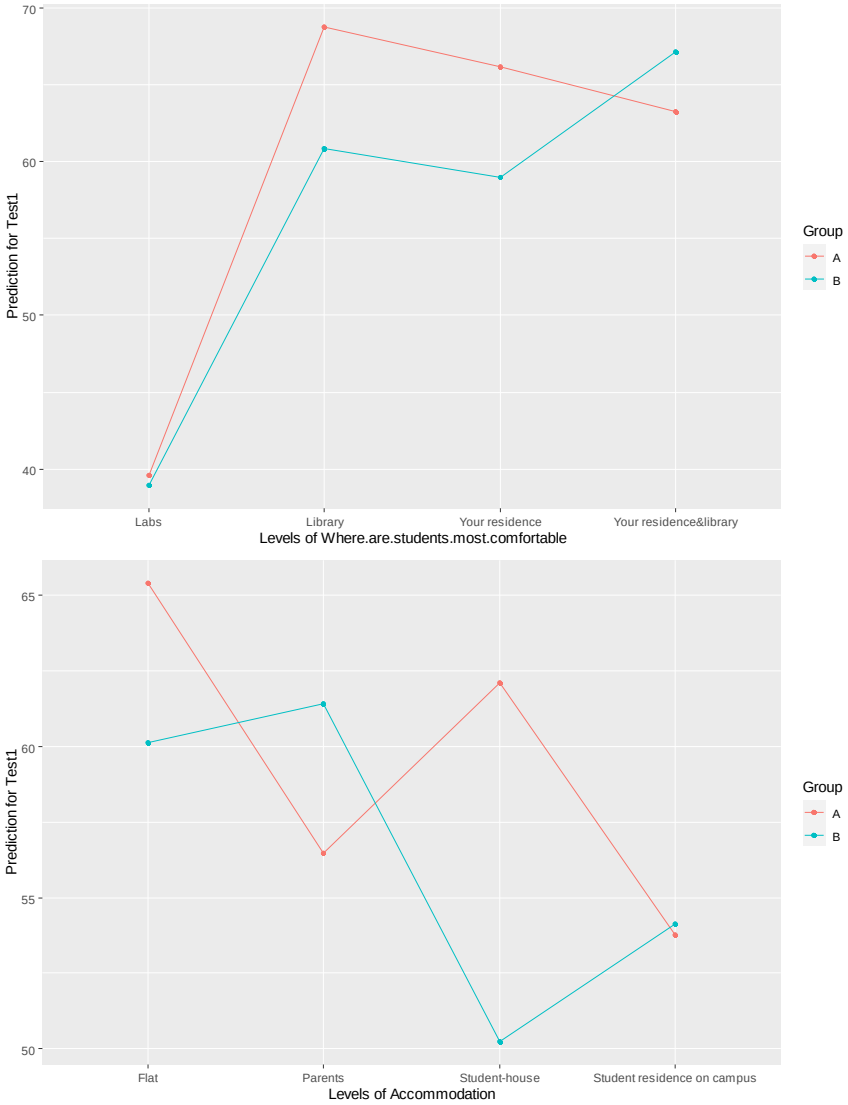


Figure 15.2: Regression slopes for Test 1

Table 15.6: Observed and adjusted means for Test 1

	Observed	Adjusted
Group		
A	64.5	60.6
B	60.1	55.7
Gender		
Male	59.5	54.8
Female	65.8	61.5
Study Place Preference		
Their residence	62.5	62.9
Library	64.6	63.9
Computer Labs	40.9	39.7
Their residence & Library	66.6	66.2

Table 15.7: Average Test 1 score of Groups A and B by group, gender, and place where students prefer to study

	Group A	Group B	p-value
Gender:			
Male	64.2	54.0	0.0361*
Female	65.0	66.5	0.7159
Study Place:			
Library	69.9	58.6	0.0413*
Their residence	66.6	58.6	0.1143
Their residence & Library	63.1	70.6	0.1704
Computer Labs	39.8	42.0	0.8796

Table 15.8: ANCOVA - Test 2 as the post-test score with interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	2	1.8	0.005	0.9412
Group	1	798	797.9	2.443	0.1209
Gender	1	2297	2297.3	7.034	0.0092**
Accommodation Type	3	168	55.8	0.171	0.9158
Study Place Preference	3	1739	579.8	1.775	0.1562
Group*Gender	1	93	93.1	0.285	0.5945
Group*PreTest	1	184	184.2	0.564	0.4543
Group*Accommodation Type	3	861	286.9	0.878	0.4548
Group*Study Place Preference	3	1346	448.6	1.374	0.2547
Residuals	109	35598	326.6		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.9: ANCOVA - Test 2 marks as the post-test score without interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	2	1.8	0.005	0.9410
Group	1	798	797.9	2.451	0.1201
Gender	1	2297	2297.3	7.058	0.0090**
Accommodation Type	3	168	55.8	0.172	0.9154
Study Place Preference	3	1739	579.8	1.781	0.1546
Residuals	117	38082	325.5		

