Conceptual understanding, career aspiration, self-efficacy and experience of third-year chemistry students

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Dedication

This work is dedicated to my beautiful family, especially my husband and parents.

Abstract

The retention of science students in universities has become a concern over the recent years, globally and in South Africa. Literature reveals that students' retention is affected by aspects such as conceptual understanding, career aspiration, self-efficacy and experience; which were considered independently and not holistically. This study aims to understand the persistence of chemistry students at the University of Cape Town in South Africa, by bringing together different factors such as conceptual understanding, career aspiration, self-efficacy and experience in chemistry.

The aim was achieved by adopting a qualitative case study approach that focused on students from the Extended Degree Programme (EDP) and Mainstream (MS) courses. Bandura's Social Cognitive Theory and Lent, Brown and Hackett's Social Cognitive Career Theory were used as the theoretical frameworks for the research. The sample consisted of 28 students of diverse ethnicity and gender from EDP and MS, who were enrolled in a third-year chemistry course. Data were collected from documents, questionnaires and interviews. Although this study was mainly qualitative, some quantitative data were generated from the analysis of the documents. The qualitative data from the questionnaires and interviews were subjected to inductive thematic analysis, which allows the themes to emerge from the study without applying a pre-existing coding scheme.

My original contribution to knowledge as it relates to students' persistence is that persistence depends on a number of inter-related factors, which are different for individual students. The study reveals that there was no relationship between academic performance and either career aspiration or self-efficacy for the cohort. This finding means that students may continue to perform well in a course even if they do not have an aspiration or a particular career in mind. Strong career aspiration and sense of self-efficacy may not necessarily result in good academic performance. Students' persistence in a study programme may be driven largely by other aspects such as personal goals and responsibilities, which obtaining a university degree may help them to achieve. The majority of EDP students persisted because they wanted to provide financial help for their family, whereas the majority of MS students did not want the money spent on their education by their parents to be wasted. This finding highlights the strong role that outcome expectation played in students' persistence.

The findings also revealed that some of the students have well-defined, but probably not always realistic ideas of a desirable career. For the majority of the students, chemistry was a second-choice option, and they did not have a career aspiration for chemistry; however, their career aspirations changed during their course of study. The Science Faculty requirement for

a second major was a strong contextual factor that had a significant influence on students' choice of chemistry.

EDP students possessed a strong sense of self-efficacy that was expressed verbally, while MS students possessed a strong sense of self-efficacy that was tacit. In terms of experience in chemistry, all students had a disheartening experience at different stages in their studies; however, the study revealed that EDP students found the transition to second-year difficult, whereas MS students experienced difficulty with the transition to third-year. Another significant aspect of their experience is that all students found support mechanisms, especially from friends and family that helped them to persist.

Other aspects of course design such as the change in structure in terms of the number of tutorials in EDP and MS as well as the faster pace in second-year chemistry were also problematic for the majority of EDP students. In conclusion, although the syllabus for the two programmes (EDP and MS) is the same, the study revealed that the learning experiences of the students in these programmes differed. An interesting finding that emerged, from this study, is the positive correlation between students National Benchmark Tests for mathematics and their third-year chemistry scores. This finding suggests the possibility of exploring the option of using scores from the National Benchmark Tests as part of the admission requirements in the Science Faculty.

Based on the findings from this study, the Science Faculty should provide adequate counselling to steer students on study paths within the Bachelor of Science degree that may help them to achieve their initial career preferences; and open their eyes to various opportunities. The Department of Chemistry should seek to revise the curriculum for both EDP and MS courses to minimise the stress related to the transition between the different years of the Bachelor of Science degree.

A note on race

South Africa's Population Registration (Act 30 of 1950) made it obligatory for individuals in South Africa to be characterized into a variety of populace group, for instance, “white”, “black” and "coloured". This Act was cancelled in 1991, and no comparative classificatory enactment at present applies. Be that as it may, for equity purposes, the University of Cape Town's application form asks South African natives and permanent residents applying to declare their populace group. Accordingly, in the context of this thesis, the terms “white”, “black” and “coloured” refer to this self-declaration. All things considered, it is likely for most of the students to declare their "populace group" in accordance with how their family were designated by the pre-1994 apartheid state.

Publication emanating from this research

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Declaration

I hereby declare that the work on which this thesis is based is my original work, except where otherwise acknowledged. I composed the thesis and all cited references are listed at the end. No part of the work has been submitted for another degree in this or any other university.

Signature: Signed by candidate Date: 17-01-2020

Print name: Ibiye Tonye Dagogo

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First, I thank the Almighty God for His strength, grace and mercy. I am nothing without you, Lord.

To my supervisors: Associate Professor Bette Davidowitz and Dr Dale L. Taylor, I am grateful for your patience and guidance. Thank you for the constant encouragement and unwavering passion for research.

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My husband Engr. Lucky Legborsi Lekor, you are very special to me. Your encouragement and support kept me going. I know all the sacrifices that you have made towards our family; thank you for always being supportive.

My parents Mr and Mrs Tonye Johnson Dagogo, I know my name was always in your daily prayer list. May God bless and keep you strong for us. My sister Boma Tonye Dagogo, you are one in a million.

To the third-year chemistry class of 2017, thank you for your willingness and openness in sharing your life experience with me. You made my dream a reality.

Big thank you to my sponsors, Niger Delta Development Commission (NDDC), Nigeria.

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Abbreviations and acronyms

BSc	Bachelor of Science
CEM1000W (CEM1)	First-year mainstream course in chemistry
CEM2005W (CEM2)	Second-year mainstream course in chemistry
CEM3005W (CEM3)	Third-year mainstream course in chemistry
CEM1009H	First-year EDP half-course in chemistry
CEM1010H	Second-year EDP half-course in chemistry
CPUT	Cape Peninsula University of Technology
ECP	Extended Curriculum Programme
EDP	Extended Degree Programme
HE	Higher Education
HOMO	Highest Occupied Molecular Orbital
LUMO	Lowest Occupied Molecular Orbital
MO	Molecular Orbital
MS	Mainstream
NBT	National Benchmark Tests
NSC	National Senior Certificate
OECD	Organization for Economic Cooperation and Development
SCT	Social Cognitive Theory
SCCT	Social Cognitive Career Theory
SES	Socio-Economic Status
SFP	Science Foundation Programme
UCT	University of Cape Town
UWC	University of Western Cape

Terminology

Certain terms are used in this study, and it will be helpful to provide a definition. Moreover, I have made a distinction between the terms that are used in the South African tertiary context, as shown in Table 1.

Table 1: Definition of terms

Term used	**Equivalent terms and meaning**
Career aspiration	Career aspiration is defined as the "degree of commitment to a given career" (Gray & O'Brien, 2007, p. 318). However, in the context of this thesis, career aspiration is defined as students' desired career path.
Self-efficacy	Self-efficacy has been defined as students' beliefs about their ability to complete a given task, and it can be affected by a student's positive or negative experiences in a course (Bandura, 1986).
Retention	This is defined as staying in university until the completion of a degree (Hagedorn, 2005).
Academic transcript	This refers to an inventory of the courses taken and grades a student has earned during the period of studying.
Terms used in the South Africa context	
Academic staff member	Faculty, Professor Member of the lecturing staff of an academic department.
Bachelor of Science (BSc)	A first academic degree usually involving three to four years of tertiary education.
Department	The academic department, School A division within a faculty or school that is responsible for a given subject.
Faculty	Graduate school; Institute In South Africa, the term *faculty* refers to a collection of related academic departments at an institution of higher learning such as a university. For example, the Faculty of Science at UCT comprises the following academic departments: Archaeology, Astronomy, Biological Sciences, Chemistry, Computer Science, Environmental and Geographical Science, Geological Science, Mathematics and Applied Mathematics, Molecular and Cell Biology, Oceanography, Physics, and Statistical Science
Grade 10	Refers to the 10^{th} year of schooling in South Africa. Most of the students are between the ages of 15-16 years. Sometimes they could be older
Historically White University (HWU)	Historically White University (HWU); Historically advantaged university. An institution of HE in South Africa that was established during apartheid with the intention of serving the white community.
Physical Science	This is a subject in South African schools offered in Grades 10 to 12 consisting of both chemistry and physics.
Postgraduate student	Graduate students Refers to students who are enrolled in postgraduate study. In the South African context, this is inclusive of those pursuing a degree towards BSc Honours, MSc and PhD.
Repeat	It implies repeating an academic year
Tutor	This term is used in South Africa and Australia; it has an American and (European) equivalent in the term, *teaching assistant (TA).*
Undergraduate	A student who is registered at a University towards the completion of the first degree (BSc)

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Chapter 1: Introduction

Globally, several studies have reported the loss of students in science faculties to other non-science-based faculties; or to outright discontinuation from university (Ogunde, Overton, Thompson, Mewis, & Boniface, 2017; Palmer, Burke, & Aubusson, 2017; Shedlosky-Shoemaker & Fautch, 2015; Villafañe & Lewis, 2016; Ye, Shuniak, Oueini, Robert, & Lewis, 2016). Additionally, there has been a reported universal drop in students' enrolment in chemistry (Chen, 2013; Lyons, 2006). Without adequate measures, this decreasing trend may soon result in global skill shortages in chemistry, which is one of the fundamental disciplines of scientific research and industry (Ardura & Pérez-Bitrián, 2018).

Students who discontinue or perform poorly in science courses are a concern for educational researchers as shown by an examination of the completion rates, which reveals that these students are struggling academically or not completing their studies (Villafañe & Lewis, 2016; Ye et al., 2016). The retention of these students in their studies has become a concern for universities globally, as it is used as a measure to assess institutional performance, and is now associated with quality teaching and learning (Crosling, Thomas, & Heagney, 2008; Mantz Yorke, 2004; Tinto, 2007). According to Hagedorn (2005), the National Centre for Education Statistics in the United States refers to "retention as an institutional measure and persistence as a student measure" (p. 6); and defines retention as staying in university until the completion of a degree.

Over the past decades, there has been a great deal of theoretical work dedicated to understanding the complex nature of student retention globally, but there appears to be a lack of useful information on strategies required to increase graduation rates (Crosling et al., 2008; Ogunde et al., 2017; Tinto, 1975, 2007; Ye et al., 2016). Several claims based on different theoretical models have portrayed their own merits as a more accurate way of representing the actual nature of student retention process (Tinto, 2007). More recently, one can argue that student retention has become a big business for many who claim to have the remedy to increasing students' graduation rates. After carefully reviewing the past and current data on student retention, Tinto (2007), identified three major areas that require further exploration. These areas are institutional actions that translate into useful guidelines for the development of effective program policies and practice. The implementation of these policies, and the need to focus on the critical linkage between institutional action and the education of disadvantaged students. A call was made to look for newer perspectives, on how the information that has been collected over the years could be transformed into actionable guidelines, for the development of more effective programmes (Tinto, 2007).

The South African educational system amongst others was and is still currently affected by the social inequalities that existed during apartheid. The apartheid system in South Africa (1948-1994) was a legitimized system of oppression which typified racial segregation and violations of human rights, designed to preserve White race superiority and privileges (Cloete & Moja, 2005; Cloete, Pillay, Badat, & Moja, 2004; Lemon, 1976). During this time, policies and laws were enacted to preserve White political, economic and cultural interests, and to deny those citizens classified as non-Whites their fundamental human rights (Lemon, 1976). Additionally, non-Whites were subjected to a segregated education system in which the majority of the schools were under-resourced and of poor quality.

As apartheid came to an end, the new government prioritized redress for historically marginalized groups across almost all state-controlled sectors, including education (Department of Education, 1997). The new government viewed education as a potential form of redress; this provision was included in the new 1996 South African Constitution (The Constitutional Assembly, 1996). After 1994, the new government enacted targeted funding policies to support low-income communities, which mainly comprised Blacks (Cloete et al., 2004). Efforts have also been made to transform higher education so that it promotes advancement through equity of access and opportunity.

Although the enrolment of Black African students in most universities in South Africa has improved significantly in recent years, there is an unequal graduation rate; more White students are graduating (Department of Education, 1997, 2006). In addition, a decline in enrolment and loss of Black African students have been reported among students in science and engineering faculties in South Africa (Case, Marshall, & Grayson, 2013; Juan, Hannan, & Namome, 2018; Lubben, Davidowitz, Buffler, Allie, & Scott, 2010; Moodley & Singh, 2015; Pocock, 2012).

It has been reported that, first, most of the students who do not complete their studies are under-prepared for Higher Education (HE) studies (Case, 2007; Kelly-Laubscher, Paxton, Majombozi, & Mashele, 2018; Lubben et al., 2010; Moodley & Singh, 2015). The reason why they are unprepared is closely associated with the ongoing legacy of apartheid, and the poor state of the high schools that students attended. Second, the effect of their disadvantaged background, coupled with the deep-rooted challenge of low socio-economic status that they face, threatens their retention and success (Subotzky & Prinsloo, 2011).

Recognizing this situation, the government revised the formula for HE funding, which provides for the statutory requirement of access and foundational initiatives, and at the same time, links funding to completion rates (Department of Education, 2006). Partly because of the funding limits, the effectiveness of undergraduate programmes is often read in terms of completion

rates. The retention of students has become the centre of attention for most universities in South Africa, and could be argued to be compelling grounds for the redress that the government seeks, and for which they are responsible; in alignment with one of its national objectives.

The purpose of this chapter is to describe how I directed and positioned the study in the South African context, and to provide a background to explain this context. The aim of the study is stated together with the research questions, and an indication of the research design. Thereafter, I defined my position in the study. To facilitate the reading of the entire thesis, the organization of the chapters is provided below.

1.1 Organization of the thesis

The thesis is presented in seven chapters, see Figure 1. In Chapter 1, I provide a background to the study, and stated the research objectives. Chapter 2 provides information on the theoretical frameworks, and a summary of relevant literature that shaped my thinking and the project. Chapter 3 summarizes the research design, including how ethical issues relating to the research were handled. The findings from the research are reported in Chapters 4 – 6. Based on the findings, the study highlights recommendations and opportunities for future investigations, which is captured in Chapter 7.

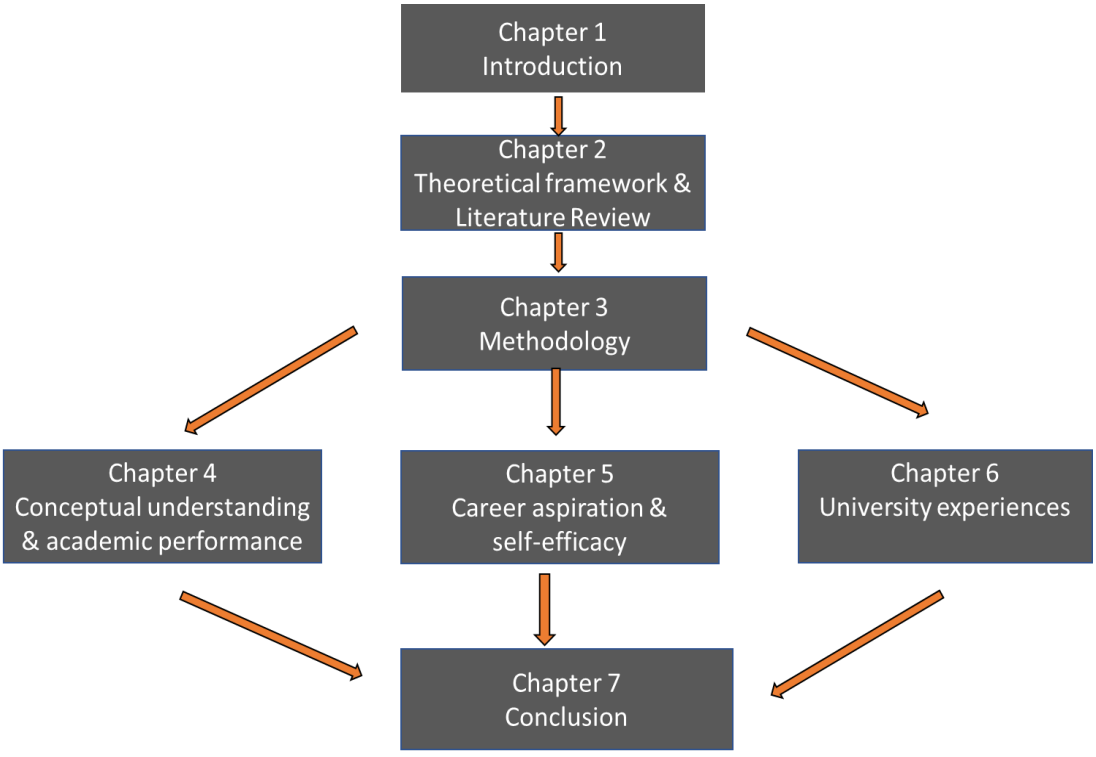


Figure 1: Organization of the thesis

1.2 Background to the study

Failure in studies has been reported to reduce students' morale and to incur higher costs for students and universities (Chan & Bauer, 2016; Koen, 2007; Ye et al., 2016). In many cases, students leave a course of study when they feel they cannot succeed, thereby losing their interest and motivation to continue (Ferrell & Barbera, 2015; Villafañe & Lewis, 2016). One way to address this issue requires that we learn about students' experiences, which this study seeks to do. This will be achieved by investigating factors that helped students in the Extended Degree Programme (EDP) and Mainstream (MS) programme at the University of Cape Town (UCT), to remain in their studies. The next section reports briefly on literature describing factors that affect students' retention.

Research studies have shown that retention can be affected by students' experiences and aspects such as conceptual understanding, career aspiration and self-efficacy, which in turn affect their performance, motivation, and decision to stay in a programme (Bandura, 1999; Chan & Bauer, 2016; Dagogo, Davidowitz, & Taylor, 2019; Lovatt & Finlayson, 2013; Ye et al., 2016). However, these researchers mostly considered the effect of these factors on student retention process independently and not holistically. To contribute to the knowledge base, which will help universities to take actions that will translate into useful guidelines for the development of effective programmes and policies, a detailed study of the collective effect of these factors on students' decision to complete a science-based tertiary programme is necessary.

Several studies have explored the career aspirations and experiences of students in EDP in the university where this study was conducted, but these researchers mostly focused on first- and second-year students (Bangeni & Kapp, 2005; Case, 2007; Kelly-Laubscher et al., 2018; Lubben et al., 2010). The current study adopts a different approach by drawing a sample from EDP and MS students, who are enrolled in a third-year chemistry course; and aims to understand their persistence by bringing together different factors such as conceptual understanding, career aspiration, self-efficacy and experience.

My original contribution to knowledge as it relates to students' persistence is that, persistence depends on a number of inter-related factors, which are different for individual students; and this aspect will be explained in detail later (Chapters 4-6). It is anticipated that the findings from this investigation will advance the state of knowledge about students' experiences in university. It may help answers the critical questions that will assist universities to promote students' graduation rates, and, by extension, help the Department of Education to achieve their long-time goal of redress.

It is important to note that although the long-term goal of this study is to contribute to knowledge around students' retention, the study is conducted with understanding that it cannot be fully argued as a retention study since the sample are students who are still enrolled in the university. Tinto (2017) noted that, while the interest of the university is to increase graduation of their students, the students' interest, on the other hand, is to complete their studies without particular attention to the university where the degree was earned. The author further indicated that students do not seek to be retained; they seek to persist. Hence, the word persistence is used in this thesis. The remaining part of this chapter shows how I further directed and positioned the study in the South African context. I present information on the initiatives at widening access to Higher Education or HE in South Africa, and explain the differences between EDP and MS programmes at UCT.

1.3 Context of the study

In response to redressing the injustices of apartheid, South Africa, as a nation, has over recent years strategically prioritised and redefined its HE values, goals and policies; and now promotes a comprehensive transformation agenda. A summary of the overall objective of the HE system is the development of a system that is typified by equity, quality and excellence (Cloete, Pillay, Badat, & Moja, 2000; Koen, 2007; OECD, 2008; Subotzky & Prinsloo, 2011). The current challenge for HE is to address and become responsive to the development needs of a democratic South Africa. This response to the development needs can be achieved by producing a knowledgeable and skilled workforce that will engage proactively in a competitive global economy, for which student retention is crucial (Cloete et al., 2004; OECD, 2008; Petersen, Louw, & Dumont, 2009).

According to Osborne (2003), initiatives targeted at widening access to HE usually take three formats, which are academic (expanding entry qualification), cultural (raising awareness of educational opportunities in HE courses through open day events) and an internal format (modification of university structures like student support, course content). A combination of an academic and internal format is employed in widening access in the majority of South African academic universities. This combination offers an alternative entry route to specially designed learning programmes for students from disadvantaged school backgrounds, often coinciding with the provision of equitable access to disadvantaged groups (Kelly-Laubscher et al., 2018; Lubben et al., 2010). All access interventions to HE require students to invest additional learning time, in some cases extending their period of study.

In response to the HE transformation agenda, current widespread shifts in student learning, and in a bid to advance learning, several universities in South Africa have established centrally

controlled academic development units. These units are tasked with the responsibility of promoting academic development across faculties, which primarily caters for the educational development of historically disadvantaged students.

Research in South Africa has shown that academic programmes with a restructured degree time frame that provides individualized attention and extra support have been able to significantly increase the retention of disadvantaged students to varying degrees (Burch, Sikakana, Yeld, Seggie, & Schmidt, 2007). There are two types of restructured degree programmes offered by universities in South Africa, both are 4 years. The first type includes a foundation year, where students complete courses designed to prepare them for tertiary studies. This is followed by the normal 3-year degree i.e. a 1 + 3 model. The second type is an extended degree programme, where the first year is extended over two years, followed by the second and third years of the normal 3-years degree i.e. a 2 + 2 model (Rollnick, 2010). EDP in the Faculty of Science at UCT is an example of such an initiative, and is explained in detail in the next section.

Research site

The study was conducted at UCT, a large research-intensive university, which is a Historically White University (HWU) in Cape Town, South Africa. The study focused on students registered in the Department of Chemistry within the university. A brief description of the undergraduate courses offered at the Department of Chemistry is provided on the following page.

It is pertinent to draw attention to the fact that EDP is a term used at UCT; generally, in South Africa, the term Extended Curriculum Programme (ECP) applies. Nonetheless, for this thesis, EDP will be used throughout the discussion as the study took place at UCT. More details about EDP, and how it differs from previous programmes and MS are provided in later paragraphs.

EDP is specially structured regarding course content and administration to accommodate the needs of students from a historically disadvantaged background, as a way of providing equitable access. The students in EDP, therefore, receive extra academic and supplementary support to ease their adjustment to tertiary education, and to establish a sound academic foundation for their retention and success. Lectures, workshops, and tutorials make up the contact time. EDP was previously referred to as the General Entry Programme for Science (GEPS). Although they are both foundationally tailored to increasing access, EDP differs from GEPS regarding the student enrolment pattern. This difference is closely associated with the changes in UCT admission policy in 2013. Unlike GEPS that provided access to students with lower matriculation results owing to their poor educational background, it is only students who meet the Science Faculty's mainstream Admission Point Score (APS) who are admitted into the Faculty and later transferred to EDP (Le Roex et al., 2016). In other words, only students

who are predicted to have a high probability of success by meeting the minimum admission threshold are admitted.

The incoming first-year students are all offered admission into the three-year Bachelor of Science (BSc) degree programme, which is the mainstream (MS) system. After four weeks of lectures, they write a test for each of the subjects for which they are registered. The students who fail the tests are strongly encouraged to transfer to EDP for the four-year route; thus, EDP begins in the 7th week of the first academic year. The other students who passed the test continue in the mainstream. The Science Faculty admission policy is based on the belief that this placement approach is likely to produce a more homogenous class of students, and that the concerted efforts put into this group of better academically prepared students will overall improve retention (Le Roex et al., 2016). It could be argued that because these students are offered the option to move into EDP after failing the class tests, the transfer process may cause them to begin to doubt their academic abilities. This doubt in their ability would not be surprising given that Lubben et al. (2010), in a similar study, reported that students in GEPS felt inferior to their peers at the initial stage of enrolling into the programme.

Undergraduate courses in the Department of Chemistry

As noted earlier, a major difference between students in EDP and MS is that they are expected to complete their degree in a minimum of 4 and 3 years, respectively. The first year of EDP is extended over two years, where the students register for four intensive full-year courses, each covering about half of the content of MS first-year course. This implies that each EDP course counts as a half course towards the degree. After the completion of their first year, EDP students begin to share classes with MS students in their second year and continue to final year. In terms of chemistry, EDP students' register for CEM1009H and CEM1010H courses in the first and second year, respectively. They join MS students for CEM2005W and CEM3005W courses, which counts as their third and fourth year respectively. The MS students, on the other hand, study CEM1000W, CEM2005W and CEM3005W, which counts as the first, second and third-year chemistry courses respectively (see Figure 2). These first, second and third-year courses are whole year courses, and are henceforth abbreviated as CEM1, CEM2 and CEM3, respectively. The minimum mark required to pass a course is 50%. The relevant extract from the Faculty Handbook that contains more information about the individual courses and information about the grading scheme at UCT is shown in Appendix 1.

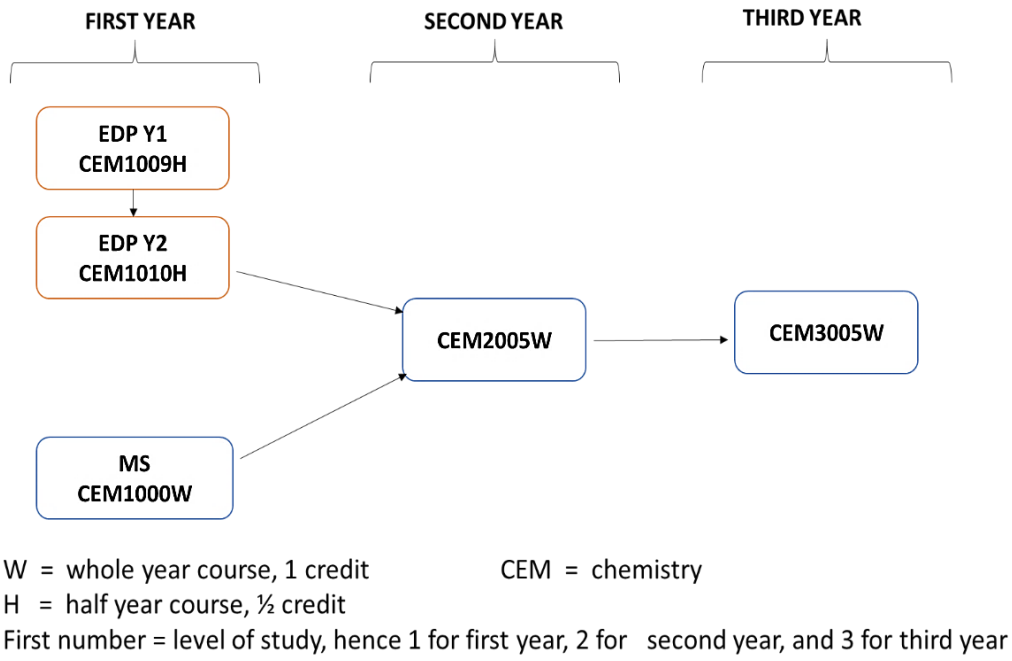


Figure 2: Chemistry courses in EDP and MS

The chemistry courses contain a practical component that counts towards the final grade. The next section states the research aim and gives a general indication of the research design.