Significant p – value * 0.001; ** 0.01; * 0.05**

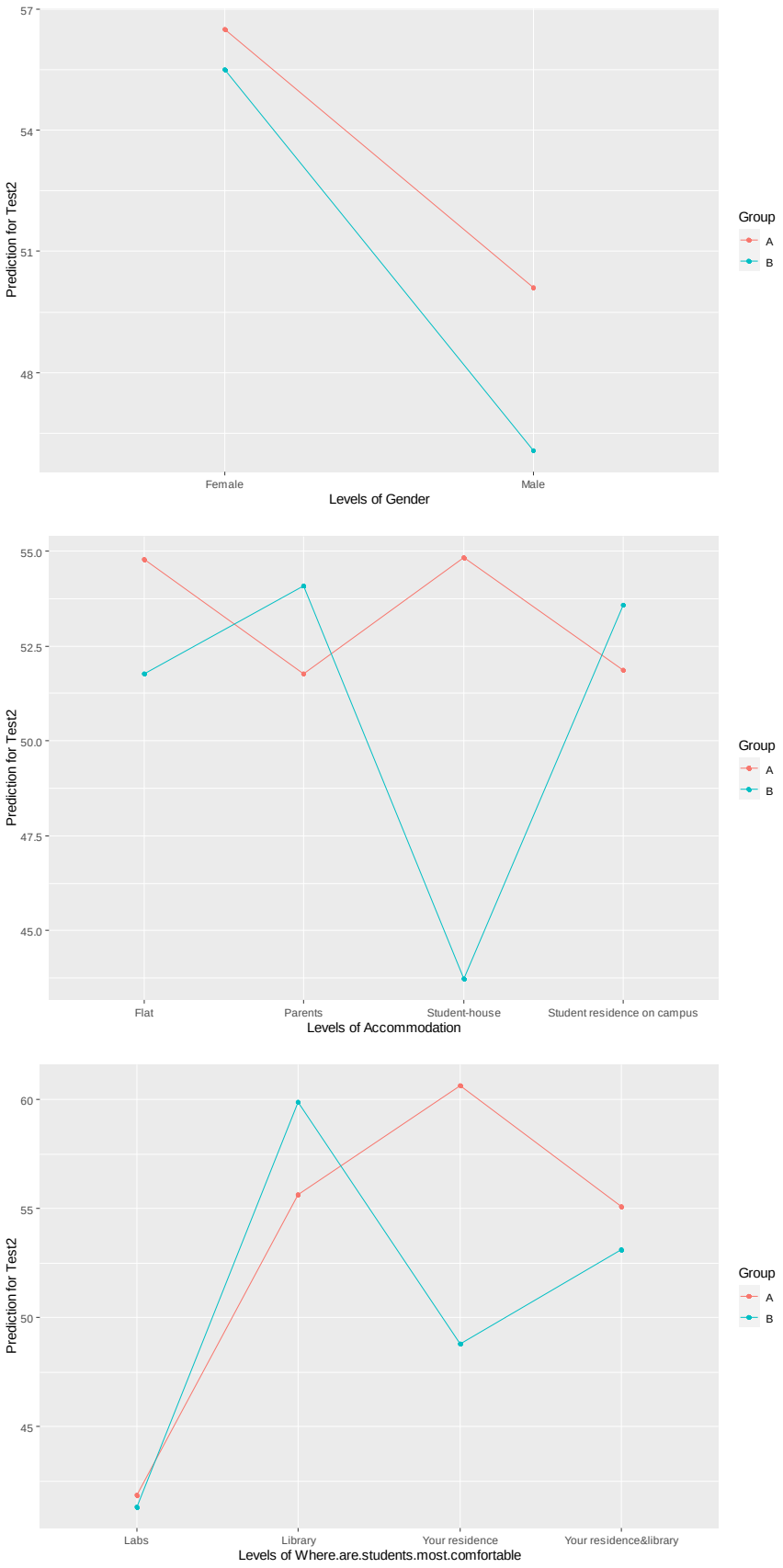


Figure 15.3: Regression slopes of the model fitted for Test 2

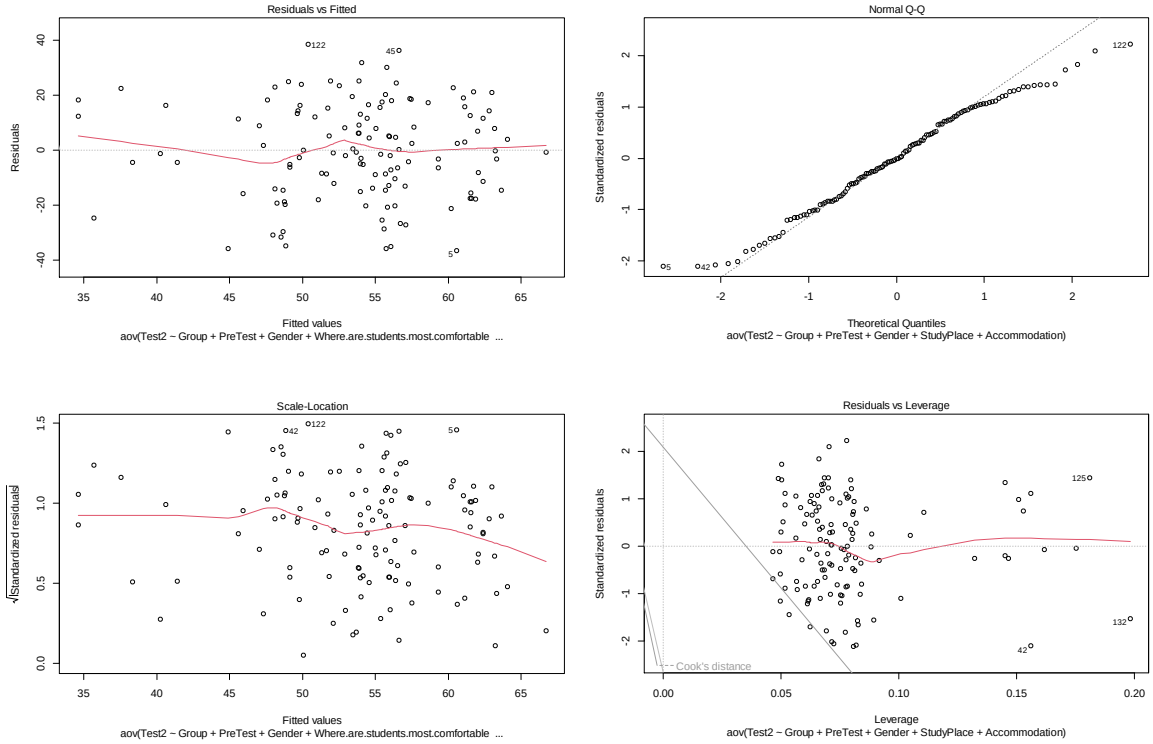


Figure 15.4: Plots of residuals for Test 2

Table 15.10: Coefficients from multiple regression for Test 2 as the post-test score

	Estimate	**p-value**
Intercept	43.1624	0.0003***
PreTest	0.1121	0.5633
Group B	-5.7862	0.0757
Gender - Male	-7.4669	0.0310*
Accommodation - Parents	-0.0911	0.9852
Accommodation - Student-House	-2.6184	0.5603
Accommodation - Residence on Campus	-0.1215	0.9799
Study Place - Library	15.2061	0.0342*
Study Place - their residence	13.5899	0.0404*
Study place - their residence & Library	13.7431	0.0530

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.11: Observed and adjusted means for Test 2

	Observed	**Adjusted**
Group		
A	56.5	54.9
B	50.8	49.1
Gender		

Male	50.3	48.2
Female	58.5	55.7
Study Place Reference		
Their residence	54.6	54.9
Library	56.4	56.5
Computer Labs	41.8	41.3
Their residence & Library	55.2	55.1

Table 15.12: Model fitting for Test2

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference, Group*Accommodation	35598	1114	1168	0.174	0.0449	0.1773
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference	36527	1111	1157	0.152	0.0462	0.148
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Study Place Preference	36722	1110	1153	0.148	0.0497	0.126
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	37989	1108	1143	0.118	0.0423	0.129
Group, Pretest, Gender, Accommodation, Study Place preference	38082	**1107**	**1138**	0.116	0.0482	0.0946

Table 15.13: Average Test 2 of Groups A and B by group, gender, and place where students prefer to study

	Group A	Group B	p-value
Gender			
Male	53.69	46.30	0.1025
Female	60.50	56.85	0.4031
Study Place			
Library	55.47	57.54	0.7791
Their residence	60.31	49.10	0.0235*
Their residence & Library	55.24	55.13	0.9851

Computer Labs	40.40	43.20	0.8276

Table 15.14: ANCOVA: Average Test 3 marks as the post-test score with interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	87	86.9	0.314	0.5765
Group	1	298	297.8	1.076	0.3019
Gender	1	1813	1813.3	6.552	0.0118*
Accommodation Type	3	361	120.2	0.434	0.7289
Study Place Preference	3	2242	747.2	2.700	0.0492*
Group*Gender	1	64	64.3	0.232	0.6308
Group*PreTest	1	62	61.7	0.223	0.6378
Group*Accommodation Type	3	884	294.5	1.064	0.3674
Group*Study place Preference	3	2017	672.2	2.429	0.0692
Residuals	109	30165	276.7		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.15: ANCOVA: Average Test 3 marks as the post-test score without interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	87	86.9	0.306	0.5811
Group	1	298	297.8	1.050	0.3077
Gender	1	1813	1813.3	6.392	0.0128*
Accommodation Type	3	361	120.2	0.424	0.7364
Study Place Preference	3	2242	747.2	2.634	0.0531
Residuals	117	33191	283.7		

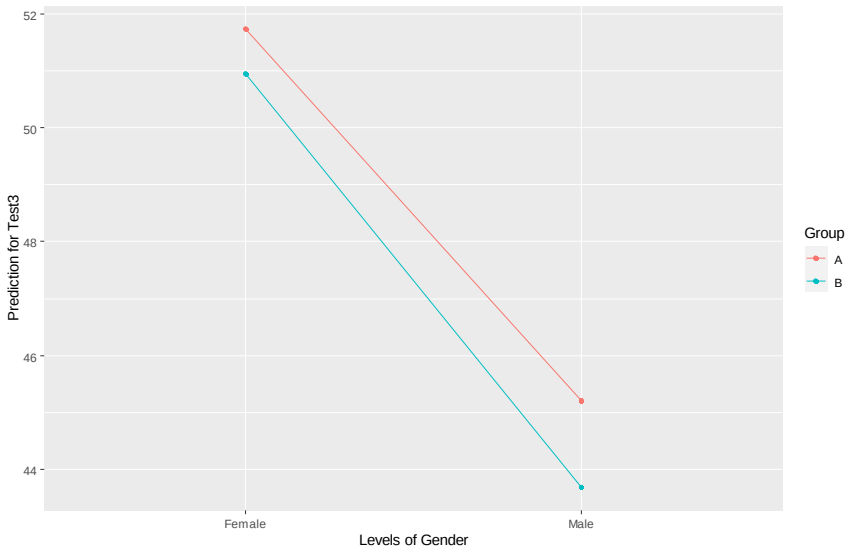
Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.16: Observed and adjusted means for Test 3

	Observed	Adjusted
Group		
A	51.7	49.9
B	47.4	46.0
Gender		
Male	46.6	44.4
Female	53.8	51.5
Study Place Preference		
Your residence	50.2	50.9
Library	53.0	52.7
Computer Labs	36.2	36.3
Your residence & Library	52.1	51.9

Table 15.17: Model fitting for Test3

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference, Group*Accommodation	30165	1093	1147	0.206	0.0822	0.0608
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference	31048	1091	1136	0.183	0.0806	0.0487
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Study Place Preference	31102	1089	1132	0.181	0.0871	0.0342*
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	33126	1091	1125	0.128	0.0529	0.0880
Group, Pretest, Gender, Accommodation, Study Place preference	33191	**1089**	**1121**	0.126	0.0591	0.0615



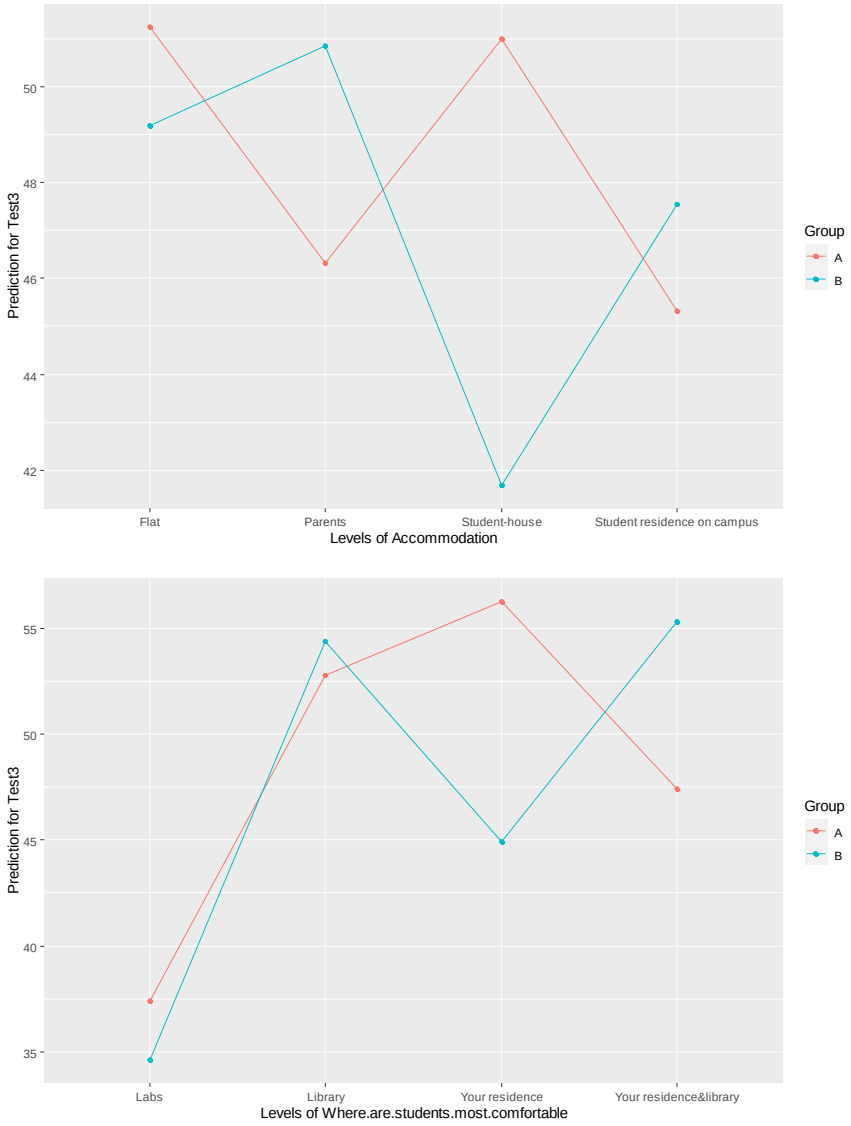
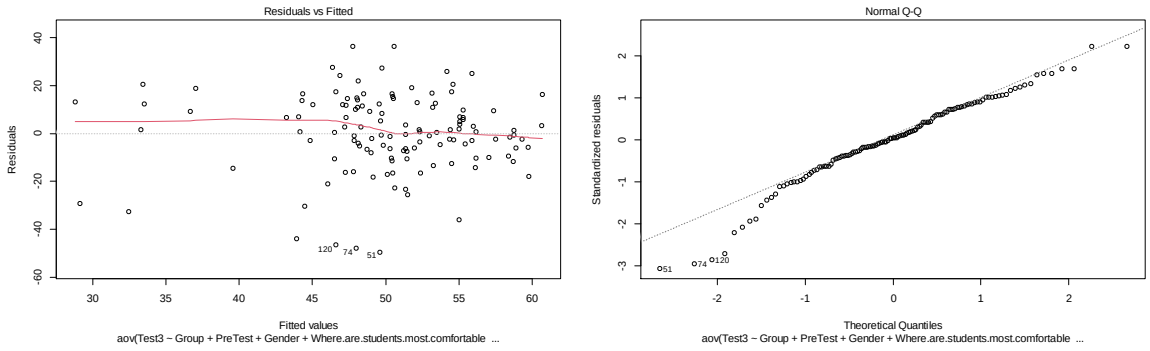