1.4 The aim of this study and an indication of research design

This study aims to understand the persistence of a cohort of third-year chemistry students from EDP and MS at UCT by bringing together different factors such as conceptual understanding, career aspiration, self-efficacy and experience in chemistry. I am considering the class of third-year students as a single case and not as individual cases. The main research question to be answered is: How do conceptual understanding, career aspiration, self-efficacy and experience in chemistry collectively influence (or not) EDP and MS students' persistence? These research questions guide the investigation:

1. What are the students' levels of conceptual understanding and academic performance in chemistry?
2. What are the students' career aspirations?
3. What are the students' levels of self-efficacy?
4. What were the experiences of this cohort of students, as they relate to studying chemistry, and how did they persist?

In addition, the specific objectives of the study are as follows:

1. To investigate students' level of conceptual understanding and academic performance in chemistry.

2. To investigate students' career aspiration and how it affected their persistence.
3. To explore students' levels of self-efficacy.
4. To describe how students' experiences in the chemistry course affected their persistence.

Although the hoped-for benefit of this research is stated in general terms in the introduction (p.3), the long-term expectation is that it will provide valuable insights that could be used to expand the scope of investigations around student retention. This benefit applies especially to those students in science faculties, as well as help to change institutional practices that will enhance retention, and help the Department of Education in achieving its long-time goal of redress.

It is helpful to mention that although it is expected that the research questions are restated in the methodology section, Chapter 3, I did not do so in this case, to avoid repetition. However, when answering these research questions in Chapter 7, they are restated for convenience.

The study is exploratory by nature because it is aimed at understanding the factors that affect the persistence of chemistry students at UCT. For studies of this type, which are guided by research questions that are exploratory and interpretive, empirical research design using primary data are most appropriate (Babbie & Mouton, 2004; Mouton, 2001). Thus, this study adopts a qualitative case study design with a social constructivist framework, which conceives truth to be relative and dependent on one's perspective. It is premised on the social construction of reality, a subjective creation of meaning (Creswell, 2013). Nevertheless, it is relevant to highlight that some quantitative data were collected from documents to help in answering the research question relating to conceptual understanding.

1.5 Positionality of the researcher

In social research, the term positionality refers to the specific position of the researcher, not only as it relates to demographic variables, but also in terms of beliefs, attitudes, understanding of people and the world in general. What is my position in this research? In agreement with Wenger (1998), I believe strongly that our frameworks of understanding are shaped by our values and life experiences. I am an international student, a Black African female from Nigeria. Although my society has its struggles, I experienced a significant cultural shock when I arrived at UCT. This experience caused considerable emotional difficulty. Fortunately, God helped me because while helping undergraduate students during tutorials, I realised I had more interest for research in chemistry education. Hence, I transferred from a PhD in Chemistry (CEM6000W) to a PhD in Tertiary Chemistry Education (CEM6001W). It is essential to make this clear because I found I could relate to some of the experiences shared

by these students. Besides, I feel this possibly could have influenced my analysis, and the way I discussed aspects of my thesis. However, to overcome this constraint, and ensure a more transparent and valid analysis; the coded data were shared with my supervisors who provided valuable feedback to ensure that the interpretations made were valid. More information on how I ensured validity of data is provided in the methodology section.

I am an analytical and organic chemist trained to master's level; thus, this was the first time I had carried out educational research, which presented new challenges. The first of these was conducting one-on-one interviews with students. The interview was relatively easy to handle because I have acquired relevant skills during my professional career. I have been privileged to sit on interview panels for teacher recruitment. Still, this was different because the participants in this study were students. In addition, these students were not competing for a position; in fact, they were crucial for the success of my research, which meant that I needed to make them feel comfortable to allow for a free flow of communication. Therefore, I was a bit nervous, but piloting the interview schedule with other students, with no links to the research, helped me to overcome this difficulty. The most exciting aspect of this experience was my ability to establish a connection with the students easily. I feel that my teaching experience in high school and working with young adults in other volunteer positions played a useful role. The second challenge was the coding of the interview transcripts as I encountered difficulty with coding the transcribed data. Thus, I turned to watch educational videos and reading textbooks, both of which provided useful insight. I believe that the skills that I have acquired during this time of my doctoral research, will find a useful place in my future career pursuit (academic role); and in my volunteering engagements.

Chapter 2: Theoretical frameworks and literature review

To effectively situate this study in a broader context of knowledge, it is important to state the theoretical frameworks that were applied in this research. These frameworks place into perspective how I perceived, made sense of and interpreted my data. The theoretical frameworks that underpin this research are described in this chapter; these are the Social Cognitive Theory and Social Cognitive Career Theory (SCCT). Although there have been many studies on SCCT across the continents, Sheu and Bordon's (2017) review showed that there had been limited studies in the South African context.

Academic research builds on and contributes to prior existing knowledge, and since the study focuses on investigating the collective influence of conceptual understanding, career aspiration, self-efficacy and experience on the persistence of chemistry undergraduate students, a review of related literature is important. The sequence of discussion in this chapter is described as follows. The chapter begins with a description of the theoretical frameworks. Thereafter, I discuss relevant literature on career aspiration, self-efficacy, conceptual understanding and students' experiences as shown in Figure 3

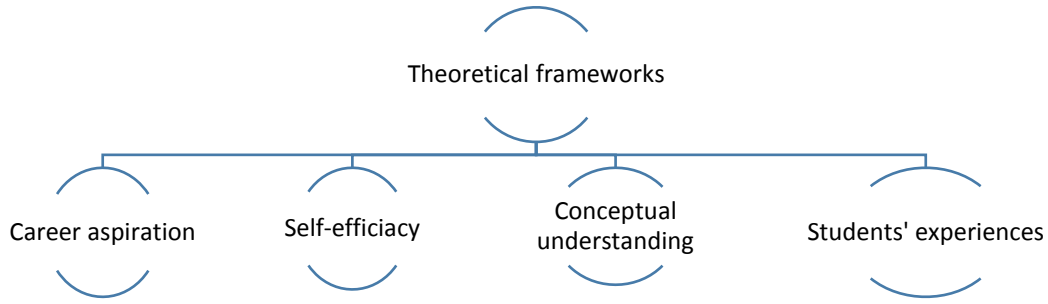


Figure 3: Overview of the theoretical frameworks and literature

The literature on career aspiration, self-efficacy, conceptual understanding and students' experiences in a South African context is described in Chapter 2.2, 2.3, 2.4 and 2.5, respectively.

2.1 Theoretical frameworks

The Social Cognitive Theory is used as the framework for this study, while the Social Cognitive Career Theory is applied as a framework for the aspect relating to students' career aspirations and choices. However, there are instances where some findings overlap with both of these theories, and in such cases, references are made to both. These theories are described in the following paragraphs.

Social Cognitive Theory

The founder of the theoretical underpinning of the Social Cognitive Theory (SCT) is Albert Bandura (1986), and the framework assumes that human ability is not a fixed attribute; instead, it is dynamic. The theory holds that "people act on their judgment on what they can do, as well as on their beliefs about the likely effect of various actions" (Bandura, 1986, p. 231). Although affirming the dual role of self-efficacy and outcome expectation, Bandura has argued that these two forms of beliefs are often differentially influential, with self-efficacy serving as a more potent determinant of behaviour.

Self-efficacy has been defined as students' beliefs about their ability to complete a given task, and it can be affected by a student's positive or negative experiences in a course (Bandura, 1986). Self-efficacy is concerned with people's response capabilities like "Can I do this?". Bandura said these beliefs constitute the most central and pervasive mechanism of personal agency (forethought) in engaging in a relevant task. These set of self-beliefs are not static; rather, they are viewed as dynamic, and are specific to particular performance domains. They also interact to a significant extent with person, behavioural and contextual factors. The literature shows that peoples' perceptions of their capabilities are postulated as helping to determine their choice of activities, environment, personal agency, thought patterns, emotional reaction, and persistence when confronted with obstacles (Bandura, 1999; Pajares & Schunk, 2001; Schunk, 2003).

Outcome expectations are people's beliefs about probable outcomes (Bandura, 1986). It involves imagining consequences of engaging in or enacting a particular behaviour such as "If I do this, what will happen". Bandura (1986) identified different classes of outcome expectations such as anticipation for physical benefit (monetary), social, e.g. approval, self-satisfaction outcomes that may importantly affect career behaviour. SCT holds that "people act on their judgment on what they can do, as well as on their beliefs about the likely effect of various actions" (Bandura, 1986, p. 231). Although affirming the dual role of self-efficacy and outcome expectation, Bandura has argued that these two forms of beliefs are often differentially potent, with self-efficacy serving as a more influential determinant of behaviour. The author further said that a strong sense of self-efficacy might sustain efforts even where outcome attainment is uncertain.

SCT postulates that goals play an important role in the self-regulation of behaviour. Bandura (1986) defined a goal as the determination to engage in a specific activity or to affect a future outcome. Goal setting helps individuals to organize and guide their behaviour, to sustain it over a long period, even when there is no external reinforcement, and to increase the likelihood that the desired outcome will be attained. Goals achieve their self-motivating quality

by linking self-satisfaction to goal fulfilment and to the enactment of behaviour that meets internally set standards. Goals are seen as helping to regulate energy expenditure, promote task persistence, and direct people's attention to important outcomes and aspects of behaviour.

SCT also postulates that competent performance on difficult and challenging tasks generally requires both component skill and a strong sense of efficacy to deploy one's resources effectively. The mechanism of self-efficacy is postulated to be the primary mediator of choice and development.

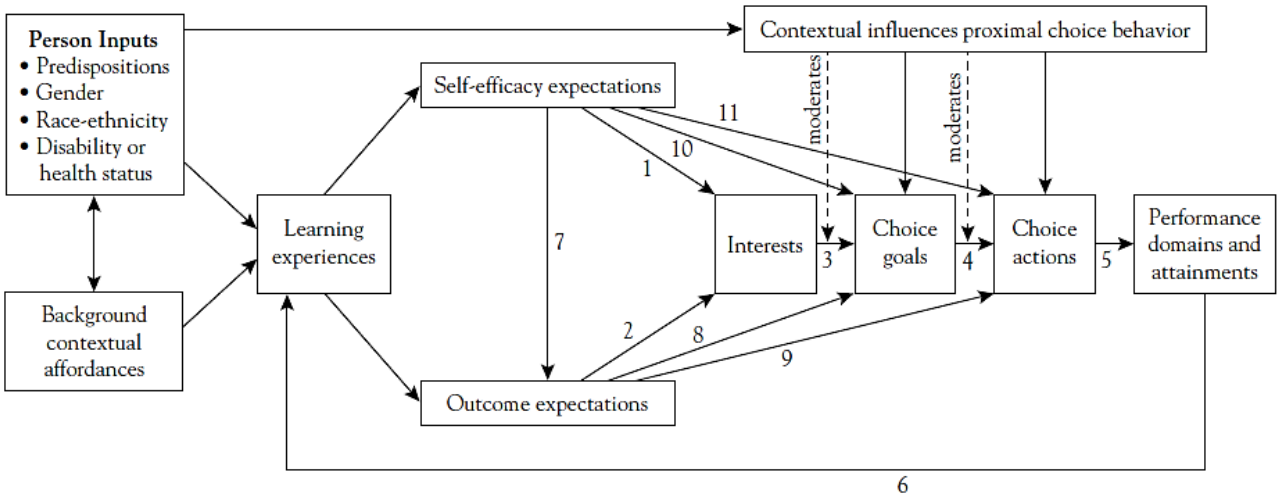
Social Cognitive Career Theory

The Social Cognitive Career Theory (SCCT) attempts to take a cognitive constructivist approach to career development, and is aimed at understanding the processes through which individuals develop basic academic and career-related interest drawing from the SCT. The SCCT was developed by Lent, Brown, and Hackett (1994) based on Albert Bandura's general SCT (1986). It describes the building blocks of career development highlighted by three social cognitive variables: self-efficacy, outcome expectation and personal goals. One of the propositions of SCCT is that the interactions between individuals and the environment is highly dynamic. This implies that there is a reciprocal influence that people and the environment exert on each other (people influence their environment and are also affected by it). The theory holds that people develop a belief about their capabilities (self-efficacy) based on their experiences. These beliefs are mostly generated from sources such as personal performances, vicarious experiences, social persuasion, physiological and affective factors (emotional states).

Furthermore, the approach adopted by Lent et al. (1994) recognizes the effect of genetic endowment, special abilities and environmental conditions on career and academic development process. It also highlights the significance of learning experiences (operant, associative and vicarious) in interaction with person, contextual influences in guiding career development. Contextual influences or environmental influences refer to the resources a person perceives as being provided by the environment where one finds oneself. Also, the theory highlights the relative importance accorded to the cognitive processes; and the interactive role of cognition in regulating motivation and action. In other words, the authors state that the effect of learning experiences on future career behaviours are mostly mediated cognitively, and emphasize the role of self-referent thinking in guiding human motivation and behaviour.

SCCT is divided into two parts: (a) sociocognitive framework consisting of the interest development, choice and performance model, and (b) person, contextual and experiential

factors. The interest development model, which is a component of the first part of SCCT posits that we are attracted to activities that we feel competent and successful. The choice model for the career choice process emphasizes how establishing a goal, taking action to achieve the goal, and attaining a level of performance helps determines future career behaviour. The performance model posits that successful performance will tend to enhance self and outcome perceptions, thereby strengthening people's interest and goals. In addition, the second part of SCCT predicts how gender and race-ethnicity shape experiences, which influence self-efficacy and outcome expectations. Attitude and values are also related to self-efficacy and outcome expectations. The different aspects of the SCCT model are depicted in Figure 4.



Note: Direct relations between variables are indicated with solid lines; moderator effects (where a given variable strengthens or weakens the relations between two other variables) are shown with dashed lines.

Figure 4: The SCCT model (Lent, Brown, & Hackett, 2002, p. 269)

Figure 4 accounts for a great deal of academic and career-related choice behaviour without undermining the significant role that the extent of one's developmental status plays in the process. The model shows that self-efficacy and outcome expectations affect people's interest. People become interested in activities in which they believe they can perform well to produce a valued outcome, and this is shown in paths 1 and 2. Interest, in turn, promotes career choice goals (this refers to intentions, plans or aspirations to study in a particular career, path 3). People will attempt to enter academic fields that align with their primary goals, provided that they are devoted to their goals. However, these goals must be defined in clear terms, at the actual point of entry.

Having a clear goal leads to 'choice actions' (path 4), which can also be described as entry behaviour, such as declaring chemistry as an academic major. Performance domains and achievement experiences (path 5) such as academic performances/grades may strengthen or

weaken efficacy and outcome expectations as shown by path 6, and ultimately, choice persistence.

The model also highlights contextual factors that comprise a structure within which choices are made and pursued. Among other things, these contextual factors may constrain or strengthen the relations between interest, goals, and actions. How the other factors in the model interact and influence each other is clearly shown in the same Figure 4 (Lent, Brown, & Hackett, 2002).

In summary, SCCT emphasizes the following points. The theory specifies goals as forming an intermediate link between interest and choice actions, and views self-efficacy and outcome expectations as precursors of interest. The more valued the expected outcomes, the more likely it is that people will adopt particular career goals and courses of action. Gender, race, physical health disabilities and environmental variables influence self-efficacy development as well as outcome expectations, and ultimately goals and performance. Performance in academic activities is the result of the interaction between ability, self-efficacy beliefs, outcome expectations and the goals that have been established. Similar to self-efficacy beliefs, outcome expectations are generated through direct and vicarious experiences with educational and occupationally relevant activities.

Translating the aspects above into career development terminology, Lent et al. (1994) said people are more likely to become firmly committed to specific rather than vague goals. Firmly held goals (as indexed by expressed choice certainty, decidedness or commitment) will be more likely to promote choice entry behaviours than will more tentative goals. The proponents of the theory further indicated that the model is assumed to depict a set of normative processes taking place under conditions of optimal voluntary control. The authors, however, recognized that in the real world, a variety of other important factors, such as cultural and economic conditions exist that may reasonably affect the explanatory power of the model. The Social Cognitive Career Theory has been applied in different countries (Sheu & Bordon, 2017), extended to at-risk female offenders in the United States (Chartrand & Rose, 1996), and applied in STEM courses; the following paragraphs highlight some of these studies.

The study by Ali and Saunders (2009) investigated the contributions of several SCCT variables in predicting the career choices of 63 high school students in Appalachia in the United States. The finding showed that 52% of the variance related to career choices was explained by the SCCT variables. The authors suggested that lower Socio-economic status (SES) rural Appalachian high school students might benefit from targeted interventions that are designed to increase their confidence and expectations about their future; in light of their cultural

considerations or background (rural Appalachia is identified with pervasive economic depression and high unemployment rates that result in extreme poverty).

Furthermore, SCCT has been applied in different cultural settings outside the United States. For instance, some researchers investigated the occupational interest and career aspirations of 600 high school students in Portugal (Lent, Paixão, Silva, & Leitão, 2010). The findings support the view that self-efficacy and outcome expectations related to interests, and interests relate to career choice criteria, in ways that are most consistent with Lent et al. (1994) SCCT's model. Nevertheless, the authors noted that social support and barriers related to career choice goals did not conform to SCCT's direct-effects predictions. Chartrand and Rose (1996) applied SCCT framework to at-risk female offenders, who are likely to experience employment and career barriers; and recommended for career intervention programmes for this population.

SCCT has been applied in STEM courses. For instance, the longitudinal study by Hardin and Longhurst (2016) measured SCCT variables of students enrolled in an introductory chemistry course, and found that men have higher coping self-efficacy, STEM self-efficacy and interest than women. Likewise, Lent et al. (2005) applied SCCT in predicting the interest and choice goals of students enrolled in introductory engineering courses at three historically Black and predominantly White universities. The authors reported that their findings fitted the SCCT model across gender and university type.

Students' career aspiration has been reported to affect their choice of study program and persistence. The next section captures relevant literature on career aspiration both outside and within the South African context.

2.2 Career aspiration

Career aspiration is defined as the "degree of commitment to a given career" (Gray & O'Brien, 2007, p. 318), and has been an interesting topic for educational researchers, who have investigated the factors that influence undergraduate students' choice of study programme and career aspirations. Choice of study programme decision has been closely associated with students' career aspiration, and is significantly affected by their learning and social experiences (Arnold, 1993; Burch et al., 2007; Hinds & Shultz, 2018; Sfard & Prusak, 2005; Woolnough, 1994). For instance, Woolnough (1994) reported that academic abilities, prior learning experiences, motivation by educators were important to students at the stage of choosing a science-based programme. Abraham and Barker's (2015) study on secondary school students in Australia showed that physics students' sustained interest in the subject largely predicts their post-secondary enrolment intention. The study applied the Sustained Enrolment Models for Physics, which drew from the Expectancy-Value theoretical foundation,

and proposes “predictive relations among students’ achievement motivation, sustained engagement, and enrolment intention in relation to physics” (Abraham & Barker, 2015, p.509).

Holly (2005), reported that learning experiences offered by universities influence students’ level of interest in the courses offered. Also, perceptions concerning jobs and opportunities for professional development have been pointed out as some other factors that influence university students’ career aspiration (Ogunde et al., 2017). Astin and Astin (1992) report a close link between the students’ involvement in institutional activities such as faculty-based research and their interest in the course. He found that if students are involved in activities such as faculty-led research or student-centred research, this is likely to produce greater satisfaction in science courses. This satisfaction may, by extension, have the potential to increase their interest in the course and career path.

A study conducted in the United States by Hinds and Shultz (2018), investigated the factors that influence chemistry students course selection in the university. The authors found that institutional and personal factors affected students’ chemistry course selection, with institutional factors playing a more dominant role. Institutional factors as classified by these authors included placement test results, academic plans, advisors, confidence and course load; while family and financial concerns, advice from friends and family made up the personal factors.

Additionally, the study by Sfard and Prusak (2005) on the relationship between identity and learning is particularly relevant here as it shows how the career aspiration of students could be influenced by past experiences, motivation by parents and academic abilities. In this research, the authors attempted to use identity as an analytic tool for investigating students’ learning. Identity was defined as the set of reifying, significant and endorsable stories about a person, which comes from collective storytelling even if it were told individually by the learners. Furthermore, the authors explained that actual and designated identities are the two sets of reifying, significant stories about a learner, which he or she endorses that somewhat affects the way they learn. Statements like: I have an average intelligence quotient (IQ), which are expressed as factual assertions and in the present tense are classic examples of actual identities.

On the other hand, designated identities are regarded as the stories, which the learner believes has the potential of becoming a part of their actual identity in the future and are expressed using future tenses (an example is “I want to be a medical practitioner”). Sfard and Prusak (2005) claimed that learning might be considered as closing the gap between these two identities: actual and designated. Sfard and Prusak’s (2005) study involved a group of 11th-grade students, consisting of recent immigrants from the Soviet Union and native Israelis

who followed an advanced mathematics programme. The impressive results of the immigrants in national and international mathematical competitions motivated the study, and the research identified salient differences in the learning processes between the two groups of students. Several factors were identified by the authors that may have contributed to the impressive performance of this group of immigrant students, such as the belief that mathematical fluency was needed to be a full-fledged human. The immigrants believed that mathematical fluency would give them leverage over the seclusion their family clan faced in their home country; which resulted from collective stories that their parents and grandparents told them. These collective stories and learning experiences shaped their career choice and determination to succeed, as they saw their designated identities as given and immutable. The findings from the study support the claim that designated identities are products of collective storytelling, and it significantly affects students' career choice and persistence.

The study by Ogunde et al. (2017) explored how the career aspirations of undergraduate chemistry students from Australia, New Zealand and the United Kingdom varied. The findings revealed that interest in the subject was a predominant reason why students choose to study chemistry, and they seem to be aware of the many career options that a chemistry degree could provide. Only a small number chose chemistry as a pathway to a specific career. Students in the study also said they need help with career planning. Moreover, only a small percentage of these students reported studying chemistry due to lack of choice or it being compulsory. Furthermore, the study also showed that in comparison to the females, males tend to study the course because they enjoy the subject, perform well, and expect a good salary.

In addition, Lubben et al. (2010) investigated the persistence of a small sample of students in GEPS programme in South Africa. The study identified the underlying reasons for students' choice of a study programme, career aspiration and the reasons for discontinuation. The findings showed that completing the degree was the main aim of programme-focused students, and their decisions were influenced by an interest in the subject. On the other hand, career-oriented students were initially motivated by role models, extra-curricular activities, and subsequently, the career they desire to pursue after graduation. It was shown that acknowledging and reinforcing students' career aspiration might facilitate decisions on progress through the programme. Absence of specific career aspiration and a lack of understanding of how a given career is related to the skills, and knowledge acquired in the programme were also noted. The study thus indicated the lack of applicability of SCCT framework in improving the retention of those students without clear career aspiration. With respect to discontinuation from the programme, the study revealed that academic workload, perceived relevance to initial preferred career, family issues, financial difficulties and attitudes

related to being part of the access programme were major reasons for discontinuing. Hence, the authors suggested a joint, structured and integrated career engagement programme in the initial stages of enrolment as a way of motivating students to persist.

Another factor that has been identified to affect student's career aspiration is gender (Fox & Stephan, 2001; Scantlebury, 2012; Villafañe & Lewis, 2016). Research studies have shown that females have a more diverse career aspiration and are more inclined toward a teaching career than males (Fox & Stephan, 2001; Sadler, Sonnert, Hazari, & Tai, 2012; Villafañe & Lewis, 2016). Specifically, in the study by Fox and Stephan (2001), where the career inclination and actual careers of a group of research graduates were investigated, showed the earlier statement to be true. It was also found in the same study that in comparison to males, females were more inclined toward a teaching career. Furthermore, it was reported in the research by Sadler et al., (2012) that high school female students were desirous of pursuing a career in medicine and health-related fields, whereas an engineering-based career path was the aspiration of the males.

Academic abilities of students have been recognised as a factor that influences students' career aspiration and by extension, their academic achievement. Woolnough (1994) investigated students' achievement and their commitment to whether or not to pursue a graduate programme in science and engineering. The study found that the academic abilities of the students who intend to study science and engineering programmes were higher in contrast to those intending to pursue art-based programmes. The author stated that perceived self-efficacy of the students in the course and career path was associated with higher academic performance.

Apart from the observed influence of perceived self-efficacy on students' academic achievement as seen from Woolnough's research, students' study habits also have a significant impact on their academic performance (Ye et al., 2016). The investigation by Ye et al. (2016) involved a group of at-risk students (students with a lower likelihood of success) in a general chemistry course. The authors found out that these students put in equal effort in attending classes and completing the task, and recorded a higher number in terms of studying outside class. However, the nature of the learning approach adopted by the students posed a downside to their academic achievement.

Motivation is another factor that affects students' academic achievement and persistence. For instance, the study by Ardura and Pérez-Bitrián (2019) applied SCT, motivation, self-efficacy and self-determination theory in investigating the effect of motivation towards chemistry and physics on the achievement of Spanish secondary school students. The study showed that grade motivation and self-determination were more significant predictors of performances for

those who did not choose chemistry and physics compared to those who did. The next section highlights literature on self-efficacy, which has also been closely associated with students' persistence.