Figure 15.5: Regression slopes of the model fitted for Test 3



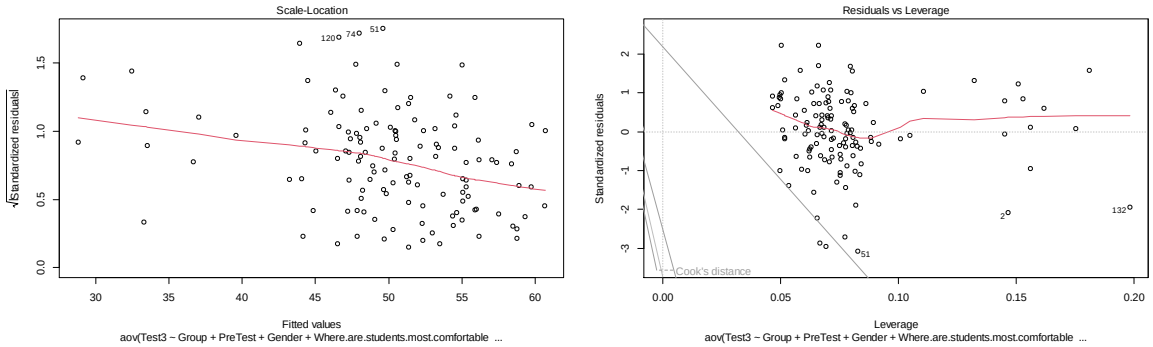


Figure 15.6: QQ-plot of residuals for Test 3

Table 15.18: Coefficients from multiple regression for Test 3 as the post-test score

	Estimate	p-value
Intercept	44.897	0.00007***
PreTest	-0.017	0.9262
Group B	-3.810	0.2087
Gender - Male	-7.103	0.0280*
Accommodation – Parents	-1.335	0.7709
Accommodation - Student-House	-3.577	0.3945
Accommodation - Residence on Campus	-4.452	0.3237
Study Place - Library	16.461	0.0144*
Study Place - their residence	14.656	0.0182*
Study place - their residence & Library	15.577	0.0192*

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.19: Average Test 3 of Groups A and B by group, gender, and place where students prefer to study

	Group A	Group B	p-value
Gender:			
Male	48.72	44.12	0.3236
Female	55.75	52.18	0.2931
Study Place:			
Library	52.47	53.54	0.8582
Their residence	55.90	44.60	0.0191*
Their residence & Library	48.06	56.60	0.0562
Computer Labs	36.2	36.2	1

Table 15.20: ANCOVA: Average Tutorials as the post-test score with interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value

PreTest	1	372	372	0.885	0.3490
Group	1	3191	3191	7.580	0.0069**
Gender	1	1779	1779	4.227	0.0422*
Accommodation Type	3	1399	466	1.107	0.3494
Study Place Preference	3	2812	937	2.226	0.0892
Group*Gender	1	1281	1281	3.043	0.0839
Group*PreTest	1	20	20	0.047	0.8281
Group*Accommodation Type	3	1216	405	0.963	0.4130
Group*Study place Preference	3	4139	1380	3.277	0.0238*
Residuals	109	45890	421		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.21: ANCOVA: Average tutorial marks as the post-test score without interaction

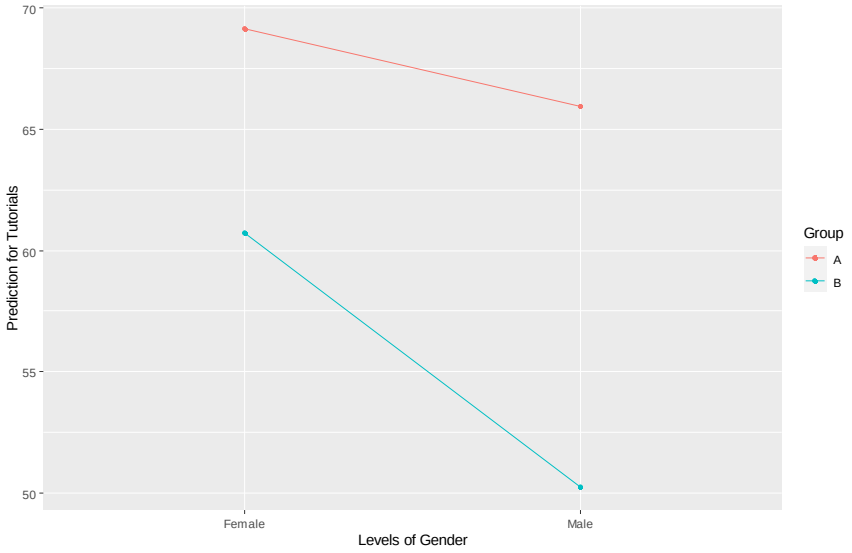
Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	372	372	0.829	0.3644
Group	1	3191	3191	7.105	0.0088**
Gender	1	1779	1779	3.962	0.0489*
Accommodation Type	3	1399	466	1.038	0.3784
Study Place Preference	3	2812	937	2.087	0.1057
Residuals	117	52547	449		

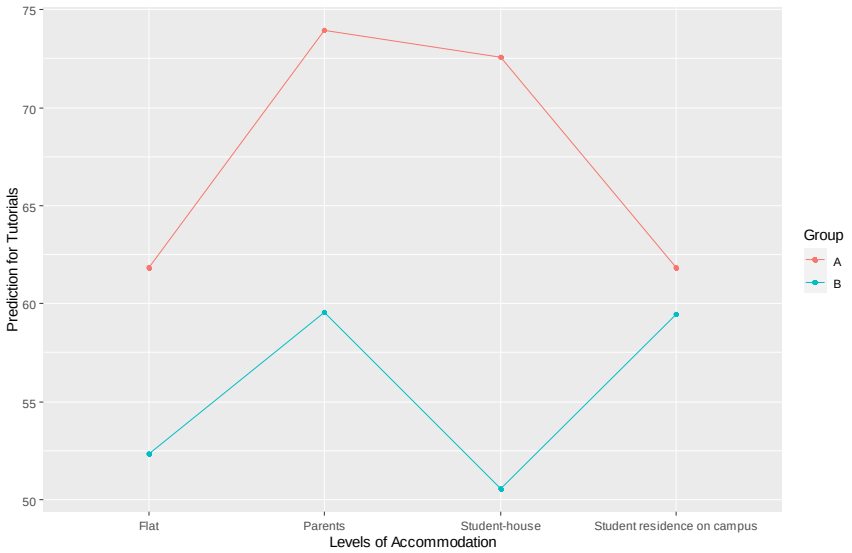
Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.22: Model fitting for Tutorials

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference, Group*Accommodation	45890	1146	1200	0.261	0.146	0.0059**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference	47471	1145	1190	0.236	0.140	0.0045**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender,	47490	1143	1185	0.235	0.147	0.0026**

Group*Study Place Preference						
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	51265	1146	1181	0.174	0.103	0.0108*
Group, Pretest, Gender, Accommodation, Study Place preference	52547	1148	**1179**	0.154	0.0887	0.0172*
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Study Place Preference	48258	1143	1183	0.223	0.141	0.0028**





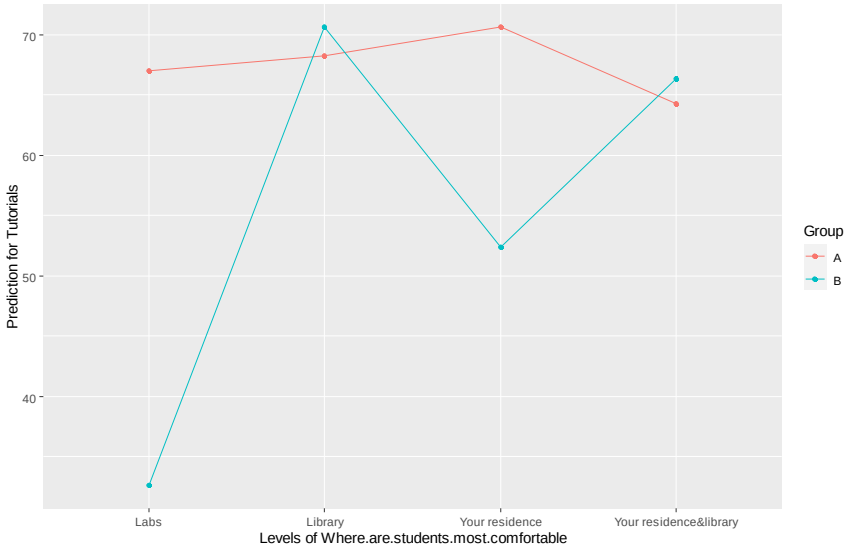
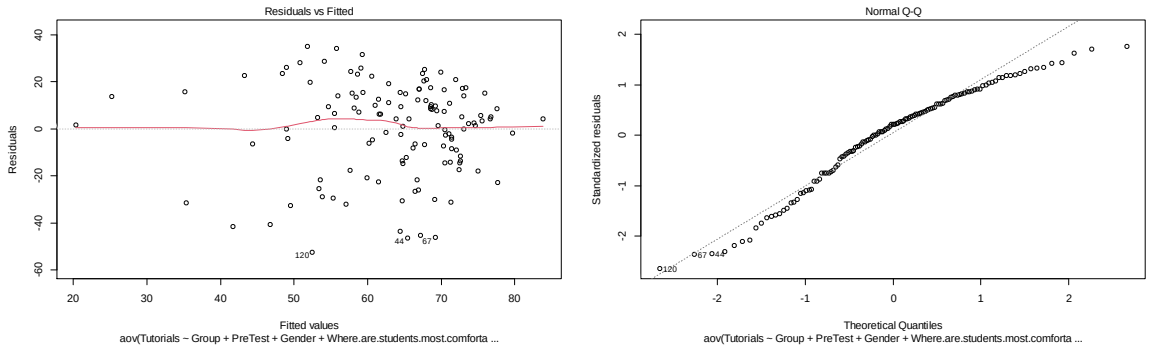


Figure 15.7: Regression slopes of the model fitted for Tutorials

Table 15.23: Observed and adjusted means for tutorials

	Observed	**Adjusted**
Group		
A	68.4	68.2
B	57.7	54.8
Gender		
Male	61.1	58.1
Female	66.4	64.9
Study Place		
Library	68.5	69.0
Your residence	61.3	61.8
Your residence& Library	66.8	65.9
Computer Labs	52.3	49.3



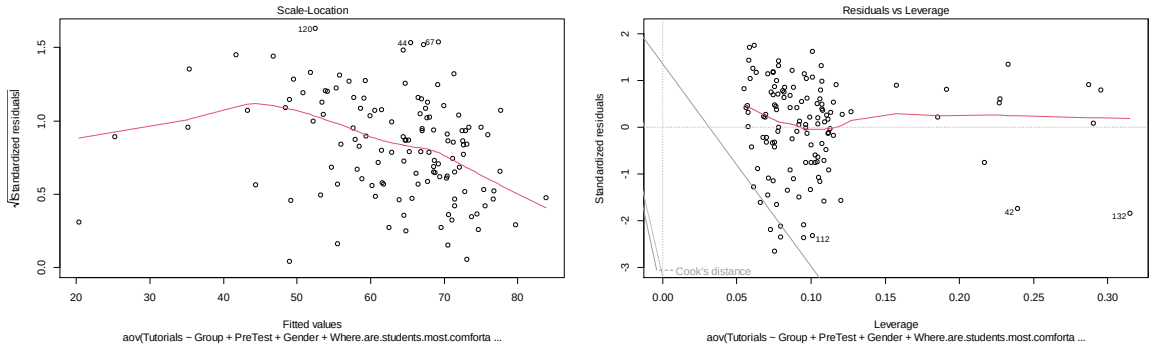


Figure 15.8 Plots of residuals for tutorials

Table 15.24: Coefficients from multiple regression for tutorials as the post-test score

	Estimate	p-value
Intercept	42.0557	0.0027**
PreTest	0.2543	0.2655
Group B	-10.6567	0.0058**
Gender - Male	-6.8438	0.0911
Accommodation - Parents	9.9952	0.0852
Accommodation - Student-House	5.8969	0.2652
Accommodation - Residence on Campus	4.1836	0.4607
Study Place - Library	17.7630	0.0352*
Study Place - their residence	11.0537	0.1539
Study place - their residence & Library	14.6774	0.0781

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.25: Average Tutorials score of Groups A and B by group, gender, and place where students prefer to study

	Group A	Group B	p-value
Gender:			
Male	68.18	52.82	0.0101*
Female	68.71	64.39	0.3427
Study Place:			
Library	69.13	67.85	0.8536
Their residence	70.21	52.63	0.0067**
Their residence & Library	65.12	68.73	0.5044
Computer Labs	64.20	40.40	0.1848