2.3 Self-efficacy

In academic setting, researchers and practitioners interested in students' motivation and learning are placing increasing emphasis on the influence of self-efficacy beliefs on students learning; as this has been shown to affect the way they learn or exhibit certain behaviours at designated levels. According to Bandura (1986), self-efficacy beliefs of individuals are defined as the individual's beliefs or judgments of his or her capability to organize and execute various tasks, which play an important role in their academic motivation and learning. It also refers to beliefs about what they can do with the abilities they have, and may vary significantly depending upon the task. In general, students' success in their studies tend to raise their self-efficacy and failures lowers it. Students who feel that they are efficacious at learning or performing a given task will participate readily, work harder and persist longer when they encounter difficulties. Additionally, these students achieve at a higher level; compared to those who doubt their learning capabilities. Students' self-efficacy beliefs influence their motivation, interest in a specific task and expected outcome for certain behaviour (Bandura, 2006). Additionally, the strong influence of self-efficacy is posited to be due to its influence on an individual's intention to either persevere or give up, thereby influencing their future behaviours by increasing or decreasing exposure to new and challenging tasks.

Individual self-efficacy belief has also been linked to students' career aspiration (Bandura, 1994). Furthermore, students' academic abilities have been associated with their self-efficacy beliefs, and by extension, their career aspiration (Li, 2012; Zusho, Pintrich, & Coppola, 2003). The role of self-efficacy is a key mechanism in Bandura's (1986) SCT model that affects one's choice of tasks, effort, persistence, and achievement. SCT, as described earlier, has been applied to explain how people learn, and persist with new behaviours. As part of a larger theoretical framework, it postulates that human achievement is dependent on an interaction between an individual's behaviours, personal factors (thoughts and beliefs) and environmental conditions (Bandura, 1986).

The formative process of people's self-efficacy beliefs has been theorized to be influenced by four sources (Bandura, 1994). These sources of self-efficacy beliefs include mastery (actual personal accomplishments or performances), social persuasion (a peer or superior's opinions about an individual's ability), modelling (observational, watching someone else) and anxiety (physiological state or reactions such as sweating; moreover, it has been theorized to be

independent of the other afore-mentioned sources). The extent to which an individual process and thinks about these four sources affect the strength of their self-efficacy beliefs, and by extension, their expectation and behaviours (Bandura, 1994; Schunk, 2003). An individual's self-efficacy beliefs for either success or failure will remain more stable when an individual has developed a well-established self-efficacy belief whether for success or failure (Schunk, 2003).

Outcome expectations strongly influence self-efficacy, and the relative dependence of these two constructs on each other is what functions mutually to predict people's behaviour. Outcome expectation is defined as a belief or judgment of the likely consequence a behaviour or action will produce (Bandura, 2006). He further posits that people make decisions about courses of action based on what they believe the likely consequences of these actions are. For instance, an individual's confidence or belief about his or her ability to succeed or fail at a designated set of tasks will cause that person to hold either positive or negative outcome expectations, respectively. This belief is also crucial in an academic setting because students do not engage in activities, which they feel will produce a negative outcome.

Moreover, in many cases, students are not willing to undertake a career path in, which they feel they cannot succeed, as they lack a sense of self-efficacy in that regard. If they do, they are more likely to drop out as there exists a high degree of self-doubt, which makes it difficult to sustain their interest and motivation to continue. Likewise, research has shown that students with high self-efficacy usually view a new task as a challenge and work diligently to master it, thereby creating a positive and enriching environment for further learning (Schunk, 2003; Zimmerman, 2000). Conversely, those with low self-efficacy will engage less and try to avoid the task when they encounter difficulty, which does not encourage further learning. Likewise, an overly high self-efficacy belief can cause a learner to prepare insufficiently for a given task such as a test or examination. Woolnough (1994) noted that the self-efficacy of students studying science and engineering courses was higher, compared to those pursuing art-based courses.

People's self-efficacy beliefs also have a significant influence on other self-referent thoughts. As an example, those who see themselves as ineffective in a specific task will continuously dwell on these deficiencies, which will make challenges appear more complicated than they are. By doing this, their attention is drawn away from the current task to their self-doubt. On the other hand, self-efficacious people will engage all their energy in the task at hand, and expend more effort as it becomes more challenging than those who are not. Furthermore, self-evaluation of learning progress by students usually sustains their self-efficacy and motivation. At the initial stages of learning activities, students usually have goals and a sense of self-efficacy for attaining them. As they work on tasks, they note their progress towards these

goals. Self-evaluation of their learning progress in this way helps sustain their self-efficacy and motivation, especially when satisfactory progress is recorded. This self-evaluation conveys to them that they can perform well, which further enhances their self-efficacy for continued learning (Pajares & Schunk, 2001; Schunk, 2003).

Students' attitude toward science has been reported to influence their achievement level and by extension, their retention (Hassan, 2008; Villafañe & Lewis, 2016). Experiences in school science play a critical role in shaping attitude toward science both within and outside the classroom. Attitudes have a substantial impact on behaviour through either facilitating the learning process or impeding it, especially at tertiary level, when science courses are perceived by students to be less important, they are more likely not pursue a science-based career. In many instances, students leave the course of study when they feel they cannot succeed, thereby losing their interest and motivation to continue. Villafañe and Lewis (2016) study explored this effect for different categories of students enrolled in an introductory college chemistry course by employing the Test of Science Related Attitude instrument. Their findings were quite surprising because contrary to expectation, it was discovered that the females exhibited a more positive science-related attitude than males. The authors, however, called for the replication of this study in other settings. In the review by Scantlebury (2012), it was reported that the reluctance of female students not to pursue a science-based course is due to their lack of association or appreciation of the relevance of the course in their lives.

Additionally, in the study by Galloway (2017), an effort was made to understand the undergraduate student perception of the value of degree skills. The investigation was carried out to identify further the skills, which the students wished to gain to increase their chances of being employed after graduation. It was reported that students with high subject involvement in their future desired job valued both subject-specific skills and generic skills; whereas, those with low subject involvement in their future desired job favour the latter. On the other hand, Juan et al.'s (2018) study on the investigation of the self-efficacy of Grade 9 students in South Africa revealed a positive relationship between self-efficacy and science achievement. The study suggested that there is a need to focus on non-cognitive aspects to improve students' achievement in science.

Dweck (2017) reported how praising students' ability and effort, lower and improve their performance, respectively. The author showed how the performance of some students classified as 'ability-praised' decreased when given a task that moved from complex to less complex over an extended period; while the converse was observed for the 'effort-praised' students. On the otherhand, the ability-praised students' performances decreased because they started losing faith in their ability; hence, they were performing at a lower level than when

they started. These students believed that their ability was fixed and cannot be improved, unlike effort-praised students.

Moreover, Hinds and Shultz (2018) highlighted the decisive role that students' self-efficacy played in motivating them to choose courses that were perceived to be more difficult. This role was associated with good prior-learning experiences and academic performance. Additionally, the study by Ardura and Pérez-Bitrián (2019) showed that self-efficacy was a good predictor of students' performance in chemistry and physics. The literature reviewed thus far captured students' career aspiration and self-efficacy. Since this study also focuses on conceptual understanding, it will be helpful to look at relevant literature, which is shown in section 2.4.

2.4 Conceptual understanding of chemical bonding

Central to understanding chemistry is conceptualising the nature of the chemical bond found in chemical compounds. As a discipline, chemistry primarily involves the formation and breakage of chemical bonds, which highlights the vital role that chemical bond theories consequently occupy in the activities of chemists (Pimentel & Spratley, 1969). Chemical bonding is a fundamental topic that is taught in the chemistry course, and it provides the foundation for further studies. In other words, chemical bonding is considered as a central topic in chemistry as it explains the interaction between matter and energy, and links atoms to molecules, and compounds to structures and involves the use of simple to complex abstract models with considerable mathematical complexity (Özmen, 2004; Williamson, 2008). It is pertinent to use the next paragraph to describe the process of student learning briefly.

Introduction to students' learning

Science educators have become increasingly concerned about revealing the difficulties associated with students' conceptualization of scientific principles. Research in this regard has shown that learners at various levels come into the classroom with fairly pervasive, stable and pre-existing beliefs about scientific knowledge that play a significant role in subsequent learning (Abraham, 2008; Özmen, 2004). This view is the dominant paradigm of learning in science, and is explained by Piaget's functioning model, which has found much useful application in chemical education research (Abraham, 2008; Tsaparlis, Pappa, & Byers, 2018).

Piaget's functioning model is concerned with how students learn. It also describes human beings as having existing cognitive (mental) structures, which interact with the environment to form learners' prior knowledge. According to this theory of learning, information can only be assimilated when these cognitive structures can transform the new information in the process

of accommodating it (Abraham, 2008; Özmen, 2004; Robinson, 1998). In other words, learners try to make sense of new information based on what they already know, and try to fit this new information into their existing mental structures. When their mental structures can successfully accommodate and come into a state of equilibrium with the assimilated information, then learning has taken place. Thus, learning takes place through the process of assimilation, accommodation, and organisation.

Some fundamental concepts in chemical bonding, which are taught during lectures such as ionization energy, stability, bonding, electrons, molecular structures, and geometry are central to many other branches in chemistry, such as analytical, organic, and physical chemistry. Thus, if students do not understand the foundation of chemical bonding, they are likely to find it difficult to understand other topics taught later in the degree. The next section describes students' experiences in South Africa.

2.5 Students' experiences in South Africa

The study by Case (2007) focused on third-year chemical engineering students' experience at UCT using the concept of alienation and engagement. In the context of the paper, alienation referred to the state of being isolated from activity to, which a student should belong. While engagement refers to a student connecting to the context of a relationship, he or she desires or expect to belong. The study revealed six possible relationships in terms of students' experiences, namely: studies, home, career, classmates, lecturers, and the wider university life. Each of these aspects is described briefly in the following paragraphs.

In terms of relationship to their studies, commitment and hard work required in the course were highlighted by the students, which resulted in a state of self-discipline and drudgery. For others, it resulted in disengaging behaviours despite the academic consequences because they could no longer withstand the pressure. In other words, the students realised that they could not continue to push themselves at the extreme level required for coping in the programme. For these students, the majority began to manifest classic symptoms of depression, such as spending a considerable amount of time sleeping and struggling to complete their academic work. Students mostly described the course in terms of the workload, referring to their days as filled with lectures and tutorials; coupled with weekends and evenings devoted to meeting the course demands. The study referenced an excessive focus on time management as a vital aspect of this student's experience, which sometimes verged on quite unrealistic expectations. The students tended to spend every available time on their academic work, thinking it was the best way to discipline themselves to work harder. The study also recognized the absence of enjoyment and excitement about studying chemical engineering in

these students' narratives because of the immense workload. With respect to university life, a greater number of the students' university life was characterized by not having time to do any other thing apart from studying, which the author referred to as 'denial of desire' implying that they were alienated from the broader life in university (Case, 2007, p. 125). However, a small number of students were passionate about engaging in outside activities, as they were not ready to sacrifice their other interests.

Furthermore, concerning this group of engineering students' relationship to home, three categories were recognized. Those who had a seamless connection between home and university life as their family provided a sympathetic ear to their struggles as well as much needed support. The second group of students, as it concerns students' experiences, were those for whom home was a place of refuge away from varsity life. The third group felt awkward and out of place on returning home because of how they have changed over the years of being at university.

In terms of careers, the study identified four categories of students. A small minority who described with excitement their desire to become chemical engineers, those who felt unsure about their ability to become chemical engineers, students who did not want to be chemical engineers, and those who felt disadvantaged because they did not have enough knowledge of what the workplace would be like; stemming from the fact that they had not experienced vacation work. Students also formed clearly defined small groups that they worked with within and outside the classroom. Some of them mentioned getting help from others outside their group if they had questions that could not be answered within the group. Students treasured the friendships they had in class, and referenced this as a reason why they were still in university at the time of the study, which is similar to the observation noted elsewhere (Potgieter, Harding, Kritzinger, Somo, & Engelbrecht, 2015).

The majority of the students in the study by Case (2007) were positive about their lecturers, and teachings in the course, which was considered an engaged relationship. Some students also interacted with their lecturers on an individual basis or in a group. Additionally, the issue of feeling cared for by some of the lecturers was also recorded. Some students said that they felt that the lecturers cared for them. The study summarized the dominant experience of being a student in this context as one of drudgery, discipline and denial, without passion, and enjoyment, which in some cases led to complete disengagement.

The study by Potgieter et al. (2015), which was carried out at the University of Pretoria, South Africa, investigated students' experiences in an access programme at the Faculty of Natural and Agricultural Science. The study reported this experience through three performance bands: good, moderate and poor performers; and showed that the design of this programme

was positively experienced by most of the students across all the different bands. Students were happy with the curriculum and theory covered, which helped them to understand concepts better. However, a sense of frustration, inability to cope and failure to identify challenges, and obtain assistance were reported for the poor performing students. The study highlighted the need to equip those students who were not performing well with academic and life skills.

Moreover, smaller classes were reported as a positive feature, and facilitated more interactions between lecturers and students; and aligns with one of the four main attributes of effective classrooms, as identified by Tinto (2012). Students are more likely to succeed in the classroom if they are more academically and socially engaged with academic staff and peers. Studies have shown that students' interaction with peers and faculty members outside the classroom contributed to their learning and personal development (Astin & Astin, 1992; Case, 2007; Engelbrecht, Harding, & Potgieter, 2014; Ogunde et al., 2017; Potgieter et al., 2015).

Furthermore, in the study by Potgieter et al. (2015), some students experienced the programme as highly intensive with a full-time table making the day very long; while others mentioned that the slower pace of the lecture delivery was beneficial. A small number of students also felt that they were spoon-fed, and this was cited as a concern. Also, students had differing opinions concerning the lecturers on the programme as some thought that they were good and knowledgeable while others did not. In terms of adjustment, the challenges of adjusting to the new social and academic setting were the major factors identified. Finding a balance between work and personal life, time management, dealing with the large volume of academic work, the fast pace of learning, personal issues and financial issues were amongst the factors identified.

The study by Wood and Lithauer (2005), which was carried at the Nelson Mandela Metropolitan University in South Africa, showed that students who complete a foundation year tend to perform better later in the BSc degrees than those with a similar academic profile in the mainstream system. Students also felt the programme helped them to cope with the demands at university. Moreover, the support that students received from the university foundation programme and family were recognized as major influences on success. As a way of overcoming difficulties in their academic pursuit, students identified coping strategies that involved the development of their academic competence and the application of the appropriate life skills, e.g. time management. Students mentioned a commitment to work, determination, perseverance and having a positive attitude as helpful measures. In terms of preparation for joining the mainstream a greater number (65%) felt well prepared while the others shared a

different opinion. Carranza (2007) cited a commitment to achieving personal goals as the most important factor that students described as significant to their academic success.

Bangeni and Kapp (2005) explored first-generation students' language and literacy skills, and practices. The study reports students' ambivalence as they found themselves straddling multiple and conflicting ways of finding out how who they were, and where they belonged. The authors found that students' relationships to home and the university were defined by fluidity, ambivalence, and change as they had to reposition themselves constantly as required. A student said that the personal attention he received in the extended program made him feel valued and recognized; which he treasured as an important experience. The authors argue that students are continuously responding to multiple and often conflicting expectations of who they are and who they should be. Also, their construction of home communities refers to an environment where they can feel at ease and just be themselves. Moreover, the lack of such an environment at university, where they can just be themselves, was recognized as a loss of home. The study also noted that while students embrace the concept of diversity in theory, in reality, students from similar class positions tend to form social groups and friendships.

In terms of alienation, Bangeni and Kapp (2005) also noted that the degree to which a student feels that they belong to a place affects their engagement and motivation to learn. A similar observation was reported by (Kelly-Laubscher et al., 2018). Both students and staff are essential in finding the right balance between challenge and support. Ensuring that this balance is maintained to prevent the feeling of alienation and in the long-run disconnection (Bryson & Hardy, 2012; Kelly-Laubscher et al., 2018).

The study by Ngcoza and Southwood (2019) explored collaborative approaches to the professional development of educators in South Africa. The authors acknowledged and considered professional networks as webs of development (networked learning communities). Furthermore, 'webs of development" imply the involvement of a learning community or space, in which different expertise are valued and shared, and where all are learners, and have something to teach and contribute. The findings showed that the conceptual thread of engagement within a networked learning community is shared through connectivity, collaboration, negotiation, dialogue and appreciation. Additionally, in the thinking of Mavuru and Ramnarain (2017), the notion of learning space is a sociocultural context, where diverse cultural and social knowledge is brought and shared by learners.

An international study conducted in the United States by Tinto (2017) focused on factors that affect students' motivation to persist. The author said that students need to persevere and expend the right effort to do so even when faced with difficulties; as they are unlikely to persist without motivation and the drive that it produces. The study highlighted how factors such as

prior school learning experience shape students' motivation and how this could be applied to promote persistence.

2.6 Chapter concluding statements

The review of the literature in this chapter reveals that the students' experience at university is influenced by several factors, such as the extent to which they feel they belong, support structures available and commitment to personal goals. Also, factors such as their conceptual understanding, career aspirations, and self-efficacy play a significant role in achieving success. Furthermore, the importance of engaging learning spaces which allows for a free exchange of cultural values has been highlighted. Attention will now be shifted to the methodology adopted in the study, and this is reported in the next chapter.

Chapter 3: Methodology

To contextualize the findings of the research, this chapter outlines the methodology employed during the study. A description of how the research process unfolded, and how modifications were made at relevant stages is provided. An effort has been made to provide the readers with a sense of how the research design was conceptualized, and a case has been provided for the choice of the methodology adopted in the study. Furthermore, an outline of the various methods used for collecting data, and the rationale for using these methods is provided. Description of the data capturing, editing and analysis; and ethical considerations observed in carrying out the study is provided.

3.1 Research design

This is an exploratory qualitative case study design, which was chosen because I wanted to investigate the collective influence of career aspiration, self-efficacy, conceptual understanding and experience on the retention of chemistry students. The case study design was viewed as appropriate to the research topic as the use of this design has proved successful in research about retention (Lubben et al., 2010). The study is bounded to understanding the experiences of undergraduate EDP and MS students in the Department of Chemistry at UCT and incorporates a social constructivism paradigm. A case study, according to Hofstee (2006), is useful when a detailed, in-depth understanding of a specific case is required. Given that studying these two unique sets of students in chemistry will provide a detailed understanding of their experiences, and assist in identifying particular concerns that are peculiar to each group, a case study design is most appropriate.

The basic feature of qualitative research is that it is used for exploration and involves going out to a natural setting or context and studying it first-hand. It is a useful method of inquiry that helps researchers to report the voices of participants, and present the differing perspectives that they may have about the phenomenon under investigation. Qualitative research provides deep details about the participants, as the study usually involves a small number of people. Furthermore, in this type of study, the researcher creates multiple views or perspectives of the research theme or phenomenon after carefully reviewing data collected from the participants. Creswell (2016) said: “report the good, the bad and the ugly” (p. 118). This approach helps the audience to have a holistic perspective about the phenomenon as the voices of individuals from different works of life, geographical regions, gender and age groups is explicitly reported (Cohen, Manion, & Morrison, 2001, 2018).

3.1.1 Relevance of the research design

Miles and Huberman (1994) defined a case as a phenomenon of some sort occurring in a bounded context, which may be an individual, a small group, a role, organization or community. A case study is an empirical inquiry that investigates a contemporary phenomenon in its real-life context when the boundaries between phenomenon and context are not evidenced, and in, which multiple sources are used (Yin, 1984). In order to effectively carry out research using a case study, the inquirer first needs to identify the phenomenon, either as a single case or multiple cases. Second, the researcher needs to identify a specific case with a clear, well-defined research objective with a relevant strategy aimed at producing an in-depth understanding of the case. Third, to explain the phenomenon, case studies need to use variables of theoretical interest (Creswell, 2013, 2016; Tellis, 1997).

Stake (1995) and Yin (1984), base their approach to a case study on a constructivist paradigm, which conceives truth to be relative and dependent on one's perspective. It is premised on the social construction of reality, a subjective creation of meaning. There are different types of case studies, which is best explained by the specific type of case being considered in the study, e.g. institutions, policies or other systems, which are studied holistically. In recognition of the fact that context is a powerful determinant of causes and effects, the case study approach tries to understand a phenomenon by observing the effects in real contexts. Moreover, it helps readers to understand ideas more clearly as is down-to-earth, and provides examples of real people in real situations, instead of merely stating abstract theories. In other words, its attention capturing nature makes it possible for it to easily harmonise with the reader's own experiences, thereby naturally allowing for generalization. Furthermore, one particular strength of a case study is how it uniquely reports complex dynamic and unfolding interactions of events and human relationships after an appropriate investigation or study.

Individual and/or staff development, formative evaluation, institutional practices; and educational policy-making are all different spheres in, which the insights gained from case studies can be effectively applied (Cohen et al., 2001). It is also useful to note that one other unique merit of this approach lies in how the research data are reported, which makes it possible for it to serve multiple audiences. The research data are usually presented in a more publicly accessible form compared with other kinds of research reports used in educational research (Cohen et al., 2018). Finally, it allows readers to extrapolate the implications of a study for themselves.

3.1.2 Conceptualization of the research design

The foremost paradigms in social science research are positivist, interpretivist and critical theory (Mouton, 2001). Creswell (2013) uses some slightly different terms, namely: technical

rational (empirical); interpretive and critical realist, respectively. As a trained analytical and organic chemist, I have been introduced to methodologies of a rational paradigm and the primacy of objectivity, and the quest for "truthful" generalizable knowledge (Mouton, 2001). This rational paradigm was my stance when I started my chemistry education research, but as I read more journals and books, I became more aware of other philosophical paradigms in educational research, and I was fascinated by the social constructivist way of thinking. I realised that to effectively answer my research question I needed an approach that will allow me to engage on an individual basis with the participants in my study to better understand their experiences, other than just considering them as a mere source of data (positivist viewpoint). Thus, my study incorporates the constructivist paradigm assumption of an emerging design, a context-dependent inquiry and an inductive data analysis (Creswell, 2013).

3.1.3 An adapted case study research design

The central question asked in this study is exploratory, which can be best addressed by adopting a research design based on generating qualitative data, for which a case study approach is appropriate (Cohen et al., 2001; Tellis, 1997; Yin, 1984). The first set of data were collected using an online questionnaire from a class of 32 students. The recorded completion rate for the questionnaire was 88% (28 out of 32), and gave a sense that the students were enthusiastic about the project. It is fascinating and pertinent to state that amongst the 28 students who completed the questionnaire, there was an equal number of EDP and MS students (i.e. 14 EDP and 14 MS). This equality implies that the responses provide a holistic perspective of the voices and experiences of students from both study programmes. The researcher could capture this information since the participants were asked to indicate their entry route. Based on participants' responses to the questionnaire, a set of interview questions were designed to gain a more in-depth understanding of their experiences in chemistry (which is associated with the rich nature of in-depth information that interviews provide). The questionnaire was useful in providing context for the story told by the interview data. More details on how the questionnaire and interview questions were designed will be provided later in the data collection method (section 3.2).

In the context of qualitative research, narrative writing has been described as using prose texts to present the findings of a research study in the forms of participants stories told by themselves or by others (Lelliott & Pendlebury, 2009). Narrative-based writing models have been considered to be pertinent to case reporting because of its resonance with human experience and inherent comprehensibility (Riessman, 2008; Zeller, 1995). Like many other

narrative researchers, I find Polkinghorne's (1995) distinction between analysis of narratives and narrative analysis useful, and this is explained in the next paragraph.

Polkinghorne (1995) differentiated analysis of narratives from narrative analysis. Making this distinction is useful because it points out the fact that narrative research, with its unique and distinctive features, overlaps the worlds of both art-based and qualitative inquiry. This difference is based on Polkinghorne's (1995) understanding of Bruner's two modes of thought, which refers to the narrative and paradigmatic mode.

Polkinghorne postulates that there are two types of analysis of narrative inquiry. The first one is an analysis of narratives, which relies on paradigmatic cognition while the second is narrative analysis that depends on narrative cognition. The analysis of narratives or the paradigmatic mode of analysis depends on paradigmatic cognition, which basically refers to a thinking skill that humans primarily engage to organize their experiences as ordered and consistent. Furthermore, a paradigmatic mode of knowing is an effort to organize general features into different categories. It attempts to fit individual details into a larger pattern. Accordingly, Polkinghorne said paradigmatic cognition "produces cognitive networks of concepts that allow people to construct experiences as familiar by emphasizing the common elements that appear over and over" (p. 10). We can use this paradigmatic thinking in narrative data analysis, which Polkinghorne refers to as an analysis of narratives.

Paradigmatic type of analysis is mostly employed by qualitative researchers. During the process, particular pieces of evidence are identified to form general concepts and categories by the qualitative researchers. In other words, the paradigmatic type of analysis seeks to identify common themes which emerge from the data. Hence, whenever this method is employed, the researcher examines the narrative data for the discovery of common themes or salient constructs and organizes them under different groups or classes using stories as data. Additionally, Polkinghorne (1995) identified two types of paradigmatic analysis of narratives, and these are explained as follows. In the first type of paradigmatic analysis, the concepts are derived from previous theory, which could be applied to the data set. The second type of analysis is one in which concepts are inductively obtained from the data; this method is similar to the grounded theory method by Glaser and Strauss (1967). Sometimes it is possible that paradigmatic analysis of narratives can be derived from a prearranged focus of one's study.

For example, when researchers interview students about their university experiences, one could prearrange categories such as the first-year experience, adjustment to university, challenges in the first year, and the like. Polkinghorne's analysis of narratives which refers to the paradigmatic mode of analysis can be summarized as follows:

- It explains the categories of particular themes, as well as the relationship among the different categories
- It describes common themes across multiple sources of data
- It seeks to produce general knowledge from a set of evidence discovered in a set of stories, hence underplays the unique aspects of each story

Therefore, in the analysis of narratives (paradigmatic mode of analysis) in the current study, findings will be arranged around descriptions of themes that are common across collected stories, as has been done in many other qualitative research studies (Polkinghorne, 1995). However, the unique story of each participant will be illustrated using four examples, whose stories fit most aspect of the research focus. These will be provided in the final chapter of the thesis.

3.1.4 Strategies for validating findings

Triangulation is essentially a strategy for improving the validity and reliability of research findings, which can be easily applied in a case study, as this approach generally uses a combination of data collection methods (Patton, 2002). Triangulation is defined to be "a validity procedure where researchers search for convergence among multiple and diverse sources of information to form themes or categories in a study" (Creswell & Miller, 2000, p. 126). Triangulation uses multiple techniques within a given method to collect and interpret data. According to Stake (2005)**,** the sole criterion for selecting a case for a case study is to provide "the opportunity to learn". In this instance, the case of third-year chemistry students at UCT was examined through detailed and in-depth data collection involving multiple sources of information; rich in context. Data were derived from a questionnaire, interviews, and documents. Documents include a writing project, examination papers, academic transcripts, National Benchmark Tests, and National Senior Certificates that were sourced from the departmental and university databases. The criteria used to select the students is described in the next section. It is important to note that each data source has its strengths and weaknesses, using triangulation helps to match the weaknesses of one with the strengths of another, and places the researcher in a position to be able to cross-check findings for validation (Patton, 2002).

3.2 Data collection methods

Having multiple sources of evidence is beneficial in a good case study. The complex nature of this research also requires that the field of inquiry is approached from different angles as

this will ‘triangulate’ or establish converging lines of evidence to make results of the investigation as robust as possible (Creswell, 2013; Patton, 2002).

The next sub-section describes the different research methods used in the data collection process, which include: documents, questionnaires and interviews. The qualitative data generated in the study were subjected to inductive thematic analysis, which allowed themes to emerge from the data without applying any pre-existing framework. I will argue for the validity of the interview transcripts by clarifying the decisions made during the transcription and the rationale behind these decisions. The researcher transcribed the interview data verbatim, but it is useful to highlight that in some instances, where some words did not aid but interfered with meaning, these were omitted, e.g. background noise, the phone ringing, exclamation sounds. These decisions addressed the reality that spoken words is often messier than the written word and produced interview transcripts that could be easily understood; since this information will eventually be included in reporting the research. The purpose of this decision is appropriate since the focus of the research is to ensure that the transcripts convey the intention of the speaker to the reader.

3.2.1 Documents

The use of documents helps qualitative researchers to study people events and systems in depth by analysing authentic written material. Official academic documents, therefore, constitute another important source of information. Having received appropriate permission from the university; several documents were examined. These included students’ writing project reports, examination papers, academic transcripts (i.e. an inventory of the courses taken, and grades earned), National Benchmark Test and National Senior Certificate results.

Writing project

The purpose of the writing project is to allow students to engage with key concepts in chemistry as well as to learn how to write a coherent scientific report based on several resources. The CEM3005W Writing project for 2017, titled “Carbon monoxide-releasing molecules (CO-RMs), a new class of pharmaceuticals” was analysed to assess students’ conceptual understanding of chemical bonding. Essential details about the questions that were analysed in the writing project are carefully outlined in Chapter 4, page 46-47.

Examination papers

The examination papers analysed in the study were the second year CEM2005W scripts, which were written in November 2016 and January 2017. These examinations were written on different dates because some students deferred their examinations to January 2017 due to student protests (Jansen, 2017).

Academic transcripts

Students' academic transcripts, which focused on their first, second- and third-year chemistry courses were analysed. It is helpful to mention that for EDP students; I took the average of their marks for first-year level courses, CEM1009H, and CEM1010H, courses to represent their first-year chemistry score. It is helpful to recollect that the minimum score required to pass any chemistry course is 50%.

National Benchmark Tests (NBT) and National Senior Certificate (NSC) examination

NBT assess the ability of students to combine aspects of prior learning in competency areas such as Academic literacy (AL), Quantitative Literacy (QL) and Mathematics that directly impact on their success in first-year, and by extension, completion of their studies. The test helps learners and universities to determine the level of academic support that students may need, especially in the first year. Thus, the results are used in course development, programme planning, and placement decisions.

NBT consist of two major tests; Academic Quantitative Literacy (AQL) and Mathematics (MAT). The AQL is divided into sections in AL and QL with a 3-hour duration, and is compulsory for all students who write NBT. The MAT paper is a separate three-hour paper, only written by students applying for certain degree programmes and who have done mathematics at school. Both the AQL and MAT are differentiated into cognitive levels, meaning there is a range in difficulty in each section, with the easier applications generally appearing first in both tests (CETAP, 2016). The results are categorized according to three performance levels, namely: proficient, intermediate and basic. Appendix 1 contains more information about how these levels are determined. All students are required to write NBT before admission into the university, but the results are not included in determining acceptance into the Faculty of Science at UCT; however, this is not the case for all faculties.

The National Senior Certificate (NSC) is a high school diploma and the main school leaving certificate in South Africa. NSC examinations commonly referred to as "matric" signifies the culmination of twelve years of formal schooling. After passing the examination, a student is awarded a certificate, which helps the student to gain admission into the university, depending on their marks. There are, however, different admission requirements that are set by each university, and these may vary according to the faculty. At UCT, the Faculty of Science requires a minimum Faculty Point Score (FPS) of 660 out of 800 to be admitted. The FPS is calculated from NSC results (see Appendix 1). Admission to chemistry requires a student to achieve at least 70% for mathematics and 60% for physical science as noted in the extract from the Faculty Handbook attached (Appendix 1). The majority of MS students wrote the NSC in 2015, while those who transferred to EDP wrote the NSC in 2014.

3.2.2 Questionnaires

Questionnaires are useful instruments that are extensively used in collecting data. The major attraction being that they can be administered without the presence of the researcher, and are often relatively straightforward to analyse. A questionnaire needs to be clear in its purpose, exhaustive in its coverage of the elements of inclusion, ask the most appropriate kind of question and elicit the most appropriate kind of data to answer the central purpose of the study. Although there are different types of questionnaires, a less structured, more open and word-based questionnaire was designed for this study based on the relatively small size of the targeted participants.

As noted by Cohen et al. (2001), to adequately capture the specificity of a particular situation for a site-specific case study, a qualitative less structured, word-based and more open-ended questionnaire may be more appropriate. Designing the questionnaire in this study was time-consuming as it involved several iterations in refining it. The questionnaire was piloted before the final version containing questions to elicit a full range of possible responses was produced. The most innocent of questions is replete with ambiguity as noted by Cohen et al. (2001), which implies that the problem of ambiguity of words is hard to control, however, it was minimized during the process of designing the questionnaire rather than being eliminated. In recognition that too many open-ended questions in a questionnaire can be a significant turn-off for participants as it is too demanding on their response time, the questionnaire was designed using a rating scale; further details are provided below.

The questionnaire comprised of sections on career aspiration, self-efficacy, approach to learning, and demographic information. The questionnaire had 32 questions that included 17 Likert scale questions, 4 multiple answer questions, 2 open-ended questions and 9 questions capturing demographic details. The Likert scale for the closed questions had 5 response categories ranging from ‘strongly agree’ to ‘strongly disagree’, from which participants were expected to choose their answers (Cohen et al., 2018; Ogunde et al., 2017). These formed the bulk of the questions asked in the questionnaire since they are easy to administer, quick to answer and relatively easy to analyse (Dawson, 2002). The questionnaire had 2 open questions in, which participants were expected to respond in their own words. It was structured in this way to enable the researcher to capture a wide variety of participant responses and gain more insight into their experiences. Open questions are useful whenever a large category of responses cannot be accommodated by closed questions (Cohen et al., 2001).

Furthermore, the flexibility that open questions offer allows the participants to come up with other topics that may be relevant to the study (Roulston, 2008). There were 4 multiple answer questions; this was intended to help the participants tick as many choices as are applicable

from a list provided. The remaining 9 questions were included to capture participant demographic information. As noted earlier, 28/32 students completed the questionnaire (88%)

A pilot study is an essential aspect of research that is instrumental in singling out potential problems. Therefore, before being administered, the questionnaire was piloted with 4 students, all of whom had no links to the study. Potential problems were identified, which called for necessary improvement (re-wording and rephrasing) of the questions to ensure that the participants could interpret and answer them as expected. The questions asked in the questionnaire were drawn from the following references and sources after making the necessary adjustment to suit the present study (Bandura, 2006; Biggs, 1987, 1999; Ogunde et al., 2017)**.** These sources have been acknowledged in the sample of the questionnaire, which is attached (Appendix 2)

3.2.3 Interviews

The interview is a primary data collection tool in qualitative inquiry. It is employed when there is a need to elicit in-depth information about peoples' experiences. There are different types of interviews, but for this research, a one-on-one semi-structured interview was employed. Interviews provide an opportunity for the researcher to watch the participant's body language and establish a personal connection (Creswell, 2016). Since my research has a strong focus on learning about students' experiences, I chose interviews as one of the major tools for gathering data in anticipation that this would give students the opportunity of sharing their personal experiences and other factors that have contributed to their success thus far. Also, from my review of the literature, this method has been used to collect information in similar projects (Case, 2007; Kelly-Laubscher et al., 2018; Lubben et al., 2010). Furthermore, the flexibility of modifying the line of enquiry as interesting issues emerge during interviews influenced my decision in choosing a semi-structured interview as my research instrument (Robson, 2002). During the interview, participants were asked questions related to:

- Describe their journey into chemistry
- Transition experiences from year 1 to 2 and 2 to 3
- Describe what helped them to persist in their studies
- Identify and describe difficult times that at some stage threatened their retention and their studies

Many of the questions that were included in the interview schedule were based on information derived from their responses to the questionnaire, which had been administered before the organising the one-on-one sessions with students. The interview schedule was therefore designed to gain a more detailed understanding of the participants' experiences based on their

responses to the questionnaire and identify important stories. In other words, the questionnaire responses provided the framework that the researcher used to create and sequence questions, and allowed decisions to be made concerning which information to pursue in greater depth during the interview sessions.

The reason for using an interview schedule is to ensure that "the same basic lines of inquiry are pursued with each person interviewed" (Patton, 2002, p. 343). The advantage of using an interview schedule is that it assists in making the interviews with different respondents "more systematic and comprehensive by delimiting in advance the issues to be explored" (Patton, 2002, p. 343). Alphanumeric characters such as EDP1 were employed to anonymise the identity of participants. An invitation email was sent to these students through the university portal, and 20 students responded, agreeing to be interviewed, but unfortunately, two participants did not arrive. Follow-up emails to the students, who did not attend the interview, did not yield any useful results as they did not respond. Thus, I formally interviewed a cohort of 18 students, consisting of both EDP and MS students, each interview lasted for 20-25 minutes on an average.

The interviews were conducted in a private and serene seminar room in the Department of Chemistry and were audio-recorded. Before the interviews, each participant had already completed the questionnaire, and had provided background information, and other relevant details such as initial career preference had been collected. It should be noted that I interviewed four students and an expert, all of whom had no links to the study, before interviewing the final-year BSc chemistry students. Based on the valuable feedback from the students in the pilot study, necessary adjustments were made to the wording of the questions which were rephrased in some instances. The pilot study also helped me to reduce the number of questions as I realised the interviews were too long.

Participants were enthusiastic about the study and their response to the interview sessions was fascinating as 18 (10 EDP, 8 MS) students attended the interview slots as scheduled. However, the only challenge I encountered was that some of them were 5 -10 minutes late for their scheduled slots, which caused a delay for other students. Despite the inconvenience these students did not leave, they waited patiently for their turn. The interviews were all audio recorded behind closed doors, and later transcribed to text files in Microsoft Word document format. Alphanumeric characters such as EDP1 were employed to anonymise the identity of participants. After this transcription process, I provided each of the interviewees with the transcripts for validation and clarification of all unintelligible aspects. The interview schedule, a sample of interview transcripts, and a sample of proof validation from participants is attached (Appendices 3, 4 and 5).

3.3 Role of the researcher and data analysis procedures

Data reduction is the first stage of the qualitative analysis process where “text data are coded, summarized and categorised” (Sarantakos, 1998, p. 207). It is a continuous practice that occurs throughout the entire process of data analysis and commences through editing, segmenting and summarizing data. It could also be described as the “process of selecting, focussing, simplifying, abstracting, and transforming the data” (Miles & Huberman, 1994, p. 10). From the descriptive information gathered throughout the entire research process, the large text files are usually reduced to “chunks” or segments of data with manageable units of meaning, so that codes may be easily attached to these units of meaning (Miles & Huberman, 1994, p.10).

The qualitative data collected in this study were subjected to inductive thematic analysis, which was done in several stages. During the inductive process of first reading severally through each interview transcripts to become familiar with the collected data, the researcher identified significant information that provided an understanding of participants’ experiences to, which a label or code was assigned (a word, phrases or connecting statements that best represent the information) (Creswell, 2013). This assignment of codes led to the next stage of the analysis, where all similar segments of data were reorganized and reduced to, which the researcher further attributed codes (categories).

The themes for this study slowly emerged from these categories. In other words, these categories of codes were then used as the basis for the development of the thematic structure (Table 2, next page). To further organize the data, I used qualitative data analysis computer software, NVivo, to help store, analyse, report and visualise the codes and themes (Appendix 6). Some of the difficulties I experienced while coding was that some statements fitted more than one category, and so I was not sure where to place them, this led to a repetition of the same quote in more than one place. In such instances, deciding for a best-fit place for the quote was challenging; however, the feedback I received from my supervisors helped me in this regard. Also, students’ answers to particular questions sometimes addressed more than one aspect of the current research study. Hence, when reporting the findings, I was not sure if it was appropriate to remove the aspects not related to what I was saying or retain them.

Table 2: Primary themes and associated codes

Primary themes	**Description**	**Codes**					
Support system	Compilation of all the support system/ resources that students engaged	**Mentor**	**Family**	**Resources-study group**	**Friends- help**	**Religion**	**Exercise-sleep**
		Mentor/role-model Parents-proud Mentor- motivation Mentor-younger-ones	Parents Family-support Parents-proud Home Help-parents	Compare-textbooks Online-resources WhatsApp Creating-platforms Motivational books-videos Study-group Building-relationships people-management	Friends Flatmate Classmates Teachers Lecturers Creating-platform Help/assist Assistance Relief/support Talking-to-lecturers	Praying Christian Muslim Traditional-prophet Spiritual-person	Sports- exercise Healthy Sleep
Journey	Movement into a chemistry career	**Interest**		**Career aspiration**	**Salary-job**	**Choice of study**	
		Extremely-fascinated Motivated Satisfied-happy Finding motivation Loved science Excited Job shadowing Career/Expo-chemistry Enjoy-subject Favourite-course-subject		Loved career Career passion High school-fantasy career Career focus POST-GRADUATE Honours Masters PhD level	Getting job Workplace Industry Job motivation Easy-getting job Good salary Make money	Transfer-to-medicine Engineering Swap Indecisive career-path Numerous switch Change-my-mind Just-picked-chemistry 2nd option chemistry No-other- option Wide-career-option	
Self-efficacy	Factors that either increased or decreased self-belief	**Doubt-fear**		**Self-confidence**		**Top-student**	
		Fear/scared Upset with myself		Increase confidence Self-confidence/efficacy		Top student Good-grades	

Primary themes	**Description**	**Codes**					
		Self-doubt- Discouraged Contemplated options Introvert Intimated Feelings of insecurity Low self-esteem		Positive feeling Nice feeling Positive attitude		Exceptional Excelled	
Experiences	Students varied experiences, difficulties and how they handled them (coping strategies)	**Handling difficulty**	**Time management**	**Conceptualization**	**Emotional difficulty**	**obstacle**	**Transition**
		Stand up for myself Sit-on-top of work Self-discipline Put-yourself-together Work hard Consoling-myself Sit-with-friends-talk Compare-textbooks Keep pushing Personal-development Not quitting Determined Persistence Positive-attitude to life Close to end Positive Perseverance Get-a-degree Deal-with-it Get-through Motivating-others	Insufficient-time Duration-time Short-time Time-consuming Lack-of-interaction-with-materials Improper time management Prioritize time	Intellectually-manage Proper-consolidation Understanding content Not-understand Difficult-content More-demanding-course Lack of interaction-material Gap-in-knowledge Increase workload Didn't-engage-well Irrelevant stuff	Hectic Struggle Frustration Challenge Difficult-times Struggle Tough-hard Personal-adjustment Acclimatize Increase-expectation-lecturers Social pressure No- compassion/ empathy Brain-switching-off	Fees must fall protest Practical session Writing report Intense lab work Financial-obligation Financial exclusion Funds Money Losing-bursary Discriminating-policy Rejection Exclusion Feeling-excluded White-lecturers Black-inferiority Language barrier Failed course	Satisfied 1st-year Enjoy-transition Primary-basic-stuff Relaxing-easy High school-based High school-stuff Busy 2nd-year Jump-again Difficult 2-3rd year Hard-difficult A lot-of-pressure Struggling Big-transition Hard-year Tough 2nd year Horrible-to-mainstream Stable 3rd year Relatively stable year Hectic 3rd year

Furthermore, to enhance simplicity the primary themes and sub-themes are illustrated in the horizontal organizational chart, see Figure 5.

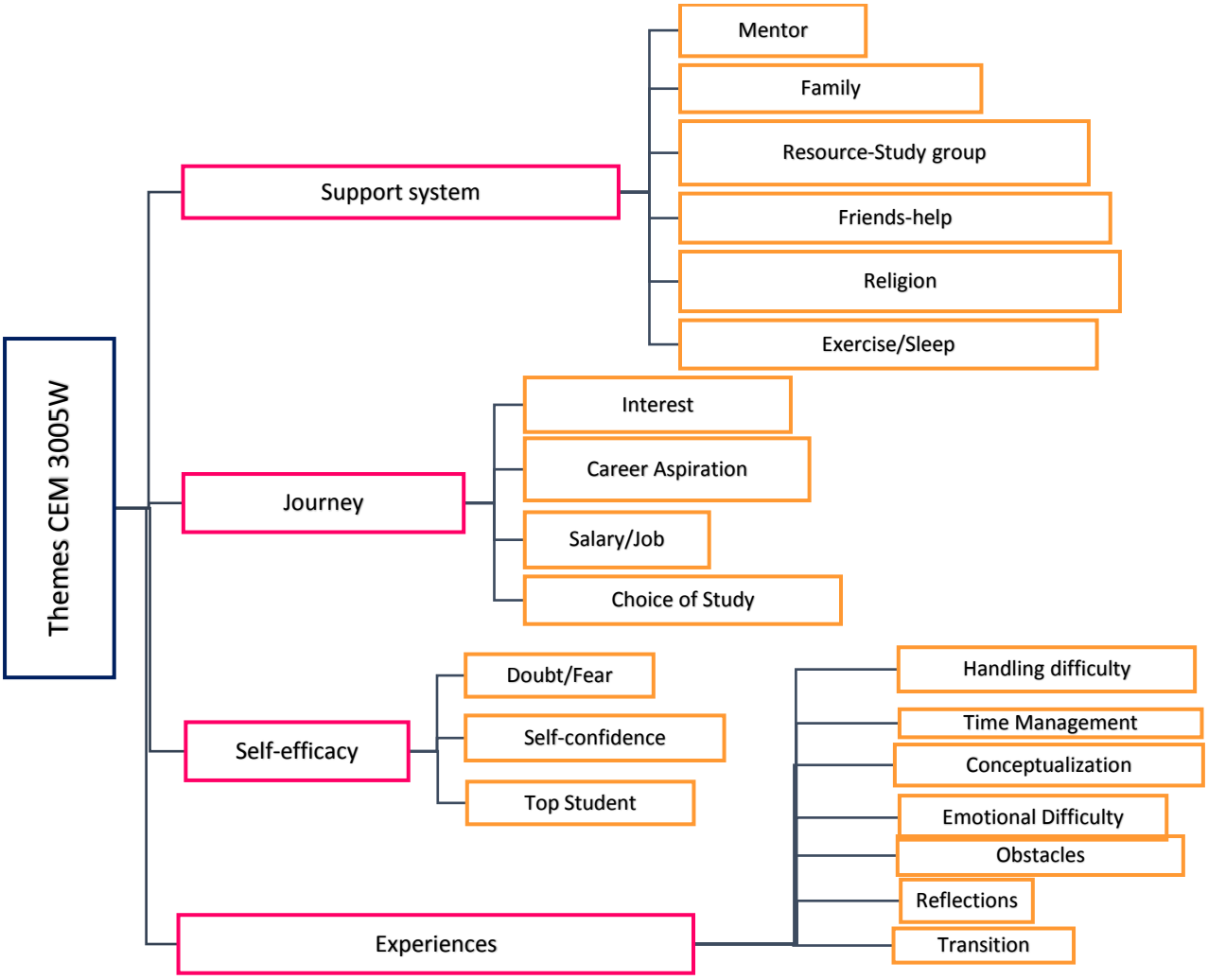


Figure 5: Primary themes and associated codes

3.4 Data sample and sampling strategy

Data sample (population)

In a research study, the population constitutes the group (usually of people) about whom we want to draw conclusions. The focus sample of this study was limited to undergraduate chemistry students who have successfully entered the final year of the BSc course. The questionnaire was completed by 28 out of 32 (14 EDP, 14 MS) of the third-year class after receiving the invitation email. The interviewees were student volunteers who responded positively to the research invitation. The sample consisted of 18 (10 EDP, 8 MS) and represented more than half of the third-year class population. A description of the participants is provided in Table 3.

Table 3: Description of the participants

Type of participants	**EDP**				**MS**			
Interview participants	10 (7 Female, 3 Males)				8 (4 Female, 4 Males)			
	Black	White	Coloured	African	Black	White	Coloured	African
	6	1	1	2	2	4	1	1
Questionnaire participants	14 (8 Female, 6 Males)				14 (5 Female, 9 Males)			
	Black	White	Coloured	African	Black	White	Coloured	African
	10	1	1	2	5	5	1	3

The schools that the students attended are categorized as private, semi-private, public and outside South Africa or SA, as shown in Figure 6.

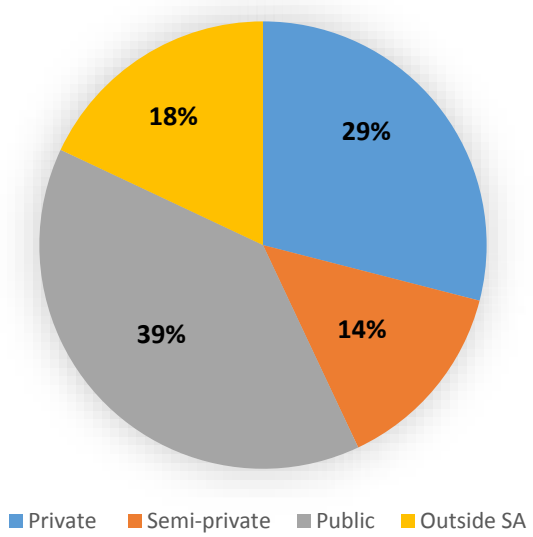


Figure 6: Type of school attended

Sampling strategy

The sampling strategies applied to this study are both purposeful and convenience sampling methods. Qualitative researchers are "almost never able to study all the members of a population of interest, however, and can never make every possible observation of the entire population" (Babbie & Mouton, 2004, p. 100). Therefore, in selecting a sample, the researcher needs to go into further detail about the relevant population to study. Qualitative researchers select each of their respondents purposefully, "the logic and power of purposeful sampling lead to selecting information-rich cases for in-depth study. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research…" (Patton, 2002, p. 46). In purposeful sampling, a particular case is chosen because it "illustrates some process that is significant in the study" (Denzin & Lincoln, 2000, p. 270). On the other hand, in convenience sampling, which is a non-probability sampling

method, data is collected from a group or population that is available or easy to reach (Denzin & Lincoln, 2000).

3.5 Ethical considerations

The protocol observed in collecting each of the data sets has been described, and the research was conducted by the research ethics protocols of UCT (Approval code: FSREC 53 – 2017). Before the administration of the online questionnaire and interview, invitation letters (emails) were sent to prospective participants explaining the purpose of the study as well as its relevance, explaining how their participation will help the institution to make adjustments that will be beneficial to future cohorts of students. Consent forms were also attached to this email, which students were advised to read carefully and sign if they were willing to participate.

Students' participation was purely voluntary, and there had not been any previous encounter or relationship that existed before this time. Hence, there was no form of power dynamics in play during the recruitment process and interviews. In terms of my supervisors, one of them was the coordinator of the writing project, in which I played no role because the exercise had been completed before my data collection took place. However, recognizing that I was a doctoral student, and one of my supervisors had taught the extended degree students in their first year does not eliminate the possibility of power dynamics. Nevertheless, considering that the rationale for conducting the research was made clear to the students, and they were given the option to withdraw from the study at any time if they they no longer felt comfortable minimized this effect.

I highlighted and discussed the scope of the research clearly to participants during the online questionnaire set-up (the first page before the start of the questionnaire), and before each interview session respectively; to ensure that participants understood the objective of the research. The class leader for the third-year chemistry students helped to facilitate the process of scheduling the interview slots for students who had volunteered to participate in the study. The participants had the opportunity to sign up for an interview time slot that best suited their busy schedule, which also indicated the venue where the interview would be conducted.

Permission for the study was granted by the University Faculty of Science Research Ethics Committee, and I gained access to students, and departmental documents related to the students. Permission was granted in August 2017 (Appendix 7). Further, permission to collect data was sought and granted by the Department of Student Affairs at UCT in September 2017 before sending out invitations to students. A set of procedures was followed to ensure the protection of the rights of participants; therefore, the names of students are not disclosed in the presentation of the data. Ethical considerations that were observed at the data analysis

stage included the following, (1) using coded names for participants instead of using their actual names to maintain anonymity; (2) participants were required to read and sign the informed consent form before participating in the research. A sample of the consent form is attached (Appendix 8).

3.6 Reliability and validity

The questions asked in the questionnaire were drawn from literature after making necessary adjustments to suit the present study, this was meant to strengthen the validity (Bandura, 2006; Biggs, 1987, 1999; Ogunde et al., 2017). Before the actual study, the questionnaire was also piloted, and the necessary adjustment was made as potential problems were identified during the pilot study as described previously. Similarly, to ensure reliability and validity, the interview schedule was piloted to see if the tool elicited the data required to answer the questions that the study set out to answer. Thus, four trial interviews formed the basis for improving the validity of the schedule. The interview schedule was piloted with four students and an expert, all of whom had no links to the study, before conducting the inverviews with the final year BSc chemistry students. Based on the outcome of the pilot study, necessary adjustments were made to the wording of the questions. Some were rephrased in instances where the questions were not very clear. The pilot study also helped me to reduce the number of questions as I realised that the duration of the interviews was too long.