Table 15.26: ANCOVA: Average Practicals marks as the post-test score with interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	177	177	0.371	0.5440

Group	1	3571	3571	7.456	0.0074**
Gender	1	3632	3632	7.585	0.0069**
Accommodation Type	3	377	126	0.262	0.8523
Study Place Preference	3	3553	1184	2.473	0.0655
Group*Gender	1	1973	1973	4.121	0.0448*
Group*PreTest	1	325	325	0.678	0.4122
Group*Accommodation Type	3	1761	587	1.226	0.3039
Group*Study place Preference	3	3573	1191	2.487	0.0643
Residuals	109	52200	479		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.27: ANCOVA: Average practical marks as the post-test score with only interaction of group and gender

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	177	177	0.347	0.5570
Group	1	3571	3571	6.983	0.0094**
Gender	1	3632	3632	7.103	0.0088**
Accommodation Type	3	377	126	0.246	0.8642
Study Place Preference	3	3553	1184	2.316	0.0793
Residuals	117	59833	511		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.28: Model fitting for Practicals

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference, Group*Accommodation	52200	1163	1217	0.266	0.152	0.00462**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference	54817	1163	1208	0.229	0.133	0.0061**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Study Place Preference	55147	1162	1204	0.225	0.136	0.0045**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	57859	1162	1196	0.187	0.117	0.0058**

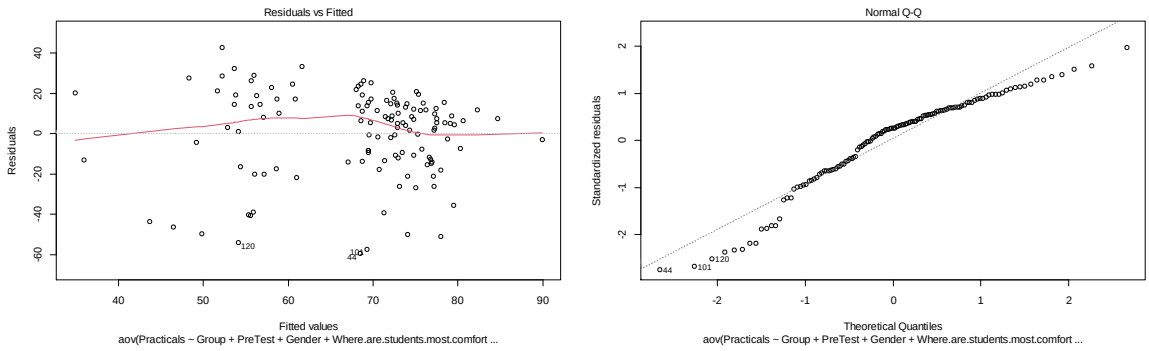
Group, Pretest, Gender, Accommodation, Study Place preference	59833	1164	**1195**	0.159	0.0943	0.0133**

Table 15.29: Average Practicals score of Groups A and B by group, gender, and place where students prefer to study

	Group A	Group B	p-value
Gender:			
Male	72.56	55.39	0.0096**
Female	75.14	71.45	0.3966
Study Place:			
Library	73.53	71.31	0.7593
Their residence	75.66	58.41	0.0121*
Their residence & Library	72.29	73.40	0.8494
Computer Labs	62.60	44.60	0.3557

Table 15.30: Observed and adjusted means for Practicals

	Observed	Adjusted
Group		
A	73.6	71.9
B	62.5	60.4
Gender		
Male	64.7	61.4
Female	73.1	70.8
Study Place Preference		
Their residence	66.7	67.2
Library	72.5	72.5
Computer Labs	53.6	52.5
Their residence& Library	72.8	72.2



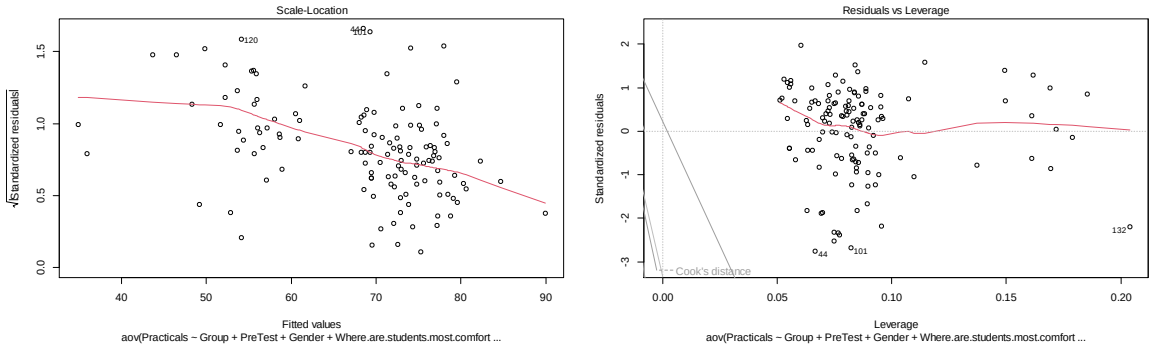
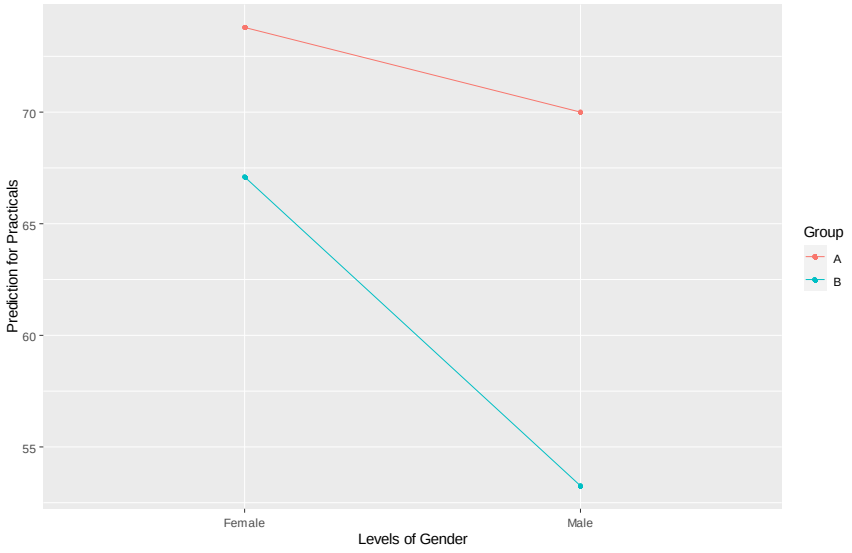


Figure 15.9: Plots of residuals for practicals

Table 15.31: Coefficients from multiple regression for practicals as the post-test score