To ensure the validity of the interview transcripts, they were sent to the participants to validate. Afterwards, the coded data were given to my supervisors, who provided valuable feedback that helped to redefine some codes and make an amendment to others. As noted by Creswell (2013) the process of checking by other members is a method of data triangulation; this practice of member checking ensures that the analysed data embodies what the study the participants' expressed. Furthermore, in some instances, when the thematic structure has been developed, the analysed data could be sent to the participants so that they could reflect on the overall findings and ascertain if the thematic structure speaks to their individual experiences; this was not done in my study. Only my supervisors participated in crosschecking the thematic structure because I was the only student working on the project.

3.7 Chapter concluding statements

In this chapter, I have described the research design and how the research was conducted. I have described the sample, and ethical considerations for the study. The research findings or outcome are reported over the next three chapters, beginning with the findings as it relates to the analysis of documents.

Chapter 4: Conceptual understanding and academic performance

In the introductory chapter, I stated that my original contribution to knowledge as it relates to students' persistence is that, persistence depends on a number of inter-related factors, which are different for individual students. In this chapter and subsequent chapters, I will be reporting on the findings from my study, and highlight how they reflect the different aspects of the research aim and demonstrate this contribution. It should be kept in mind that the findings, as reported in this thesis, are to be considered in terms of the social constructivist theoretical perspective, as previously noted in Chapter 3. This chapter focuses on students' conceptual understanding of chemical bonding and academic performance in chemistry. It begins with a description of students' conceptual understanding, and for this aspect, a writing task (the writing project) was analysed. Afterwards, attention is drawn to their academic performance before university and their progression over the years. Related documents like examination papers, transcripts, NSC and NBT scores were analysed, and the findings are reported. The following notation N and n are used in this chapter, and represents the total number of students and a subset of the total number of students respectively. There were instances where some students' data were missing, and this has been noted in the relevant sections.

4.1 The writing project

The writing project is an integral part of the course design for final year chemistry. I herein highlight the relevance and position that it occupies in the design of the chemistry course at UCT. The purpose of the exercise is to allow students to engage with key concepts in chemistry, as well as to learn how to write in a coherent scientific report based on available resources (Davidowitz, 2004). The writing project for 2017 focused on the topic of chemical bonding, which is fundamental, but one that students find difficult (Tsaparlis et al., 2018). Thus, it offered an opportunity to check for students' conceptual understanding of chemical bonding by analysing their synthesis of information around an important topic. For this study, the focus was on part A of the writing project exercise, as this is the relevant section. I find it useful to present an overview of the project below to provide a complete picture of the task, afterwards, I will return to part A. The title of the writing project, and a brief overview is shown on the next page.

Title: Carbon monoxide-releasing molecules (CO-RMs), a new class of pharmaceuticals.

Overview:

> Carbon monoxide (CO) is an odourless toxic gas often produced as a by-product from partial combustion of carbon-based fuels. CO gas is toxic when encountered in large quantities as a result of its competition with the oxygen-binding sites in the bloodstream, i.e. Iron in the haemoglobin. Nevertheless, CO can also serve as a therapeutic agent for various diseases if released into the cells and tissues in controlled amounts. Certain molecules can achieve this and are hence referred to as carbon monoxide-releasing molecules (CO-RMs). The writing project for 2017 centres on transition metal carbonyl complexes as a new class of pharmaceuticals that releases therapeutic amounts of carbon monoxide. (Appendix 9: Chemistry Department CEM 3005W Writing Project 2017)

As noted earlier, attention is now shifted to part A, and subsequent pages elaborate on this.

Part A: Carbonyl complexes and CO release

For part A, students were asked to describe the molecular orbital (MO) diagram of the CO molecule. They were also required to describe and explain the effects of coordination of CO to metal ions on the MOs of an octahedral complex. Students were advised to consult the following materials: 4th edition of Housecroft & Sharpe (2012) and Romão, Blättler, Seixas and Bernardes (2012). To aid students' writing, the guidelines below were provided:

Format of project

Part A: Carbonyl complexes and CO release

Your report should address the following sub-topics / themes:

1. A simplified MO diagram for CO, accompanied by a written explanation of the diagram (in your own words). [Figure 2.15 (a) in the 4th edition of Housecroft & Sharpe should be used as the basis for your discussion]
2. A qualitative account of the bonding of CO to a metal centre (Dewar-Chatt-Duncanson model). MO diagrams are not required, but you should illustrate your discussion with appropriate orbital overlap diagrams (Department of Chemistry CEM3005W writing project 2017).

As shown above, part A contained two questions; the analysis for each question is reported.

Question 1 (Q1)

A simplified MO diagram for CO accompanied by a written explanation of the diagram.

The figure that students were instructed to use in explaining the molecular orbital or MO diagram is shown to facilitate understanding of how the analysis was done (Figure 7).

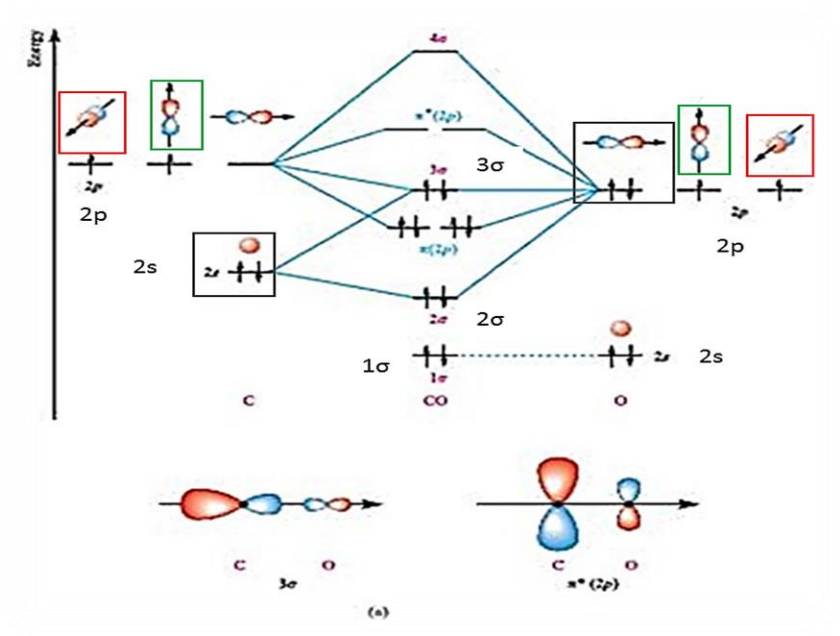


Figure 7: MO diagram (Housecroft & Sharpe, 2012, p. 51).

It was observed that some students did not use the simplified MO diagram as instructed; instead, the MO diagram from Romão et al. (2012) was used, see Figure 8.

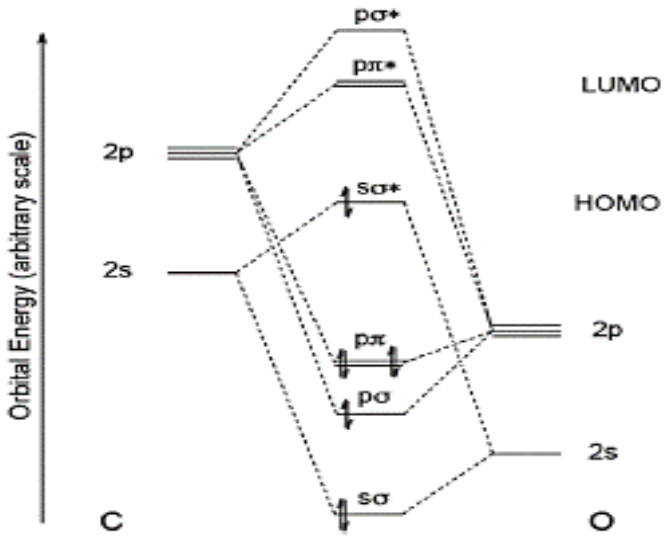


Figure 8: Simplified MO diagram for CO. (Romão et al., 2012, p. 3575.)

Regardless of the diagram that students used, the emphasis was on evaluating conceptual understanding. Hence both diagrams were accepted for assessment of the writing project in terms of the guidelines provided to the students.

Question 2 (Q2):

A qualitative account of the bonding of CO to a metal centre (Dewar-Chatt-Duncanson model).

In order to explain the bonding of CO to the metal centre, students were expected to use the

Dewar-Chatt-Duncanson model (Figure 9). The analysis of this question was easier because all the students used the same diagram.

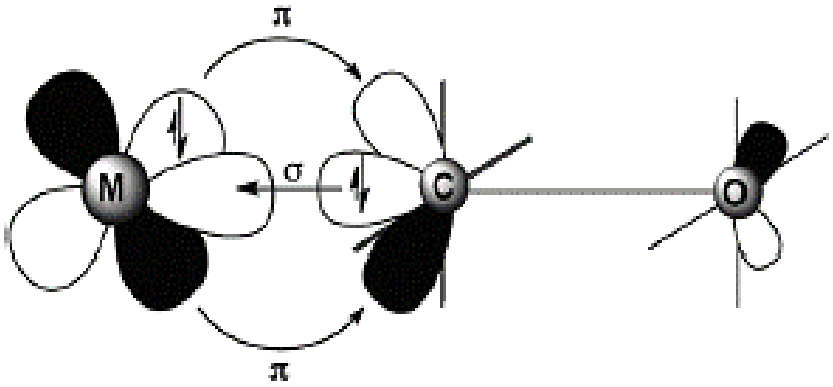


Figure 9: Back-bonding between CO and a metal ion (Romão et al., 2012, p. 3575)

4.1.1 Method of analysis

Sets of rubrics, also referred to as assessment frameworks were developed for the analysis of both questions arising from the writing project. These were cross-checked and validated by the course convener and a senior member of the academic staff in the Department of Chemistry before use. The rubrics were developed because the writing project was allocated to different lecturers within the department to assess. Thus, I decided to develop a rubric to ensure uniformity of marking. Moreover, since my project was focused on assessing students' conceptual understanding of chemical bonding (molecular orbital theory), which is only a section (part A) of the writing project, I felt it would be a waste of time to assess all aspects of the writing project. Instead, a rubric that details aspects that are relevant to the research would be more useful. As earlier stated, some students used a different diagram other than the one they were instructed to use in answering Q1; consequentially, two rubrics were developed to accommodate all students. The researcher did not consider this as a basis to disqualify the students since the essence of the exercise was to check for conceptual understanding of key concepts. For question 2 a single rubric was used. During the analysis, I followed these guidelines:

1. What was the approach to the question? Did the student clearly understand the task?
2. Was there an effort to provide detailed explanation using specific terms or were broad and general answers provided? Does the flow of ideas show that the student understands the science involved?

In addition, since the rubric was weighted with respect to an understanding of the task and concepts, a high mark implies that the student has a good understanding of the aspect of the writing project that was assessed. The converse holds for low marks. Each question was allocated 50%, and no incidence of plagiarism was recorded during the exercise. To provide

further details, a breakdown of one of the rubrics used for assessing Q1 is provided in Table 4, only applicable to those who used the diagram from Housecroft & Sharpe (2012, p. 51).

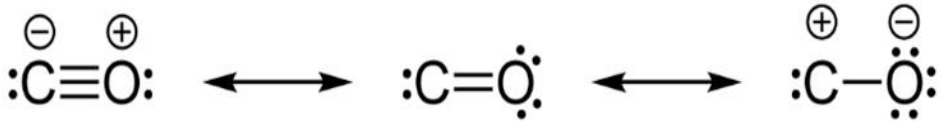
Table 4: Rubric for assessment of Q1

Q1: A simplified MO diagram for CO (without orbital mixing)	% allocated
Lewis structure + description of the molecule In Lewis dot notation a formal positive charge resides on O and a negative charge on C as shown $^{-}:C\equiv O:^{+}$	10
Atomic orbitals (AO) to molecular orbital (MO) formation In this case, it is assumed that the energy difference between the 2*s* orbital on O and that on C is so large that no interaction occurs. *Marks awarded: 5* On the other hand, the 2*s* orbital on C can interact with the one 2*p* orbital ($2p_z$) on O to form the 2σ orbital. *Marks awarded: 10* The 2σ orbital has a little bonding character; the 1σ orbital is non-bonding *Marks awarded: 5* This occurs as the symmetry of the two orbitals is similar *Marks awarded: 5* The σ bonding orbital, 3σ, arising from the combination of 2p orbitals on C and O lies above the π orbitals. The remaining 2*p* orbitals of both C and O have the correct symmetry to overlap forming the π2*p* and π2*p** orbitals *Marks awarded: 10*	35
Mention the total number of MO formed from atomic orbitals Overall, there are 8 MOs formed from 8 AOs, 5 of, which have been filled by 10 electrons (4 from carbon and 6 from oxygen) resulting in 3 bonds between the atoms and a lone pair on each.	5

Those students who had a sound understanding of the science involved were able to use specific words when describing the process of how MOs were formed. In addition, there was a logical flow of ideas that demonstrated that the student understood the task. I will proceed by showing one good and a poor example to illustrate how the students answered the question; which will be labelled 'excellent' and 'weak' respectively. These terms are only used in describing the aspect of the writing project that was analysed for this research and did not refer to the overall student performance in the writing project as assessed by the Department of Chemistry.

An example of excellent performance for Q1

This student (MS3) was able to draw the Lewis structure and provided a detailed description of the CO molecule as captured in the excerpt:



Carbon monoxide consists of a triple bonded oxygen and carbon with three covalent bonds with a high dissociation energy and short bond distance characteristic.[1] It is a diatomic molecule formed from the interaction of the two atoms to produce molecular orbitals. Oxygen and carbon each consists of an s and three p orbitals. From Figure 1, we see that the s orbitals are lower in energy than the p orbitals. The orbitals of oxygen are also lower in energy to carbon due to oxygen being more electronegative i.e. has greater tendency to attract electrons.[2] Due to linear combinations from atomic orbital mixing, molecular orbitals are formed. The energy gap between the 2s and 2p orbitals increases across the periodic table, thus there is a larger separation in oxygen than in carbon, as shown in Figure 1.[1]

Furthermore, MS3 was able to describe and show how MOs were formed. Attention was drawn to specific atomic orbitals that combined to form the resulting MOs. For example, specific references were made to MO diagram in the explanation and a direct link was established in each case as required e.g. "*s* orbitals and p_z orbitals of both atoms are of correct symmetry to form the σ interactions" and "The two mixed AOs of the π symmetry in the y plane produces two MOs of π characteristic in the y plane". See the excerpt below for details:

The s orbitals and p_z orbitals of both atoms are of correct symmetry to form σ interactions. The four atomic orbitals (AO) are mixed to form four σ molecular orbitals (MOs). The p_x orbitals of each atom are of π symmetry along the x plane. The two mixed AOs of the π symmetry in the x plane produces two MOs of π characteristics in the x axis. Similarly, the p_y orbitals of each atom are π symmetry along the y plane. The two mixed AOs of the π symmetry in the y plane produces two MOs of π characteristics in the y plane. As shown in Figure 1, the lowest energy orbital is the σ orbital which results from the constructive overlap of the s orbital of oxygen and s orbital of carbon.[1,2] One can observe that the 3σ, 4σ and $2\pi^*$ is largely of carbon character whereas the 2σ, 1π and 1σ is largely of oxygen character. There is also an antibonding orbital, σ^*, which is higher in energy than the σ orbital. Similarly, this orbital forms from atomic orbital overlapping of the s orbitals from each atom, however the superposition is destructive.[3]

The s and p orbitals of carbon and oxygen are similar in energy such that additional orbital mixing occurs. Both s and p_z orbitals are involved in the σ molecular orbitals, thus resulting in sp hybridization.[4] The first interaction lowers the energy of the first σ orbital and raises the energy of the higher σ which affects the σ^* orbitals. This results in the raising of the second σ orbital above the π orbitals and altering the shape of the orbitals.[3,4]

The student answered the final part of the question by mentioning the number of MOs that were formed in each case. Moreover, reference was made to the number of electrons occupying the respective lowest and highest occupied MOs, as shown below:

As previously mentioned, carbon monoxide has 10 valence electrons (four from carbon and six from oxygen), where four of the shared electrons are from oxygen and two from carbon.[3] We conclude from this the 4 bonding pairs of electrons and 2 antibonding electrons where 2 electrons from oxygen is present in one bonding orbital with the σ MOs being the highest occupied molecular orbital (HOMO) and the two degenerate π^* orbitals are the lowest unoccupied molecular orbitals (LUMO), which confirms the triple bond of carbon monoxide.[1,2]

An example of weak performance for Q1

As seen in the following excerpt, there was no specific reference made to the atomic orbitals which interacted to form the resulting MO. The student (EDP8) did not draw the Lewis structure, although a fair description of CO molecule was given:

> Carbon monoxide contains one carbon and one oxygen atom, these are bonded together through three covalent bonds. Of these 3 covalent bonds there is one sigma bond, one π-bond and a dative covalent bond. Some orbitals appear to be indistinguishable by displaying both the characters of s and p orbitals. CO has an oxidation state of 2+. The dative bond formed due to the one of the lone pairs on oxygen being used to form a triple bond and this stabilises the dipole moment. The electrons pair from the HUMO are therefore transferred to the bond

Although the student attempts to describe how MOs are formed, no details were provided as in the case of MS3; neither was there a reference to the number of resulting MOs that would form:

> As observed in the figure the carbon orbitals have energy higher than that of oxygen. This is shown by the energy of the 2s orbital of carbon being closer in energy to the 2p of oxygen. Carbon can also be seen with an empty p-orbital that can be hybridised for bonding with the other 2s orbital electrons.

I noticed that those students who did not properly understand the concept, MO theory, avoided making specific references, rather general or broad statements were provided. It was more as if they were trying to be safe, instead of revealing their lack of understanding. The rubric used for assessing Q2 is shown in Table 5.

Table 5: Rubric for assessment of Q2

Q2: A qualitative account of the bonding of CO to a metal centre	% allocated
In both MO diagrams the ten valence electrons occupy $s\sigma$, $s\sigma^*$, σp and 2 $p\pi$ orbitals giving a bond order of (8-2)/2=3, corresponding to the C-O triple bond ($C\equiv O$)	10
Students may mention this in the description of bonding HOMO - Highest Occupied Molecular Orbital LUMO - Lowest Occupied Molecular Orbital In both MO models, the HOMO is a σ, or σ^* orbital *Marks awarded: 5* The LUMO consists of a pair of π* orbitals *Marks awarded: 5* This explains how CO can act as a ligand. The filled σ (or σ^*) HOMO orbital of CO donates a pair of electrons to the metal acting as a Lewis base *Marks awarded: 5* However, an important feature is that the empty π* LUMO orbitals of CO have the correct symmetry to overlap with the d_{xz}, d_{yz} and d_{xy} orbitals on the metal. *Marks awarded: 5*	40

Q2: A qualitative account of the bonding of CO to a metal centre	% allocated
If these orbitals are occupied, as will be the case if the metal is in low oxidation state, the electrons can back-bond to the metal *Marks awarded: 5* Therefore, carbonyl complexes preferentially form with transition metal centres in relatively low oxidation states, since these provide filled *d* orbitals of proper energy to facilitate the back bonding. *Marks awarded: 5* The effect of back bonding is to strengthen the M-CO bond in low oxidation state metal complexes *Marks awarded: 5* The CO ligand is known as a π-acceptor or π-acid In higher oxidation state metals complexes, it will be much weaker, allowing fine-tuning of metal-ligand interactions *Marks awarded: 5*	

Like Q1, those students who correctly understood the task and the science were able to explain the process of bonding of CO to a metal centre in a logical manner. They used specific terms and made direct references to the diagram as relevant; whereas the opposite was observed for those students, who did not. I will continue by describing one excellent and fair example to illustrate how the students answered the question. The term fair is used here because the class generally performed better in this question compared to Q1, so I could not find a report to describe as a poor or weak performance.

An example of excellent performance for Q2

This student (EDP26) was able to provide a detailed explanation by mentioning the orbitals that occupy the HUMO and LUMO, and how the π* LUMO orbitals of CO with the correct symmetry can overlap with the orbital d-orbitals on the metal. Furthermore, reference was made to the oxidation state of the metal and the CO-ligand as a π acceptor (acid) as seen:

Carbon monoxide reacts with many low valent metal ions forming carbonyl complexes with M-CO bonds. It reacts even with metals in their elemental solid state to produce volatile metal carbonyl complexes. According to Romao and co-workers, CO prefers soft Lewis acids. The highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO) shown in figure 1 above, are orbitals that interact with a metal ion or atom to form the above-mentioned M-CO bond. The HOMO of CO, which is of σ^* character, donates its electron pair to an empty metal orbital forming a σ bond. π-donor interaction between the next highest occupied π orbital on the CO with properly oriented empty metal d orbitals. LUMO orbitals of CO have the acceptable symmetry to overlap with filled d-orbitals of the metal, land when their energies match, a bonding interaction is formed in which metals d electrons are back donated to an empty antibonding orbital of CO (pπ*), see figure 2. CO has all the characteristics of a π-acceptor (π acid), and indeed is regarded as one. The M-CO bonding scheme is synergistic, a stronger σ donation increases the electron density at the metal, therefore enhancing the back-donation mentioned earlier. This bonding scheme is favoured for metals in low formal oxidation states with high-energy d electrons.

An example of a fair performance for Q2

This student (MS21) explanation indicates a fair attempt to answer the question:

What makes carbon monoxide bind so strongly to transition metals, and thus makes transition metal complexes the most ideal CO-RMs is the fact that it has multiple ways to overlap with the orbitals of those metals. The highest occupied molecular orbital (HOMO) of CO, which is the higher-energy of the two σ-MOs, can effectively overlap with empty d orbitals, as in the bottom of Figure 2, acting as a σ-donor to form a bond. In addition, the two π-MOs can also donate their π-electrons to empty d orbitals of the metal. This is contrasted by a back-donation of electrons from filled d orbitals of the metal to the LUMOs of CO, namely the two π*-MOs, facilitated by the fact that they can both overlap very effectively. It is the cumulative effect of these three bonding interactions that makes CO have such a high affinity for metal centres.

The results that were obtained after analysing the writing project are shown in the next section.

4.1.2 Presentation and discussion of results

As a way of organizing the results, I decided to follow this sequence to allow for clarity:

- What was the students' performance with respect to Q1 and Q2?
- How did MS and EDP students' performances compare in the writing project?
- What was the performance of the class in the writing project?

I will be considering 25 students for the writing project because 3 students were repeating the course and were exempted from having to complete the task. These 25 students were drawn from the sample of 28 out of the class of 32, who had given informed consent to participate.

I could not use ANOVA to analyse the data because my sample size was small; instead, I used a t-test and reported the effect size (Cohen's d). A t-test is used to determine if there is a signficant difference ($p<0.05$) between the mean of two groups. Cohen's d is a measure of the effect size and is used to indicate the standardized difference between two means (Cohen, 1988; Sun, Pan, & Wang, 2010)**.** Thus "an effect size provides a quantitative measure of the magnitude of the difference between groups or association between variables" (Bakker et al., 2019, p. 2). In this research Cohen's d is a measure of the difference in means of performance in various tests or tasks. The effect size value can be interpreted as small (0.20), medium (0.50) or large (0.80) (Cohen, 1988)

4.1.2.1 Students' performance Q1 and Q2

The average class performance with respect to Q1 was 62% and 79% for Q2 for the class [N = 25]. The difference in the class average shows that the performance was better in Q2 than Q1. A comparison of students' performances in both questions is shown in Figure 10.

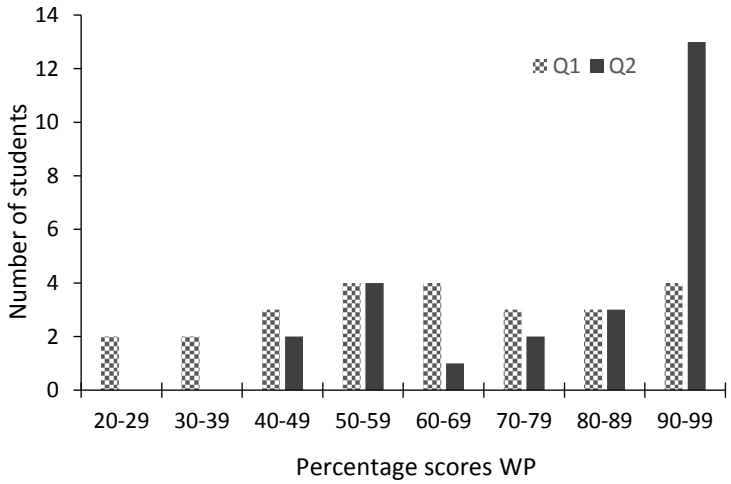
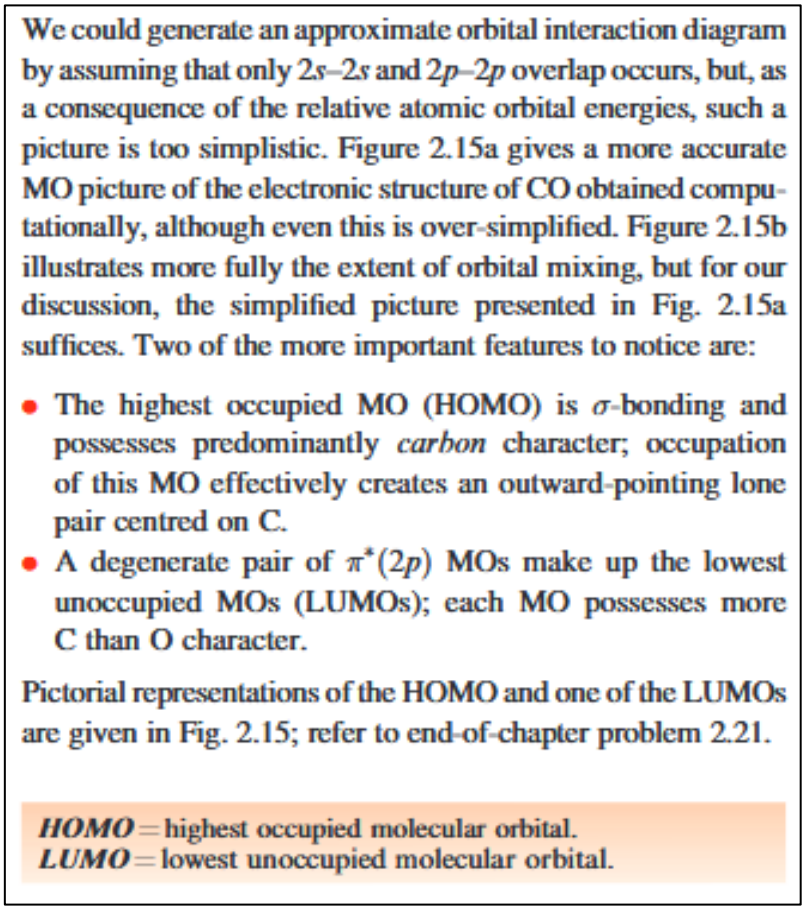


Figure 10: Students' performance in Q1 and Q2 of writing project

It is vital to highlight that Q1 *(A simplified MO diagram for CO without orbital mixing),* was more intellectually demanding than Q2 *(A qualitative account of the bonding of CO to a metal centre; Dewar-Chatt-Duncanson model)*. This is because one needs to understand some basic concepts before an effective explanation can be provided on how the molecular orbitals or MOs are formed. Furthermore, in all the references that students were advised to consult (textbooks, articles) there was no detailed explanation provided for MO diagrams in any of these texts as required for Q1, unlike Q2 where a detailed explanation was provided in the literature. For example, Figure 11 shows an excerpt from one of the textbooks students were advised to consult. A thorough, explanation was not provided for the formation of MO diagram for CO. Thus, it was left to each student to read more carefully and deeply; and then extract information provided in the text, and apply this to the explanation of MO diagram of CO. Stated differently, students were expected to understand how MOs are formed and then apply the knowledge in their explanation.