	Estimate	p-value
Intercept	49.077	0.0011**
PreTest	0.2578	0.2899
Group B	-11.5148	0.0052**
Gender - Male	-9.3953	0.0304*
Accommodation - Parents	4.1516	0.5006
Accommodation - Student-House	-0.5375	0.9240
Accommodation - Residence on Campus	1.2686	0.8338
Study Place - Library	20.011	0.0263*
Study Place - their residence	14.7155	0.0760
Study place - their residence & Library	19.6657	0.0275*

Significant p – value * 0.001; ** 0.01; * 0.05**



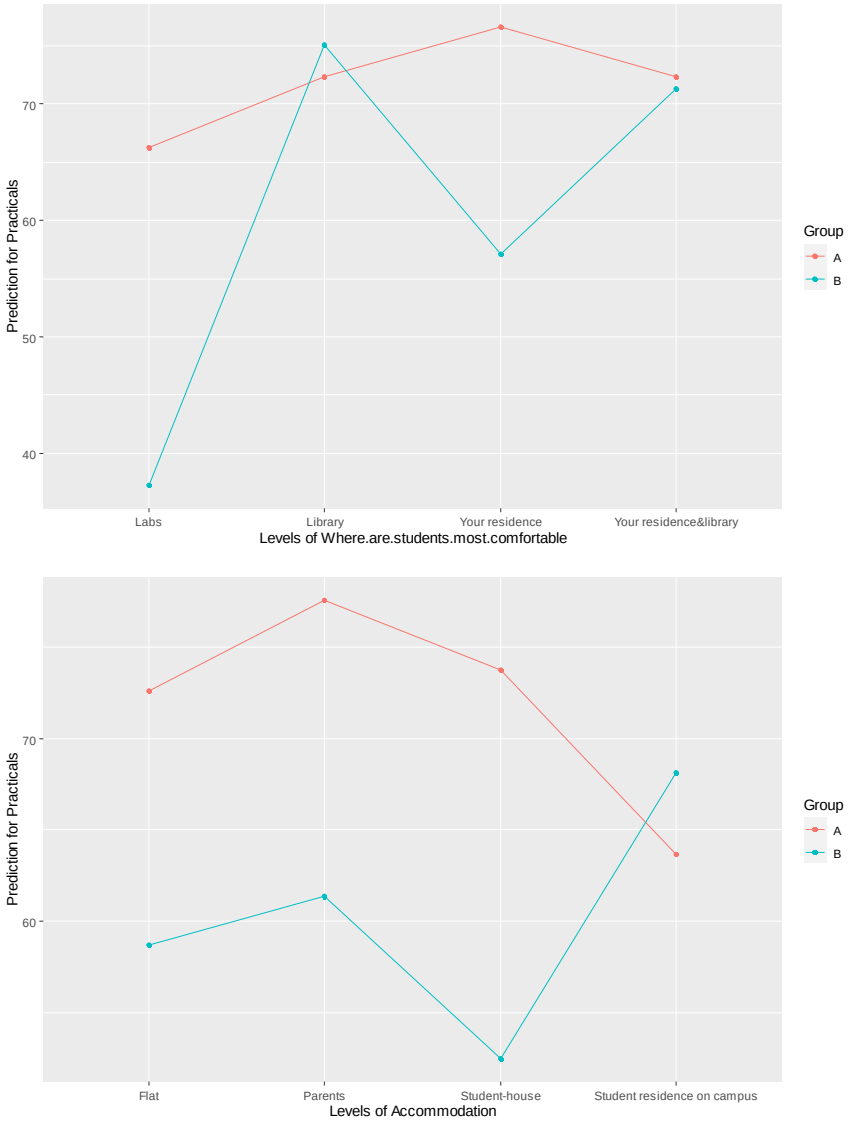


Figure 15.10: Regression slopes of the model fitted for Practicals

Table 15.32: ANCOVA: Average Assignment marks as the post-test score with interaction

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	46	46	0.121	0.7281
Group	1	4663	4663	12.381	0.0006***
Gender	1	2135	2135	5.669	0.0190*
Accommodation Type	3	636	212	0.563	0.6407
Study Place Preference	3	1374	458	1.216	0.3074
Group*Gender	1	482	482	1.280	0.2604
Group*PreTest	1	367	367	0.975	0.3257
Group*Accommodation Type	3	1251	417	1.107	0.3494
Group*Study place Preference	3	2469	823	2.185	0.0939
Residuals	109	41055	377		

Significant p-value * 0.001; ** 0.01; * 0.05**

Table 15.33: ANCOVA: Average assignment marks as the post-test score with only interaction between group and study place preference

Source	D.F.	Sum Squares	Mean Square	F-value	p-value
PreTest	1	46	46	0.117	0.7326
Group	1	4663	4663	11.958	0.0008***
Gender	1	2135	2135	5.476	0.0210*
Accommodation Type	3	636	212	0.544	0.6534
Study Place Preference	3	1374	458	1.175	0.3225
Residuals	117	45625	390		

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.34: Model fitting for Assignments

Model	Deviance	AIC	BIC	R^2	Adjusted R^2	p-value
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference, Group*Accommodation	41055	1132	1186	0.246	0.129	0.0117*
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Pretest, Group*Gender, Group*Study Place Preference	42525	1131	1176	0.219	0.122	0.0099**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender, Group*Study Place Preference	42887	1130	1172	0.213	0.122	0.0082**
Group, Pretest, Gender, Accommodation, Study Place preference, Group*Gender	45142	1130	1164	0.171	0.0999	0.0126*
Group, Pretest, Gender, Accommodation, Study Place preference	45625	**1130**	**1161**	0.163	0.0981	0.0111*

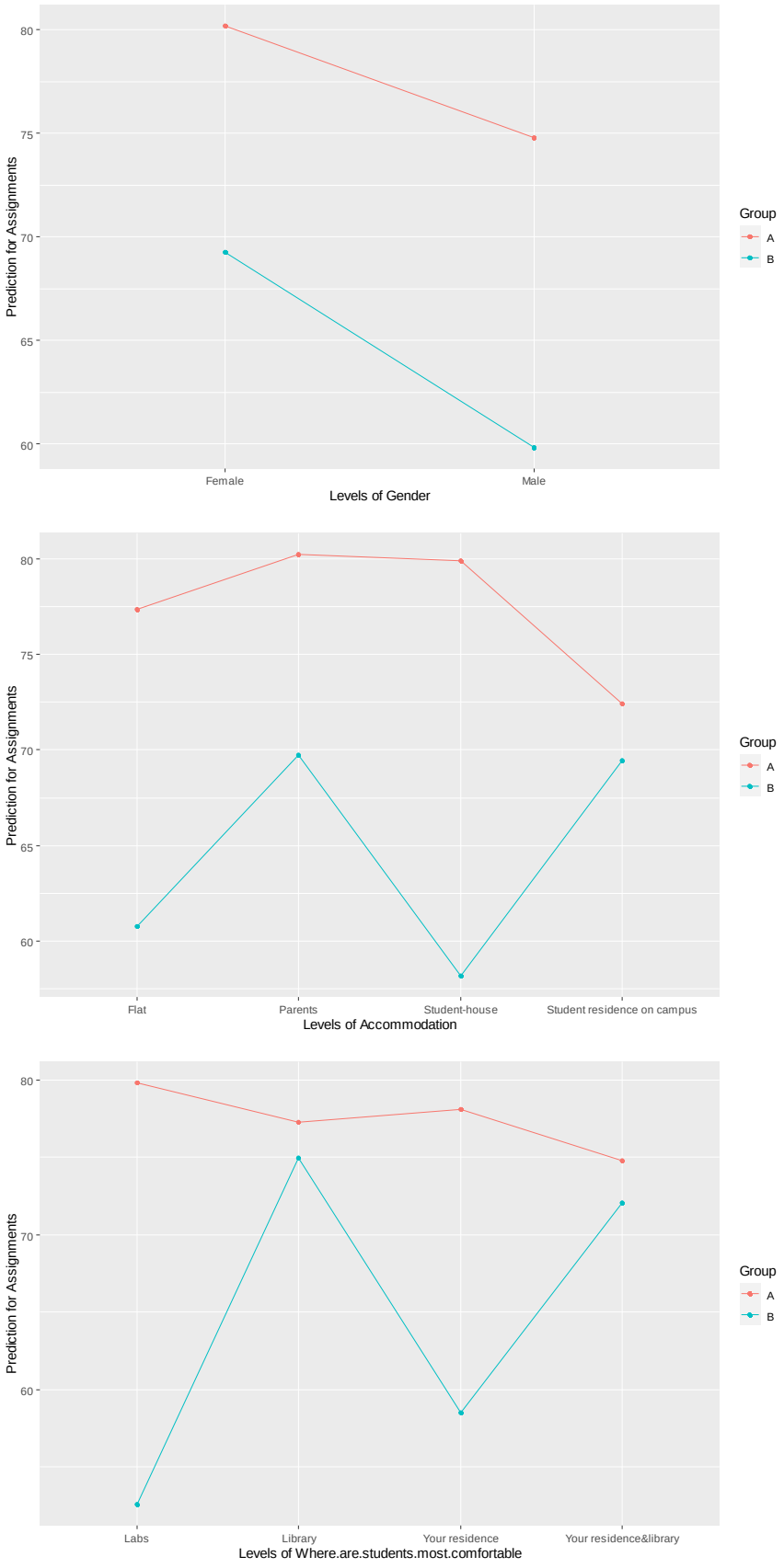


Figure 15.11: Regression slopes of the model fitted for Assignments

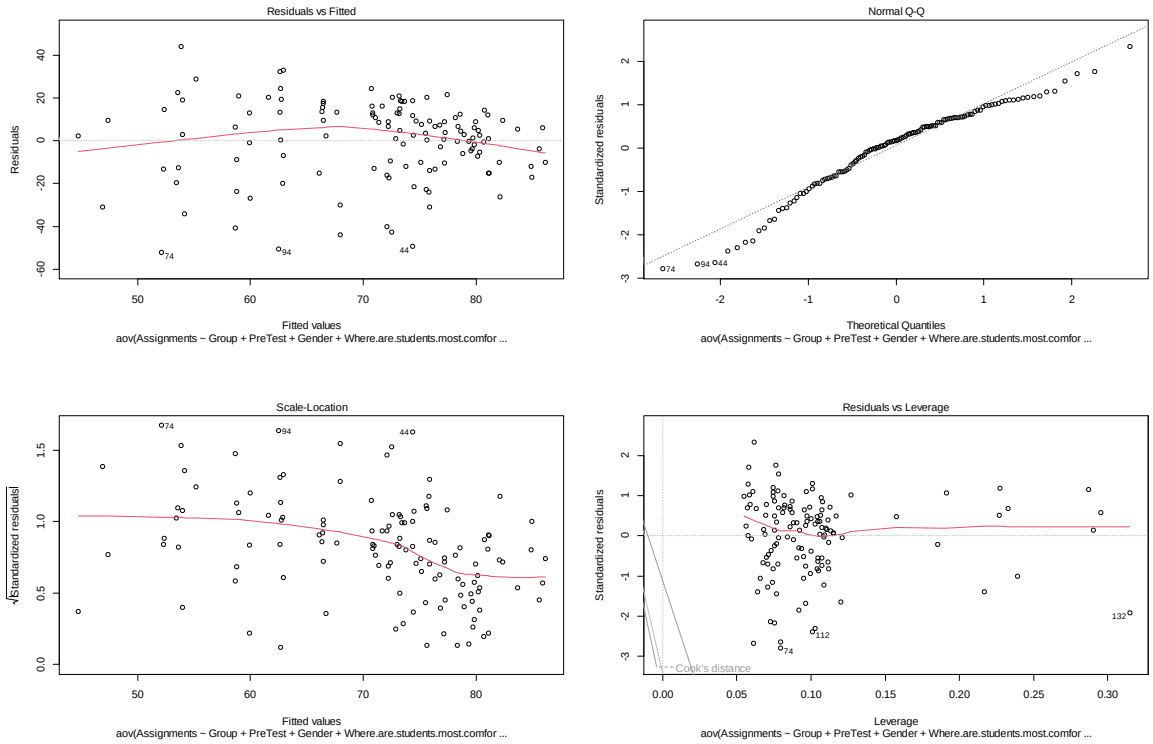


Figure 15.12: Plots of residuals for assignments

Table 15.35: Observed and adjusted means for the Assignments

	Observed	**Adjusted**
Group		
A	77.1	78.2
B	64.1	64.0
Gender		
Male	68.0	67.2
Female	74.8	74.9
Study Place Preference		
Their residence	69.5	68.6
Library	74.8	75.2
Labs	66.9	66.2
Their residence & Library	75.1	74.4

Table 15.36: Coefficients from multiple regression for assignments as the post-test score

	Estimate	**p-value**
Intercept	73.9567	<0.000***
PreTest	0.0241	0.9095
Group B	-12.8550	0.0004***

Gender - Male	-7.8226	0.0388*
Accommodation - Parents	6.3884	0.2362
Accommodation - Student-House	1.1082	0.8217
Accommodation - Residence on Campus	2.143	0.6848
Study Place - Library	7.6138	0.3290
Study Place - their residence	1.4374	0.8416
Study place - their residence & Library	6.8483	0.3752

Significant p – value * 0.001; ** 0.01; * 0.05**

Table 15.37: Average Assignments score of Groups A and B by group, gender, and place where students prefer to study

	Group A	**Group B**	**p-value**
Gender:			
Male	75.3	59.4	0.0052**
Female	79.5	70.7	0.0165*
Study Place:			
Library	76.9	72.4	0.4799
Their residence	77.2	58.7	0.0027**
Their residence & Library	75.9	74.1	0.7329
Computer Labs	77.6	56.2	0.1855