We could generate an approximate orbital interaction diagram by assuming that only 2*s*–2*s* and 2*p*–2*p* overlap occurs, but, as a consequence of the relative atomic orbital energies, such a picture is too simplistic. Figure 2.15a gives a more accurate MO picture of the electronic structure of CO obtained computationally, although even this is over-simplified. Figure 2.15b illustrates more fully the extent of orbital mixing, but for our discussion, the simplified picture presented in Fig. 2.15a suffices. Two of the more important features to notice are:

- The highest occupied MO (HOMO) is σ-bonding and possesses predominantly *carbon* character; occupation of this MO effectively creates an outward-pointing lone pair centred on C.
- A degenerate pair of $\pi^*(2p)$ MOs make up the lowest unoccupied MOs (LUMOs); each MO possesses more C than O character.

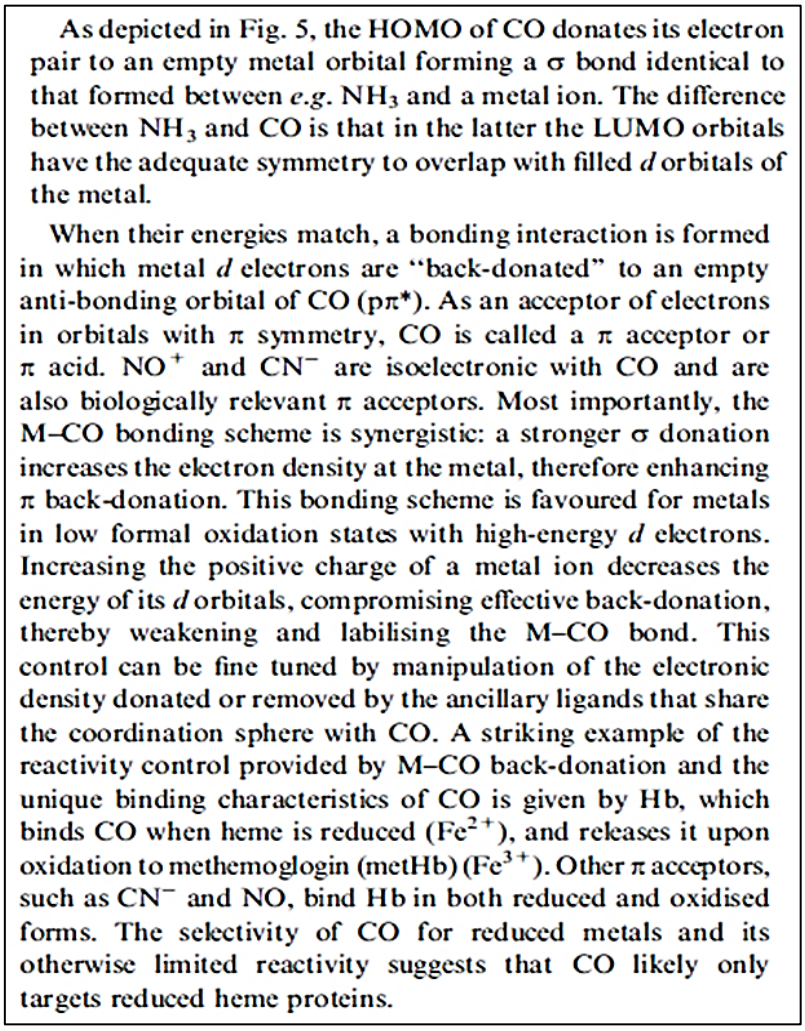
Pictorial representations of the HOMO and one of the LUMOs are given in Fig. 2.15; refer to end-of-chapter problem 2.21.

HOMO = highest occupied molecular orbital.
LUMO = lowest unoccupied molecular orbital.

Figure 11: Excerpt showing an explanation of the formation of MO (Housecroft & Sharpe, 2012, p. 51).

On the other hand, for Q2, there exists a body of articles that clearly explains this concept. Thus, students who were diligent in finding the articles in the literature seemed to have no difficulty in abstracting this information and presenting it in their own words. For example,

Figure 12 below shows an excerpt from an article explaining the back bonding of CO to the metal centre.



As depicted in Fig. 5, the HOMO of CO donates its electron pair to an empty metal orbital forming a σ bond identical to that formed between *e.g.* NH_3 and a metal ion. The difference between NH_3 and CO is that in the latter the LUMO orbitals have the adequate symmetry to overlap with filled *d* orbitals of the metal.

When their energies match, a bonding interaction is formed in which metal *d* electrons are "back-donated" to an empty anti-bonding orbital of CO (pπ*). As an acceptor of electrons in orbitals with π symmetry, CO is called a π acceptor or π acid. NO^+ and CN^- are isoelectronic with CO and are also biologically relevant π acceptors. Most importantly, the M–CO bonding scheme is synergistic: a stronger σ donation increases the electron density at the metal, therefore enhancing π back-donation. This bonding scheme is favoured for metals in low formal oxidation states with high-energy *d* electrons. Increasing the positive charge of a metal ion decreases the energy of its *d* orbitals, compromising effective back-donation, thereby weakening and labilising the M–CO bond. This control can be fine tuned by manipulation of the electronic density donated or removed by the ancillary ligands that share the coordination sphere with CO. A striking example of the reactivity control provided by M–CO back-donation and the unique binding characteristics of CO is given by Hb, which binds CO when heme is reduced (Fe^{2+}), and releases it upon oxidation to methemoglogin (metHb) (Fe^{3+}). Other π acceptors, such as CN^- and NO, bind Hb in both reduced and oxidised forms. The selectivity of CO for reduced metals and its otherwise limited reactivity suggests that CO likely only targets reduced heme proteins.

Figure 12: Excerpt showing explanation of back donation of electrons (Romão et al., 2012, p. 3575)

Students' performance in Q2 reflects their ability to assimilate information from sources provided; and implies that they understand how orbitals overlap to produce stable metal complexes. Having considered the class performance in the questions, I decided to look more closely at how each group, MS and EDP performed.

MS and EDP students' performance in Q1 and Q2

For Q1, the averages for MS and EDP students were 70% (n=12) and 54% (n=13), while it was 86% and 72% for Q2 respectively for the same number of students (Figure 13). A two-tailed t-test that respectively compares MS and EDP students' performance in Q1 and Q2 shows that there was no significant difference: t (25) = 1.8407, p = 0.0798; t (25) = 1.7484, p = 0.0937. A medium effect size as shown, Cohen's d (Q1) = 0. 7584, Q2 = 0.7026, means that the difference in performance may or not be significant in this setting.

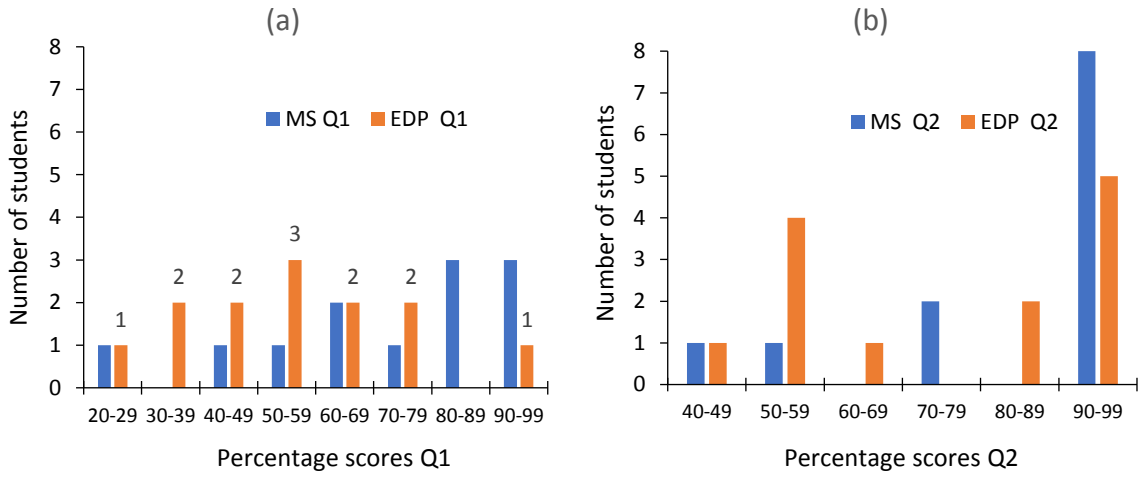


Figure 13: Comparison of MS and EDP students' performance in Q1 (a) and Q2 (b)

As seen from the chart above, there is a smaller spread of marks for Q2 with more students achieving over 90%. Only two students failed to achieve 50% for Q2. The number of students achieving more than 80% for Q2 is almost the same for EDP and MS, which contrasts with the performance for Q1. In the next section, the class performance in the writing project (summation of Q1 and Q2 scores) is reported.

4.1.2.2 Class performance in the writing project

The class average for the writing project (sum of scores Q1 and Q2) was 70% (N=25), and this is represented in Figure 14.

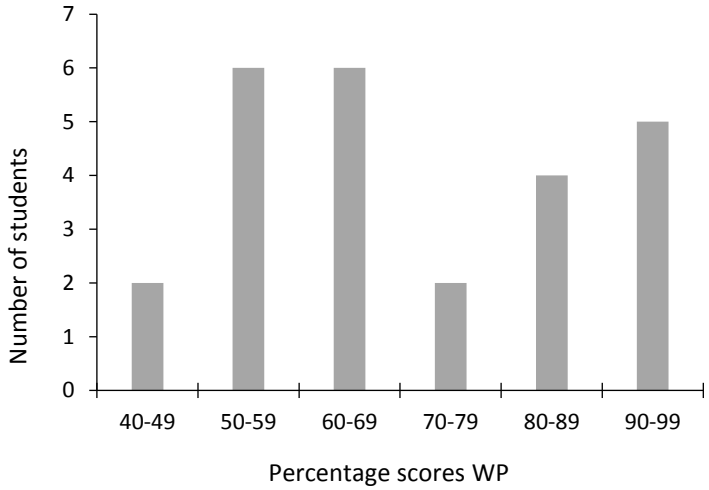


Figure 14: Class performance in writing project

As shown in the chart above, the majority of students performed well with 9 (36%), achieving over 80%. In the next subsection, a comparison of MS and EDP students' performance in the writing project is provided.

4.1.2.3 Comparison of MS and EDP students' performances in the writing project

The class performance for MS and EDP students, respectively in the writing project was 78% (n=12) and 63% (n=13), and a comparison of this performance is illustrated in Figure 15.

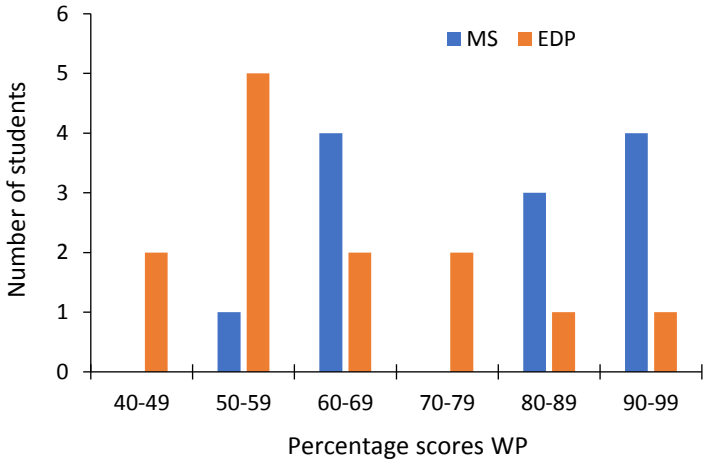


Figure 15: Comparison of MS and EDP students' performance in writing project

There was a difference in the performance of MS and EDP students as indicated by the averages of 78% and 63%, respectively. The chart shows that 7 MS students achieved over 80%, while only 2 EDP students managed to achieve at this level. The majority of EDP students fell into the 50-69% band with 2 of them failing to achieve a passing grade. A two-tailed t-test shows that the difference in performance is significant: t (25) = 2.3779, p = 0.0261 with a strong effect size (Cohen's d = 0.9788), meaning it is significant. In general, MS students performed at a higher level than EDP students. This difference in performance may be associated with the fact that two-thirds of MS students are English First Language speakers most of whom attended private schools. The EDP students are a more diverse group with respect to language and high school attended. The majority of EDP students (84%) have English as an additional language. Almost a third of EDP students attended no-fee paying schools with only 2 students attending a private school. This is in line with findings from a longitudinal study on the writing project by Theka and Davidowitz (2018), which revealed that students who had English as a first language as well as those who attended private schools performed at a higher level than the rest of the cohort.

A summary of the comparison of the students' (EDP and MS) results, as obtained from the analysis of Q1 and Q2 of the writing project is summarized in Table 6.

Table 6: Results for the analysis of the writing project

Group	Average mark Q1			Average mark Q2			Average mark total (Q1 + Q2)		
	%	n	SD	%	n	SD	%	n	SD
Whole group	62	25	22.2	79	25	20.9	71	25	16.8
MS	70	12	23.7	86	12	18.5	78	12	15.7
EDP	54	13	18.5	72	13	21.4	63	13	14.9

Based on the performance of students in the writing project, I decided to probe further by scrutinising their examination papers that included questions on chemical bonding (MO diagrams) to see how they performed as this will help in determining if any meaningful relationship existed between their performances in the examination and the writing project. Hence, students' second-year examination papers, which included questions on chemical bonding were analysed and is described in the next section.

4.2 Examination papers

The examination papers analysed in this study were second-year CEM2005W scripts, which were written in November 2016 and January 2017, respectively. These examinations were written on different dates because some students deferred writing examinations to January 2017 due to student protests late in 2016 (Jansen, 2017). The difference in dates did not present a problem as both examinations included questions on MO diagrams, and the analysis only focused on this aspect. Questions B9 and B7 were assessed from the November 2016 and January 2017 examinations, respectively (Appendix 10). It is useful to note that the questions on MOs in the examination required students to construct MO diagrams, while the writing project required them to explain the diagrams provided.

4.2.1 Method of analysis

There was no need to construct a rubric for the analysis of the examination scripts since the questions were uniformly assessed by the same person. This analysis was cursory because I was only interested in obtaining information on students' performance to compare with the result obtained in the writing project. Hence, students' marks in the section assessed was scaled to 100% to allow for uniformity when compared with the writing project. It is pertinent to highlight that throughout the discussion in this thesis, the second-year examinations only refer to the marks obtained from this analysis, and is henceforth abbreviated as 'Y2 exams.'

4.2.2 Presentation and discussion of results

In reporting the results, I will follow the sequence below to allow for clarity, and discussion will be provided accordingly:

- Class performance in Y2 exams
- Comparison of MS and EDP students' performances in Y2 exams
- Comparison of MS and EDP students' performances in Y2 exams and Q1 (writing project)

4.2.2.1 Presentation of the class performance

As mentioned earlier, this analysis was aimed at recording students' performance in Y2 exams to compare with the writing project. The class average was approximately 49% (N=25), see Figure 16.

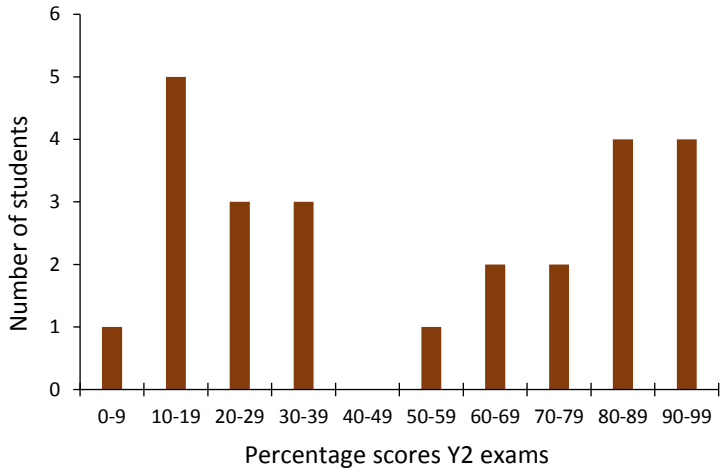


Figure 16: Class performance in Y2 exams on MO (N=25)

As apparent from the figure above, there was a spread of performance as students were represented in all bands except 40-49%. However, 13 students scored above 49%, while 12 students scored below 40. This divides the performance into two broad bands of good and weak performance. In the next subsection, the performance of MS and EDP students in the examination is compared.

4.2.2.2 Comparison of MS and EDP students' performances

Having seen the class performance in the examination, I thought it useful to compare the performance of each group (MS and EDP). The average performance for MS and EDP students respectively were 54% (n=12) and 43% (n=13), shown in Figure 17. A two-tailed t-test shows that the difference in performance is not significant: $t(25) = 0.8042$, $p = 0.4311$. A

medium effect size (Cohen's d = 0. 3293) means that performance may or not be significant in this setting.

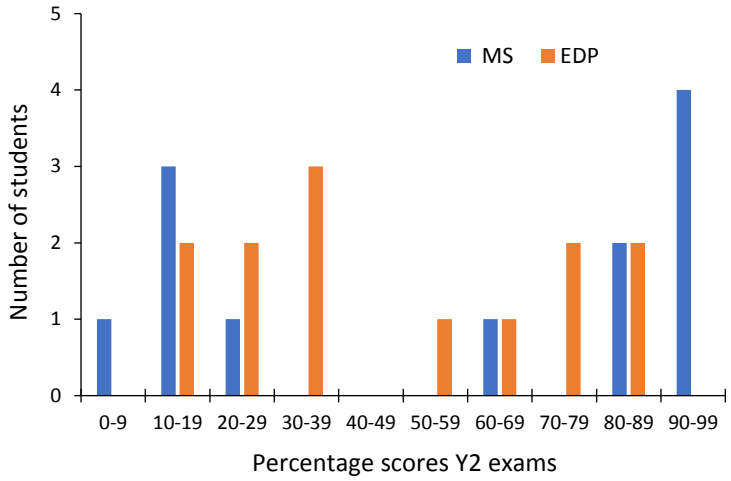


Figure 17: Comparison of MS and EDP students' performance in Y2 exams

As observed from the figure above, 4 MS students were in the 90-99% interval, whereas none of the EDP students had a score in this region. For the 80-89% interval, there was an equal representation of both EDP and MS students. Furthermore, in the 0-9% interval, only one MS student is represented, and it is important to highlight that this student did not answer the question in this section; thus, no score was awarded. There was no information available for the researcher to determine whether the student omitted or ignored the question due to lack of understanding. It is also possible that other factors, such as insufficient time may have played a role.

Moreover, I decided to compare this performance in Y2 exams with marks obtained in Q1 of the writing project. This comparison seemed logical because the examination question was based on MO diagrams, similar to Q1 in the writing project. There was no question on the back bonding of CO to metal centre in the examination as typified in Q2 of the writing project, and this is understandable because this concept was covered in third-year. Hence, I checked for the extent of students' conceptual understanding by comparing their performances in these two exercises (Y2 exams and Q1); illustrated in Figure 18. A two-tailed t-test shows that the difference in performance is not significant: t (25) = 1.6132, p = 0.1141. A medium effect size (Cohen's d = 0. 4657), means that performance may or not be significant in this setting.

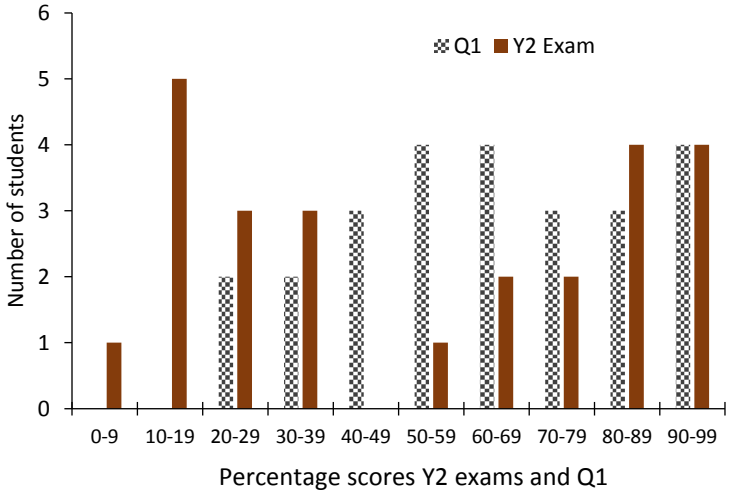


Figure 18: Comparison of class performance in Y2 exams and Q1 (writing project)

Figure 18 shows that no student had a score within the range of 0-19 in the writing project unlike Y2 exams. This performance was not surprising because students had studied for an extra-year, taking cognizance of the time interval. The examination was written at the end of the second year, whereas the writing project was completed in third year. The benefits of having studied for an extra year and gaining a better understanding of concepts is arguably a reason for this trend. Again, the writing project was not done under examination conditions; thus, students were probably more relaxed, and had more opportunities to seek alternative help; inclusive of consulting textbooks, to improve their understanding. Furthermore, it is also likely that they received help from friends, tutors or even lecturers. Moreover, all students were entitled to a consultation session with an expert (consultant) who was meant to assist them to improve the draft, which had to be submitted a few weeks prior to the hand in date. Also, I decided to compare students' individual performances in the two exercises (Y2 exams and Q1) to see if there is a relationship between the two scores. As observed from Figure 19 below, there is no obvious relationship. Those who seemed to perform well in Q1 (writing project) did not do so well in Y2 exams, although there are few instances where the performances were close.

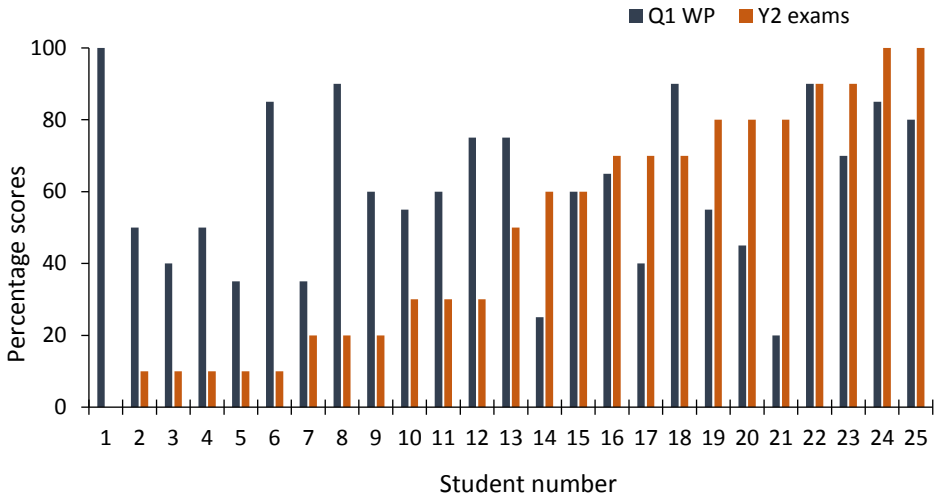


Figure 19: Showing individual performance in Y2 exams and Q1 (writing project)

One may have expected that students who performed well in the second-year examination on MO diagrams would achieve high marks for Q1 in the writing project. This was not the case for about a third of the cohort, as is evident from Figure 19 above. The results were mixed with 9 students achieving a lower mark for Q1, 2 students achieved the same score and the mark for 14 students achieved was higher mark than for Q1. A paired two-tailed t-test shows that the difference in performance is not significant: t (25) = 1.7410, p = 0.0944. A medium effect size (Cohen's d = 0. 4657), means that performance may or not be significant in this setting.

4.2.2.3 MS and EDP students' performance in Y2 exams and Q1 (writing project)

I decided to compare MS and EDP students' performance in Y2 exams and Q1 (writing project) as distinct categories as this may reveal if any meaningful trend exists in the respective performances; the results are shown in Figure 20.

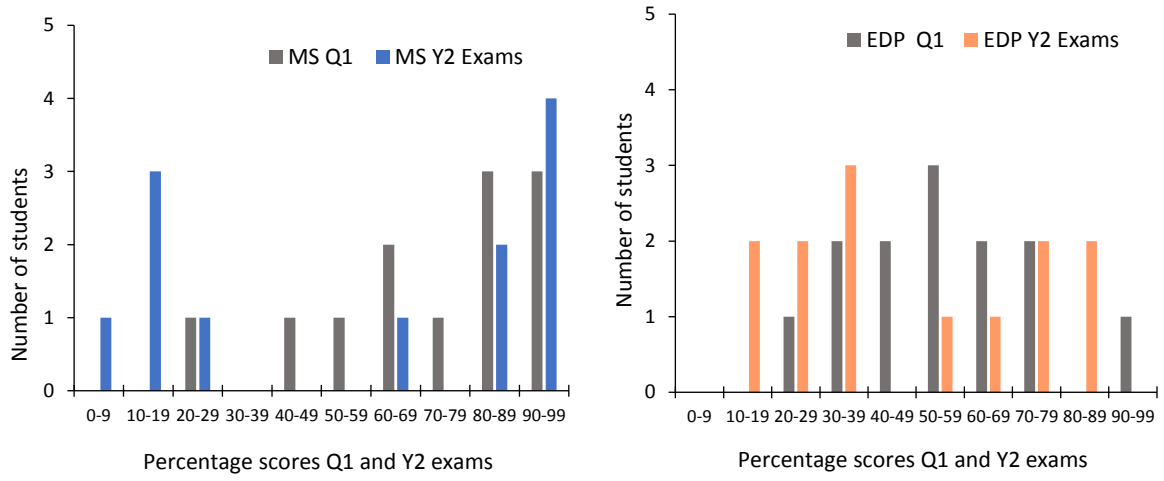


Figure 20: Comparison of MS and EDP students' performance in Y2 exams and Q1

Half of MS students obtained more than 70% for Q1 and second-year exams, as shown in the chart above. Additionally, 3 MS students were in the 10-19% band in Y2 exams, while none of them had a score in this region in Q1. As noted earlier, one MS student had a score in the 0-9 interval in Y2 exams, and as earlier explained, this was because the student did not answer the question.

On the other hand, the performance of EDP students was better in Q1 than Y2 exams as fewer students failed Q1 compared with the Y2 exams. One EDP student achieved above 89% for Q1, while none of them had a score in this region in Y2 exams. Moreover, 7 EDP students did not perform well and achieved below 40% for Y2 exams. The results obtained from the analysis of Y2 exams and Q1 (writing project) are summarized in Table 7. A two-tailed t-test that respectively compares MS and EDP students' performance in Q1 and Y2 exams shows that there was no significant relationship: t (12) = 1.1370, p = 0.2704; t (13) = 1.2086, p = 0.2396. A medium effect size (Cohen's d [MS] = 0. 4981, [EDP] = 0.4915) means that performance may or not be signficant in this setting.

Table 7: Results for Y2 exam and Q1 (writing project).

Group	Average mark second-year exams			Average mark Q1 (writing project)		
	%	n	SD	%	n	SD
Whole group	49	25	32.32	79	25	20.71
MS	54	12	40.55	86	12	23.69
EDP	43	13	26.26	72	13	18.50

As discussed earlier for the overall mark for the writing project, EDP students, on average, performed at a lower level than MS students.

4.3 Academic transcripts

Having looked at students' performances in the exercises described earlier, it seemed logical to examine their performances in previous years, and to compare it with their final year grades. This led to the analysis of the academic transcripts, focused on CEM1, CEM2 and CEM3. In this analysis, I was checking for trends in the overall performance of the class, followed by the performances of both categories of students (MS and EDP) for the duration of their degree. There was no need to look at individual performances as this would make the analysis more complex, rather an effort has been made to present an overview of the students' performances as they progressed through their study. A more focused analysis on individual performances will be reported in the final chapter when typical cases of EDP and MS students are

incorporated to provide an overarching theme for the entire discussion. It is useful to state that some students failed the chemistry course at some stage but passed it on the second attempt. The second attempt score was used in this analysis. An MS student who failed CEM3 did not re-register. For the ease of reporting the grades for the first, second and third academic year or levels are henceforth abbreviated as Y1, Y2 and Y3 respectively.

4.3.1 Method of analysis

An analysis was carried out on students' academic transcripts for the researcher to have an overview of their performance in chemistry from Y1 - Y3. This was intended to check for trends and reveal relative performances of both categories of students.

4.3.2 Presentation and discussion of results

In organizing the results, I followed the sequence below:

- What was the class performance in CEM1, CEM2 and CEM3?
- How did the performances of MS and EDP students compare in each of the courses?

4.3.2.1 Presentation of the class performance in CEM1, CEM2 and CEM3

The final class grades for CEM1, CEM2 and CEM3 courses were 73% (N=28), 60% (N=28) and 62% (N=28), respectively. Figure 21 shows the result and indicates a gradual decline in performances over the years. This may reflect the increasing complexity and cognitive demand of the courses.

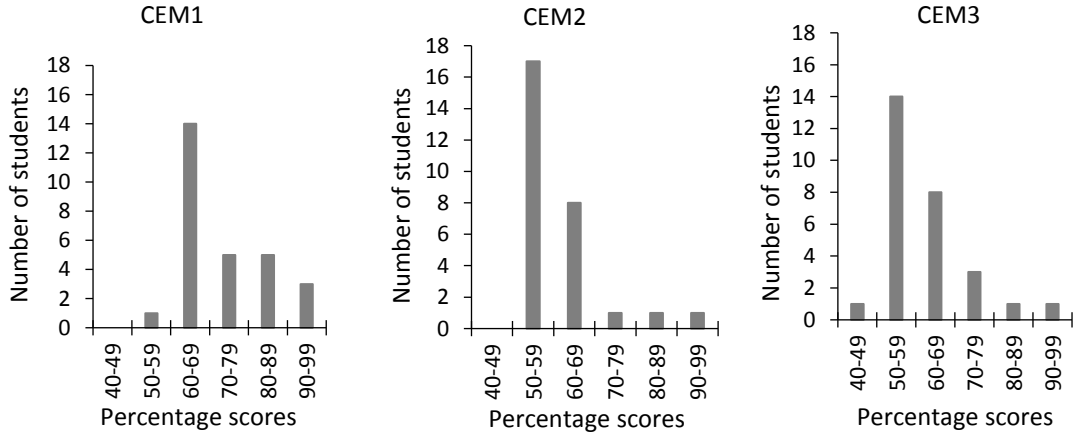


Figure 21: Class performance in CEM1, CEM2, and CEM3 (N=28)

As seen from Figure 21 above, there were more students in the 50-59% band in Y2 compared to Y1; and by the Y3, there is a student within the 40-49% region. This is not surprising because the curriculum is designed to increase in complexity and cognitive demand as students' progress, and may account for the gradual decline in performance as found in other studies (Freedman, 1956; Schreiner & Pattengale, 2000; Tobolowsky & Cox, 2007).

Freedman (1956) referred to the decrease in academic performance as students' transition from first-year to second-year as the sophomore slump. This slump, according to the same author, is associated with a feeling of inertia, and confusion caused by a lack of clarification with reasons for attending university, and choosing majors.

Still referring to Figure 21, in Y1, 3 students achieved above 89%, while in subsequent years there was only one student who achieved this grade. Looking at the same figure in terms of top-performing students, in Y1 there are 7 students who achieved 80% or more, by Y2 there were only 2 students in this band.

4.3.2.2 MS and EDP students' performance in CEM1, CEM2, and CEM3

The performance for MS and EDP students in CEM1, CEM2, and CEM3 is compared below.

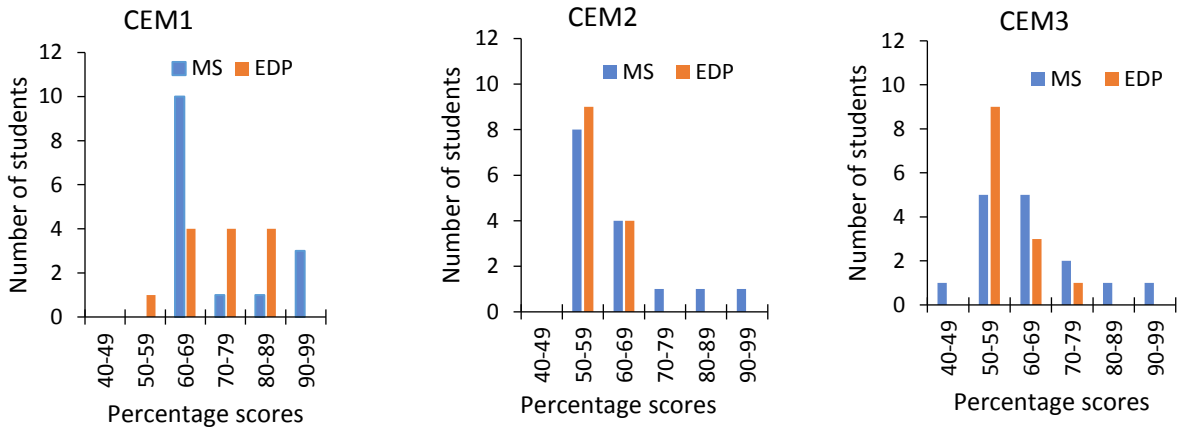


Figure 22: MS and EDP students' performance in CEM1, CEM2 and CEM3 (N=28)

The performance for these students was similar in Y1 but changed as they progressed (Figure 22 and Table 8). Stated differently, the performances for the two groups were similar for Y1. There is a decrease in performance for Y2, greater in the case of EDP students. There is a marginal improvement for EDP students from Y2 to Y3 where there is now a student in the 70-79% band. Taking the Standard Deviations (SD)s into account, the two groups are performing at a similar level overall, the difference being the two high performers in MS.

Table 8: Students' performances in CEM1, CEM2, and CEM3

Group	Average mark for CEM1			Average mark for CEM2			Average mark for CEM3		
	%	n	SD	%	n	SD	%	n	SD
Whole group	73	28	10.22	60	28	10.45	62	28	10.62
MS	73	15	11.99	62	15	13.54	65	15	12.41
EDP	73	13	8.20	58	13	4.37	58	13	7.04

4.4 National Benchmark Tests and National Senior Certificate examination

After analyses of the academic transcripts, I decided to look at students' performance in the entrance exams into university, to have an idea of their academic performance before entering university. This led to the analysis of the scores from their NBT and NSC; the latter is also referred to as the Grade 12 result. The Grade 12 result is currently the only general measurement of the academic ability of first-time entering students in South Africa. In the study by Lourens and Smit (2003), which was conducted at Pretoria Technikon (a university of technology in South Africa), the authors mentioned that Grade 12 aggregates play an important role in terms of students' first-year success. The analysis of NBT and NSC scores allowed me to gain a complete picture of the students' academic profile from registration to final year. One of the difficulties encountered while analysing NBT and NSC scores was the issue of missing data. Some of the students were international students; thus, there is no NSC score available. Also, few students failed to write NBT.

4.4.1 Method of analysis

I did a quick analysis with respect to students' NBT and NSC results to have an overview of their academic profile prior to registration. Nonetheless, it is helpful to highlight that for the NSC analysis, only students' scores in English, Mathematics and Physical Science were used, as these were the subjects most relevant for admission into Science Faculty. Given that Maths is known to be a predictor of performance in chemistry at tertiary level (Potgieter, Davidowitz, & Mathabatha, 2008), I decided to use NBT maths score for the students in this study. As it is not possible to obtain the mark for the chemistry component of the physical science examination for matric, NBT maths score could be a proxy for their chemistry score on entry to university. Linear regression analysis for NBT maths score against the final score for CEM300W showed the model was significant with $F(1,21) = 31.258$, $p < .001$ and explained about 60% of the variability in the model (the adjusted R^2 value was 0.579). The regression co-efficient suggests a positive association between CEM3005W and NBT maths, where a one-unit increase in NBT maths score is associated with an increase of 0.520 in CEM3005W score. With respect to the assessment of model fit:

- inspection of a histogram and Normal P-P plot of the regression standardised residuals showed some deviation from normality, which was not too serious; the plot still showed some symmetry;
- inspection of a scatterplot of the standardised residuals against the standardised predicted values to evaluate the assumption of constant variance showed no particular pattern in the cloud of points; one case had a residual smaller than -2.

The findings from the regression analysis are in line with Potgieter et al. (2008) thus it is valid to use NBT scores as a proxy for the Grade 12 chemistry score on entry to university. It is important to note that henceforth, whenever NBT is mentioned it refers only to NBT maths score.

4.4.2 Presentation and discussion of results

The following sequence is followed to allow for clarity:

- What was the overall class performance?
- Comparison of MS and EDP students' performances?

4.4.2.1 Presentation of the class performance in NBT

The average performance for the class in NBT was 62% (N=24), see Figure 23.

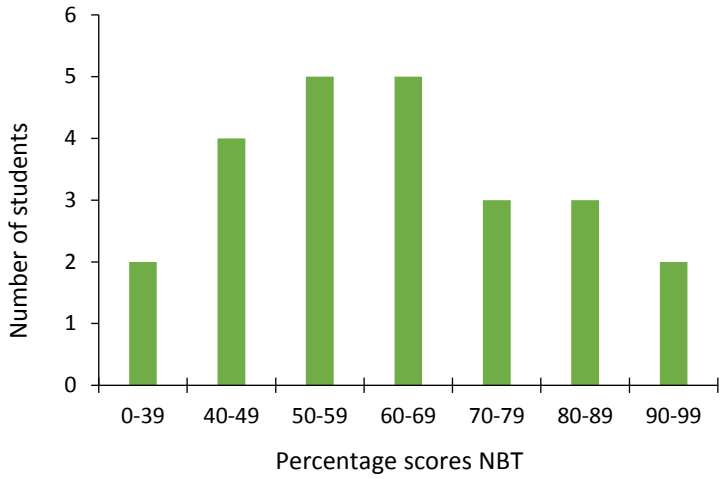


Figure 23: Chart showing class performance in NBT (N=24)

As seen in the chart above, there is a spread of scores, with 75% of students achieving above 50%. Only two 2 students were in the 0-39% band.

4.4.2.2 Comparison of MS and EDP students' performances in NBT

The average performance for MS and EDP students, respectively in NBT were 69% (n=13) and 55% (n=11); a comparison of the performances is illustrated, Figure 24.

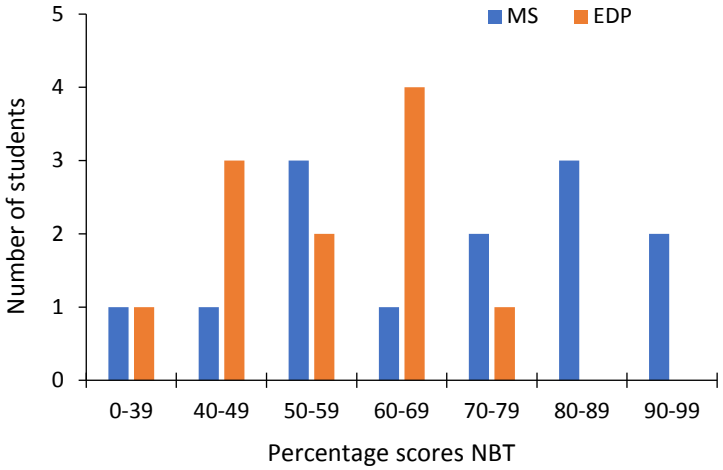


Figure 24: Comparison of MS and EDP students' performance in NBT (N=24)

As seen from the chart above, only MS students are found in the region above 79%. It is obvious that EDP students on the whole performed at a lower level than MS students. A two-tailed t-test: t (24) = 2.2361, p = 0.0375 and a large effect size (Cohen's d = 0.9504), shows that the difference in performance is significant in this setting.

4.4.2.3 Presentation of the class performance in NSC

The class average for NSC was 80% (N=21), and the result is shown in Figure 25. It is useful to reiterate that this average only captures performance in English, Maths and Physical Science.

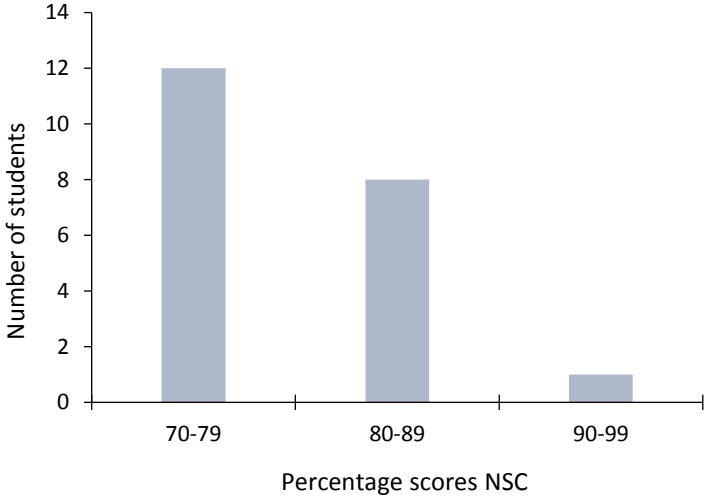


Figure 25: Class performance in NSC (N=21)

An average of 80% for 21 students indicates that the performance was good. Furthermore, none of the students had a score below 70%, which reflects the standard required for admission into the Faculty of Science at UCT. In Chapter 3 I noted that students are required to attain at least 70% for mathematics and 60% for physical science to gain entrance to the

Science Faculty. The NSC scores reported above are an average of the marks for mathematics, physical science and English. A more nuanced picture emerges when comparing the performance of the students in this study with the results reported for performance in two key NSC subjects, namely mathematics and physical science. The percentage of students achieving over 70% for maths was 15.4% in 2014 and 6.6% in 2015. For physical science, the percentage of students achieving over 60% was 13.1% in 2014 and 12.8% in 2015 (Department of Basic Education, 2019). Thus, the cohort of students in the current study were among the top achievers in mathematics and physical science in the year in which they wrote the NSC.

4.4.2.4 Comparison of MS and EDP students' performances in NSC

The average performance in NSC for MS and EDP students respectively were 81% (n=12) and 78% (n=9), and a comparison of the performance is shown (Figure 26)

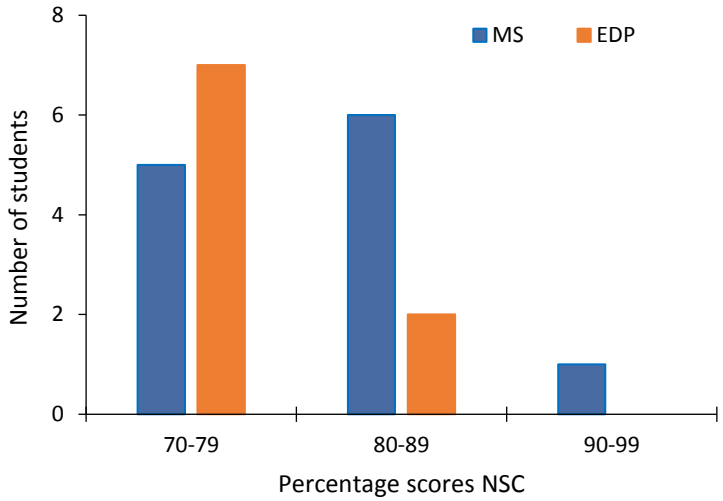


Figure 26: Comparison of MS and EDP students' NSC results (N=21)

As seen from the chart above the majority of EDP students were in the 70-79% class interval, whereas most MS students had a score in the 80-89% band. However, the relative performance for both category of students is close. None of EDP students had a score in the 90-99% interval, a grade achieved by one MS student. A two-tailed t-test shows that the difference in performance is not significant: t (22) = -0.4945, p = 0.6283. The small effect size (Cohen's d = 0.200), shows that the difference in means may not be significant in the same setting.

4.4.2.5 Comparison of MS and EDP students' performances in NBT and NSC

After analysing NBT and NSC, I decided to compare those students whose results were available for both groups to see if any relationship exists (Figure 27)

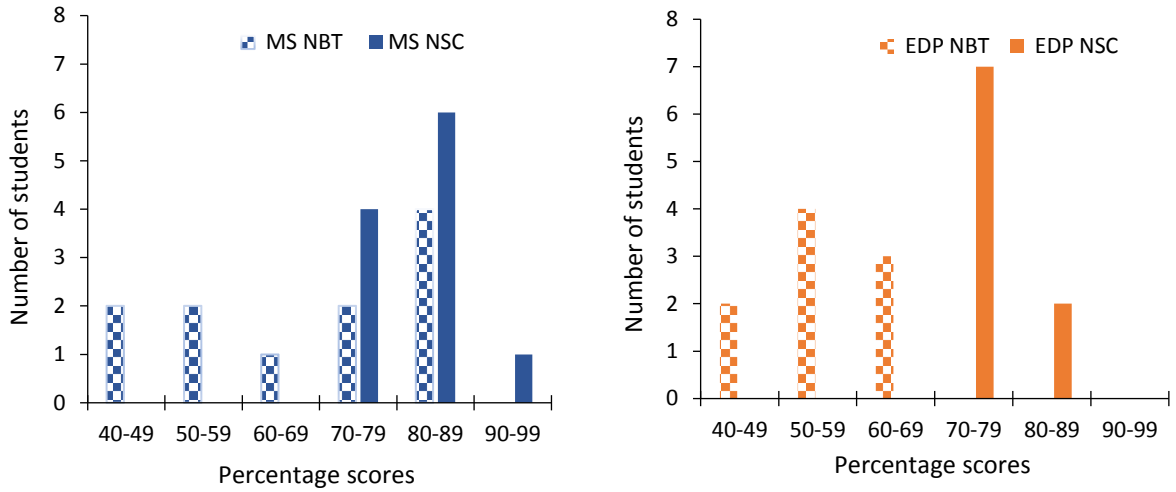


Figure 27: Comparison of MS and EDP students' performance in NBT and NSC (N=20)

For MS students, the performance was better in NSC compared with NBT. As seen in the chart, none of the mainstream students had a score below 70 in their NSC examination, whereas 5 students had a score that is below 70 in NBT examination. More specifically, two students had a score in the 40-49% interval.

On the other hand, for EDP students, the performance in the two examinations is split into two bands. With respect to NSC, none of them had a score below 70 like MS students, while for NBT, none of EDP students had a score above 69%. The results are summarized in Table 9. A two-tailed t-test that respectively compares MS and EDP students' performance in NBT and NSC shows that there was a significant difference: t (11) = -2.4498, p = 0.0306; t (9) = -6.6158, p = 3.7817E-05 a Cohen's d (MS) = 1.1516, (EDP) = 3.4441.

Table 9: Results for NBT and NSC

Group	Average mark for NBT			Average mark for NSC		
	%	n	SD	%	n	SD
Whole group	62	24	13.93	80	21	4.77
MS	69	13	18.83	81	12	5.12
EDP	55	11	10.63	78	9	3.47

I have taken time to analyse the documents relating to students conceptual understanding and academic performances prior, and during their study at the university. In the next section, I have attempted to compare students' performances across different measures to see if any meaningful relationship could be established.

4.5 Overall comparison of scores for NBT, CEM1-3 and writing project

In this section, I have attempted to bring together all aspects of the analysis done so far in this chapter, to see how students' performances compare relative to each other. Before proceeding to discuss the results, it is useful to highlight some of the decisions that were made that helped me to choose the particular constructs to include in this final comparison. These decisions are listed:

- A decision was made to include the writing project scores even though these are already incorporated in CEM3 final marks because this was the central point of the analysis in this chapter. I wanted to see if the performance in the writing project, could be compared with any of their performances in chemistry in Y1, Y2 or Y3.
- I decided not to include the Y2 exam score since these are already incorporated in CEM2 marks. Besides, I only considered a small aspect of the exam, which accounts for a very small percentage of the total marks.
- With respect to NSC, I also decided not to include this construct in this final comparison because the relative performance for both groups as earlier noted was very good with an average of 80%. Hence, I felt it would not be most suitable in terms of trying to identify differences in performances between the two groups.
- Concerning the National Benchmark Test or NBT, this construct was chosen because it revealed significant differences between the two groups. Also, since the test was written before registration, it helped me to determine their academic level before university.
- The data from the students' transcripts, which details their CEM1-3 scores was also included in the analysis, because this helped me to see their academic progression from Y1 – Y3.

Based on the information above, I decided to compare students' NBT, CEM1, CEM2, CEM3 and writing project (for 23 students for whom there was a complete data set, see Figure 28). Normalization of the results was done using a method similar to that reported in the literature (Cendán, Joledo, Soborowicz, Marchand, & Selim, 2018). In line with Cendan et al.'s study, the class average was subtracted from students' actual scores, and it is these values that were used in plotting the chart. Students above the zero-mark achieved above the class average (horizontal axis), while the converse holds for those below the zero-mark.

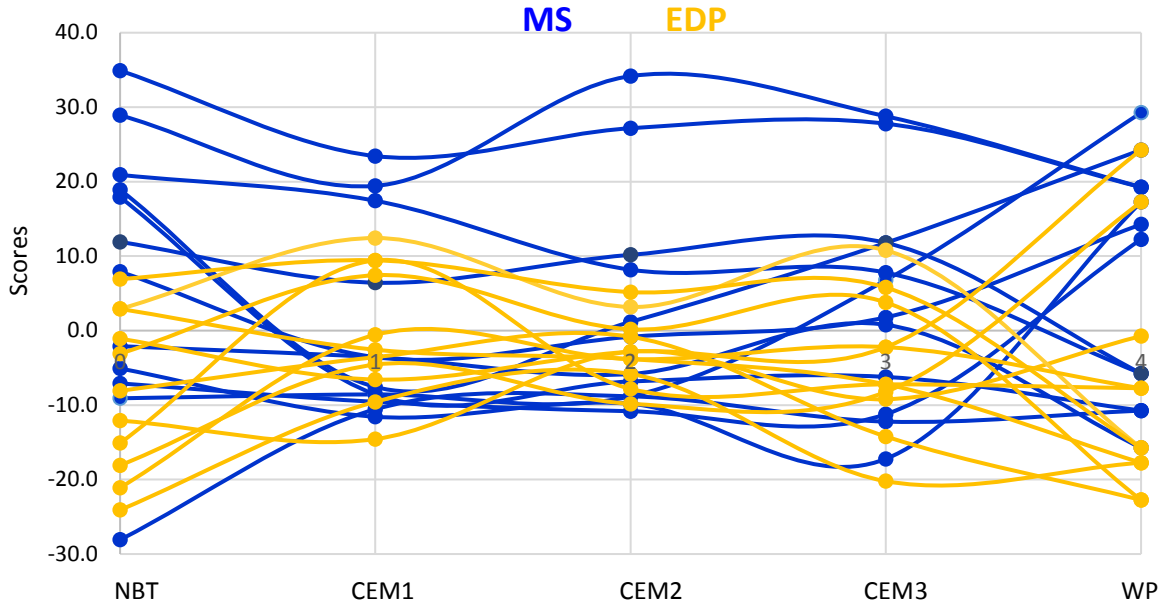


Figure 28: MS and EDP students' performance in NBT, CEM1, CEM2, CEM3, and writing project (n=23)

The following observations were made with respect to MS and EDP students, as depicted in Figure 28. There is considerable overlap between the performance of two groups of students with two top-performing students from the MS group who clearly distinguish themselves from the rest of the cohort. The majority of EDP students started their tertiary studies with lower NBT scores than MS students. The performance of EDP students seems to show a more clearly defined wave-like pattern moving from NBT, CEM1, CEM2, CEM3 and the writing project. The wave arises because of the dip in performance in CEM2. The reason for the wave-like pattern will be explained later when considering the qualitative data (section 6.2), where I describe the transition experiences of the students. As will be seen in Chapter 6, the majority of EDP students experienced difficulty on transitioning into CEM2. The extent of overlap in performance of the students in MS and EDP shown in Figure 28 provides empirical evidence that for this cohort, the extended programme is fulfilling its intention of addressing issues of equity and opportunity in higher education.

In Figure 29 below I compare the performance of 6 selected students.

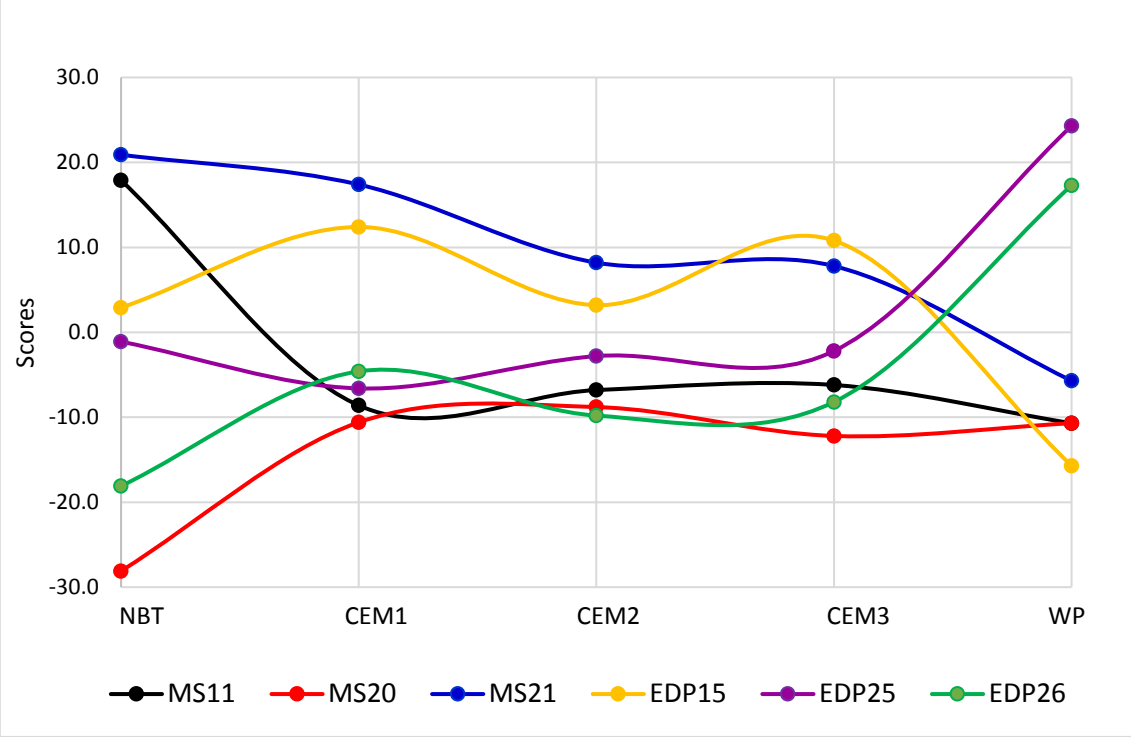


Figure 29: Selected MS and EDP students' performance (n=6)

As seen in Figure 29, MS11 started with a good NBT score but performance in Y1 showed a marked decrease relative to other students. The performance of this student seemed to reach a steady state throughout the degree. MS20 improved from having a very low NBT score to achieving a higher CEM1 score and maintained this level of achievement for Y2 and Y3. MS21 began with a good NBT mark, and achieved a good grade in CEM1, but his performance declined in Y2 after which it remained constant. The performance of EDP15 typifies the wave-like pattern described above with a decrease in performance from Y1 to Y2 and an increase in performance from Y2 to Y3. EDP25 and EDP26 were among those students who performed well in the writing project task, although they were not among the top-performers in the class. This may highlight the significant role that help from others (friends, lecturers, consultants) may have played in achieving higher than average scores for the writing project.

4.6 Discussion

The data collected for the writing project and examination quesitons measured accuracy of students' responses relative to the scientific canon. An important reason why there was a better performance for Q2 compared to Q1, was that there was no detailed explanation provided for MO diagram for CO in all the texts that students were advised to consult, unlike Q2. Comparing the performances of EDP and MS students in the writing project showed that

there is a clear trend that MS students perform better than EDP students. The writing project was designed to allow students to gain the skills required for writing in the discipline, while at the same time engaging with concepts in chemistry. My analysis focused on a small aspect of the writing project with questions on chemical bonding as such; it was not necessarily a good measure of students' conceptual understanding of chemistry.

Analysis of the second-year examination (Y2 exams) and Q1 (writing project) showed that generally, students performed better in Q1 than Y2 exams. Additionally, students' performances in these two exercises showed that there was no relationship between the two scores. It is helpful to remember that the question in the examination required students to construct MO diagrams, while the writing project required them to explain the diagrams provided. I argue that explaining the diagram is a more challenging task, as the drawing of MO diagrams is more algorithmic, i.e. the student follows a sequence of steps. If students do not understand the bonding in CO, they will not be able to explain MO diagrams. Despite the more challenging nature of the Q1 (writing project), students performed better than in the writing project, see Table 7, and I argue that the fact that students were all allowed to speak to a consultant to improve their original work played a role. Moreover, the writing project was not done under examination conditions, unlike the second-year examination; and the benefits of having studied for an extra year and gaining a better understanding of concepts could be a reason why they performed better.

In terms of the transcript, which captures CEM1-3 scores, the results earlier reported showed that the two groups seem to be performing at a similar level overall. The difference being the two top-performing students in MS**.** Also, NSC results showed that the class average for both groups was good and close, which was to be expected based on entrance requirements. For NBT, EDP students performed at a lower level compared to MS. An interesting finding that emerged, however, is the positive correlation between students' NBT and CEM3 scores.

The final analysis, which compared the students' performance for NBT, CEM1-3, and writing project showed that MS students' profile follows a similar trend to that of EDP students. Notable differences are lower NBT scores for EDP students, Y2 marks in a very close range for EDP students and Y3 marks in a similar range for both MS and EDP students except for the two top-performing MS students.

So how do these findings align with the theoretical framework? The SCCT model proposes that good academic performance will result in repeated behaviour; which in this case is persistence in chemistry. However, as seen from the analysis of the documents, for the majority of students there was no positive relationship between their performances from Y1 - Y3, which should have resulted in sustained behaviour (persistence). Their persistence may

have been associated with factors, other than good academic performance, which the qualitative data summarized in subsequent chapters uncover. The qualitative data revealed the strong role that personal goals and outcome expectations played in sustained behaviour, and agreed with Bandura's (1986) SCT model.

4.7 Chapter concluding statements

This chapter showed a comprehensive analysis of documents relating to students' conceptual understanding of chemical bonding, and their academic performance as they progressed through university. Comparison of performances of EDP and MS students on all the different measures, writing project, CEM1-3 and NBT indicates that MS students perform better than EDP students. Nonetheless, given the small sample and the large standard deviations, there is no established significant difference between the cohorts. An interesting finding that emerged, however, is the positive correlation between students' NBT and CEM3 scores.

Students' academic performance is not the only measure of success. Performance can be affected by other aspects such as career aspiration, self-efficacy, and affective factors, which can be captured by learning about their experiences. I have taken the time to uncover the differences between EDP and MS students using the data from the different constructs measured in this chapter (which essentially captures their marks). It will be interesting to see if the qualitative data collected, which captures their experiences, will help to explain the differences in performances noted for both groups; which it does. This will be carefully unpacked in Chapters 5 and 6.

Chapter 5: Career aspiration and self-efficacy

The chapter introduces the reader to the first of four main themes that inductively emerged from the analysis of students' narratives, in which the actions and experiences of the students as it relates to chemistry are reported. Each of these themes is fully described in Chapters 5 and 6. It is pertinent to highlight that the analysis reported in the thesis draws mostly from the interview data. References will be drawn from applicable sections of the questionnaire to support the discussion when necessary; at that point, it will be indicated. I have also used alphanumeric characters such as EDP1 to anonymise the identity of participants. This chapter outlines the findings as it relates to students' career aspiration and self-efficacy.

Literature has shown that students' career aspiration is closely associated with their choice of study programme. Hence the description that follows in the next section also captures information on students' choice of study programme. The study programme decision was revealed while students were describing their journey into chemistry. It is helpful to remember that career aspiration has been defined in this thesis as the students' desired career path. Moreover, I do not intend to classify the findings based on gender and race; however, there are instances during the discussion where I refer to these aspects to make some points explicit.

5.1 Presentation of findings

Students perceive the value and features of a study programme in different ways. This perception must be captured to assist universities in improving their study programmes by engaging in more effective processes and strategies. In several cases, the findings reported in Chapters 5-6 were based on spontaneous responses from students and were not as a result of the line of inquiry in my interview protocol. As noted in section 3.2.3 my interview questions were semi-structured and participants referred to these aspects on their own. In recognition of the above, the findings in the study will be discussed under four overarching themes:

1. Journey: How I came to be doing a chemistry course
2. Self-efficacy: How I saw myself
3. Experiences: My varsity education and how I survived
4. Support system: What helped me to remain in my studies.

The discussion will begin by first considering what participants said collectively, before making specific references to EDP and MS students as it becomes necessary. For the sake of clarity, the words students, participants, and interviewees will be used interchangeably at different

times as it refers to the sample population. The same applies to lecturers and teachers because students used these words interchangeably during their conversations.

5.2 Journey: How I came to be doing a chemistry course

To effectively narrate participants' stories and provide a detailed explanation of the issues that emerged from the analysis, findings relating to students' journeys into chemistry are grouped under four broad categories. These include interest, career aspiration, second-choice, and job options, and each of these will be discussed in subsequent pages.

5.2.1 Interest

Students mentioned that they opted for chemistry because of their interest in the subject, as seen in a typical quote: *"Ok, so in high school, I really liked chemistry" (EDP13).* One of them (MS9), said his decision to study chemistry was made in high school (grade 10). Other, disciplines like medicine, engineering were not considered, because of his interest in the subject: "*Yes, I signed up for BSc. So, it was always BSc Chem. […] It is a tough course, but it is one of the subjects that I enjoy*". Still on the subject of 'Interest' other participants indicated that they developed an interest in chemistry from high school, but then it was not strong enough for them to pursue pure (research-based) chemistry. For instance, MS11 indicated that he developed an interest in fragrance chemistry (production of perfumes), from high school. After researching the admission requirements, he discovered that a chemistry degree was needed. This discovery motivated his enrolment; however, he mentioned that his passion has always been in fragrance chemistry:

> So, I do love chemistry, but not enough to go into pure chemistry. My passion is with perfumes basically. I wanted to study fragrance chemistry in my postgrad, so I had to do an undergrad in chemistry to get to a postgrad in fragrance chemistry. So that's basically the plan […]. But I have always been doing chemistry with the idea in my mind that, I am going to do something that I love with this afterwards. So that helps (MS11).

Interestingly, EDP1 indicated that she developed interest and became passionate about nanotechnology in high school. She had an encounter with a teacher's nephew who was studying nanotechnology, where he explained the strides nanotechnology was making in medical science. Based on this interaction and her growing fascination with the topic, she began gathering more information:

> […] and he described the ways nanotechnology could be used in several ways. Specifically, how it can be used in open heart surgery, cholesterol removal operation. So, he spoke about the research, and I was extremely fascinated […] Then I also started making more research about it. And the more I found out about the applications, I became more interested […]. At the

> moment at home I have a folder that contains information about nanotechnology. It contains snips of magazines I have collected over the years (EDP1).

Subsequently, in grade 11, she found out that the University of Western Cape (UWC) had initiated a nanotechnology programme. After contacting the course convener who extended an invitation, she was allowed to job-shadow and talk with the people working in the nanotechnology laboratory. During the visit, she was told that to do nanoscience, she needed a chemistry degree as described:

> Then they also told me that I need a chemistry Hons degree to get into nanoscience. So that was the only way I could see I could see to do nanoscience in the country. So, cos I needed a chemistry honours to do nanoscience that's why I decided to do a BSc in chemistry (EDP1)

Additionally, the statement below describes her persistence despite her poor grades in the course, which is because of her strong affinity to what she wants to do afterwards:

> […] So, in chemistry I always felt like my marks didn't go according to my passion. Everyone else will look at my marks and say, "why are you still studying this? You are obviously not good in it". This is because my marks were really bad (EDP1).

Extra-curricular experience and role models

Some interviewees referenced extra-curricular experiences such as a visit to a research laboratory, science expedition or job shadowing on the decision to pursue a science degree. Their participation in these events aroused their interest in science and informed their decision. For instance, EDP1 interest in nanotechnology described earlier, motivated her involvement in a science debate competition on nanotechnology, which was organised by the South African Agency for Science and Technology Advancement (SAASTA): *"So I did the debate. I loved nanotechnology, so they choose me to speak".* This aroused her interest further, and she had the privilege to speak with one of the judges, who later invited her to visit his nanotechnology laboratory at iThemba Labs in Cape Town.

Additionally, the influence of extra-curricular experience in the subject area on students' decision to pursue a tertiary programme is also recognized in the case of MS11. He mentioned that he started developing a passion for fragrance chemistry during his visits to his mother's office, who worked as a landscape architect. He was exposed to the nature of work done in the office during the internship: *"I used to go there, and from there I got very interested in it […] And I also did some job shadowing and internship there, so that's when I began to pick up interest in it".* Another participant (MS2) who initially wanted to study medicine, mentioned that she became interested in pursuing postgraduate study in drug development during a science expedition:

> We went on a science expedition, and KXXX was one of the speakers […] and he spoke to us and he told us a bit about what his Lab is doing "And I was like WOW! that's a different take on chemistry […] you are not physically helping people but you are in a way, indirectly helping them, I think it makes a bigger impact because doctors are there to give the medicine, and we are there to make it.

Interactions with role models, and advice from experts also aroused students' interest in choosing their study programme as shown in the following quotes: "*It was actually one of my teachers who was very good, that spotted my interest and encouraged me […] one of teacher encouraged me to do chemistry in high school" (MS9)* and *"I think mostly the Lab work. So, I was the Lab assistant, and I would help the Lab teacher in prepares (helped in preparing the Lab reagents) […]. Ever since then I just really loved working in a Lab" (EDP13).*

Additionally, the role played by a teacher in arousing a student interest is reported: "*but the one that was teaching chemistry, she made sure that we understood the topics. Even the way she taught it was good. She was the one of the people that made me to love chemistry" (EDP14).*

Academic abilities

I found that some students chose chemistry based on their prior achievement level in the subject in high school as illustrated: "*I was good at chemistry in high school, I choose chemistry" (MS16)*. Chemistry was a component in physical science, which was studied in high school. Also, because they performed well in the subject, this informed their decision, when they were not accepted for their initial preference. A student used his achievement in physical science in high school as a criterion; when he could not continue with his engineering dream (EDP18). This idea of students using their high school achievement in a subject to select a tertiary programme caused him to be trapped because he could not meet the demands of Y1 chemistry course. This difficulty in meeting the academic demands eventually led to his moving into the extended programme, and he described university chemistry as 'crazy':

> But I came to find out that chemistry at high school level and university level is totally different [...] Chemistry at University level is crazy (deep breath) […] So, in first year I struggled to keep up with the course work in chemistry. And so, I decided to decant it, as that will make it a bit easier to pass (EDP18).

Still on the conversation of students becoming trapped in a study programme because of a wide gap (mismatch) between their high school experience of the subject matter and university, is the case of MS7, who failed to gain admission into medicine. She explained, "*I enjoyed chemistry, and I thought it was quite easy, so I thought 'ok I will stick with chemistry'*.

However, having studied chemistry to Y3 level, she expressed significant displeasure and had regrets about her enrolment. Like EDP18, she realised that university chemistry was *"very different from what I originally thought it would be".* Nevertheless, despite the difficulty, she continued for reasons best described in her own words:

> But then 2nd-year chemistry was very different especially because of all the thermo stuff. And so, I had to struggle with that. And by the end of second year, I didn't want to take another year to choose a different major so I just continued with chemistry. Since I had already done it in my second year, I thought to myself 'I may as well just do one more year'. And then yeah [deep breath], this has been the hardest year of my life [pause] And now I am doing 3rd year chemistry, which I don't enjoy (MS7).

She remarked, "*it is possible to do well in high school and not do so well in University" (MS7)* since the two systems are completely different. In addition, EDP15 explained that before her first year in university, she had an interest in engineering, but applied for medicine because: "*[…] my parents encouraged me to do medicine"*. However, she was not accepted and then decided to study chemistry because of her high school performance in the subject was good. However, she emphasized that although she was already enrolled in chemistry, her interest in the course per se started developing as she continued studying:

> And because I was good at maths, I was good at chemistry in high school, I choose chemistry. But still at that point I had not decided that I wanted to do chemistry […] This is because as the years went by and I continued to study chemistry, I realised I really love chemistry. I see myself in love with this field (EDP15).

The case above represented a typical example of some students, whose response to the questionnaire indicated that they enjoyed studying chemistry in high school, which was why they chose it. However, during interviews with this same set of students, I came to realise that they actually started enjoying the course and had a better disposition towards the discipline at the end of Y1. Many factors could be responsible for this occurrence; however, it could be argued that these students were not well informed. For clarity, it is pertinent to note that it was possible to trace participants' questionnaire responses because of the background information that was collected.

5.2.2 Career aspiration

Some students' movement into chemistry was influenced by either their career aspiration for chemistry itself or looking forward to what they wanted to do with the degree in the future. To better capture the students' responses, and provide a detailed description, I have decided to proceed by first considering the career aspiration of the students collectively, before streamlining it to those who chose chemistry as a first-choice. It is important to note that I

based this analysis on their initial self-reported career preferences. As will be seen later, there was a significant record of career diversion, but reporting in this thesis only focused on their initial desired career.

Indecisive career-path

Before I continue, it is useful to note that first, most of the students did not have a clear-cut career path or aspiration towards any field of study as reported: "*I think the career that I was supposed to choose was within the science field, but then I didn't know yet. So, I changed my career choices for like five (5) times" (EDP15).* A typical case of a student with an indecisive career path was MS4, who initially desired to study computer science because *"my brother had studied computer science engineering, and I was just very jealous that he knew everything about computers*". But after she enrolled for computer science and maths in Y1, she realised she was not enjoying the courses "*So then I changed my degree, and I was like I'll change it to subjects that I enjoy more*". This assumption of 'subjects I will enjoy more' led to several changes as recounted:

> And I also love maths and I didn't really know what I wanted to ever do, so I was like let me do maths [laughter]; and maybe a computer science may be cool […] And so then I decided maybe I wanna change to maybe engineering, and I was like 'NO' maybe I should do actuarial science. Cos I also wanted to maybe do medicine and then I changed my mind with that. And then I didn't want to do medicine anymore, so I continued with my BSc (MS4).

During the interview session, MS4 emphasized that the major problem she faced in university and her studies stemmed from not knowing what to do in terms of her career when she left school. There was no clear career path; hence, she tried out several options to see what would work best as detailed:

> I think the big thing for me was not knowing what I wanted to do when I left school. I just enjoyed everything at school. I never knew 'oh yeah I definitely wanna be this, I definitely wanna do an accounting degree, I definitely wanna do science. I had no idea, so I was like let me just do science. And then I can maybe just pick up subjects that I enjoy for first year and then see where I go. And that's what led to all my changes because I couldn't see where my science degree was taking me. Like I never had an idea of what I wanna do (MS4).

Furthermore, there is another category of students who came to UCT with a clear-cut idea of what they wanted to study, but after studying the course for a year, came to realise that they either did not like the course or had lost their passion; hence transferred to another course. As an example, a student said she decided in grade 11 that she wanted to study astrophysics, but after enrolling, realised she did not have the passion anymore:

> Well in grade 11, I actually had the intention of doing astrophysics. And I then came to 1st year and everything was nice. But something in me could just feel that I didn't have that passion for astrophysics anymore […] Yes, but something in me was like I don't really have that passion for astrophysics. So, I said cool, then I'm gonna switch to chemistry and physics (MS3).

I also observed that some students had a career aspiration, but it was towards a field outside chemistry. They decided on chemistry after changing their majors severally in first year; thus, it was not surprising that even after studying chemistry for three years some of them still had plans to return to their initial preference. Finally, only a small number of students were clear on the career they wanted to pursue since high school.

Career aspiration of students who chose chemistry as a first-choice

In this section, the aim is to discuss the career aspiration of the students who chose chemistry as a first-choice. The first-choice category refers to those students who specifically chose chemistry as one of their majors in first-year. Out of the 18 interview participants in this study, 3 signed up for chemistry from the onset as stated: "*For me it has always been chemistry" (MS11)*. It is important to note that role models-expert advice, extra-curricular experiences and interest significantly influenced these students' decision to choose chemistry. It is helpful to recount that MS9's decision to major in chemistry was made during high school, particularly in grade 10; and EDP13 developed a passion for chemistry while helping her teacher prepare for laboratory session in high school. In contrast to these cases, MS11, signed up for chemistry not because he is fascinated about the discipline per se, but because he needed the degree for postgraduate study in fragrance chemistry as previously noted.

It will be useful to bring in information from the online questionnaire to support the point made so far on this discussion of chemistry as a first-choice. One of the questions that were asked in the questionnaire was intended to capture information on students' first-choice of study (question 24). All 28 questionnaire participants answered the question, so it provides a holistic picture of the career aspiration of this cohort of Y3 students. As evident from Figure 30 below, only 4/28 participants signed up for chemistry as a first-choice, while a more significant proportion of the remaining 24 students signed for courses in engineering and medicine. Two participants merely indicated BSc, so it was difficult to place them in a specific category. Furthermore, a student stated more than one course; thus, it was impossible to differentiate, which was the first option. Consequently, this was assigned as 'No clear choice'.

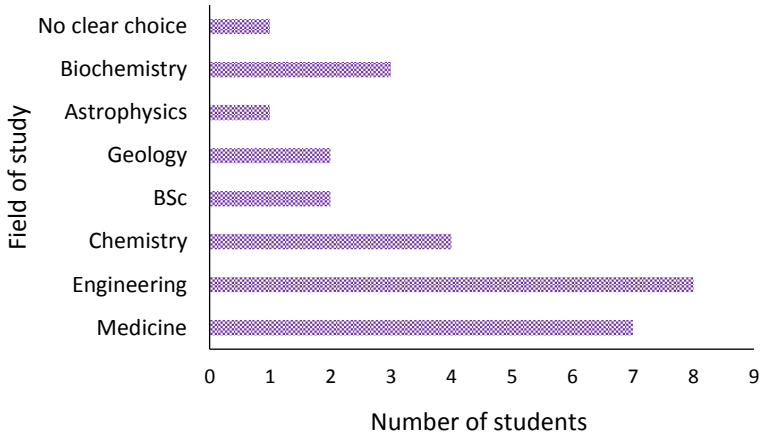


Figure 30: Students' first-choice of study (obtained from questionnaire)

5.2.3 Second-choice

The second-choice includes those students who chose chemistry because they were denied their initial career preference, e.g. engineering or medicine. From the analysis of the interview data, only 3 students chose chemistry as a first-choice, while the remaining students initially opted for courses in other disciplines; making it a second-choice for the majority. There was an almost equal split between an initial preference for medicine (n=4) and engineering (n=5). Most students indicated that they preferred other disciplines but ended up studying chemistry. The major reasons for this occurrence were *'denied initial career preference so I had to continue with my second option'.*

"Denied initial career preference" was a prominent reason student gave for converting into chemistry: *"How I ended in science was only because I didn't get into medicine" (EDP6), "I got turned down for chemical engineering" (MS10), "But then you see UCT did not accept me for chemical engineering they only accepted me for chemistry" (EDP17).* An international student who came to UCT with the plans of studying medicine is a typical case (MS2). Although her grades were good, she was not accepted for medicine because according to her explanation UCT has a strict policy that restricts international students from being accepted into medical school if they do not have permanent residency and if their home country has a medical school. Unfortunately, this was the case for MS2. However, she decided to continue with a BSc degree with the intention of re-applying for medicine in Y2 "*but they still said NO for the same reason obviously*", regardless of her good grades "*For the 1st semester I got a 94 and the 2nd semester a 93*". Consequent on this multiple refusals, coupled with other events, she resorted to continuing with chemistry to undertake postgraduate study in an area that would still indirectly satisfy her long-time desire to save lives, as earlier described. There is another group of students who chose chemistry because in the majority of cases UCT rules for the BSc degree will mean that students are required to choose two majors to meet the requirements

to graduate. Choosing chemistry based on this requirement was classified as partner-choice, which will be discussed in the next paragraph.

Partner-choice

"UCT required two majors for enrolment" was recorded as a reason why some students chose chemistry, and I categorized this as a partner-choice. Typical quotes are provided: "*And then during orientation week we were told that we need another major as we can't do just one major", (EDP17).* For instance, an international student realised on arriving at UCT that she needed to take two majors to meet the admission requirement, hence the decision: "*And then when I came here, they said you must have two majors, so I decided to take chemistry" (EDP5).* While another MS student also said: "*And when I came here, they said you must have two majors, So, I choose chemistry as my second option on that day, without really knowing so much about the field itself" (MS16).*

As a final note in this section, first, it is pertinent to state that few students only decided to make chemistry a major in Y2. In Y1, they were introduced to the foundation courses in sciences, but as they continued to study chemistry, they realised *"it was getting more interesting and in-depth" (MS10),* and then decided to make it a second major. Second, over the years of studying chemistry, some of them found aspects of the programme that they preferred. For example, a student who initially applied for medicine, choose drug discovery as an area for research at postgraduate level (MS2); and a student with chemical engineering as a first-choice made some changes in her career plans, and planned to pursue an honours study in chemistry (EDP15). By contrast, EDP12 explained that although chemistry is a subject she understands, she does not like it, and has failed to develop a passion for it even after studying it for several years as quoted: *"I don't like chemistry. I do understand it, but it's not really my thing*". As a result, she only considers chemistry as a stepping stone to her initial career preference "*I still want to do medicine [laughter]. I still imagine myself being a medical student*". Another student's perspective is expressed:

> For me the only reason I stayed in chemistry is because I want to do chemical engineering. So, I was like 'keep at it, keep at it, and just graduate, and once you graduate it is over'. You won't have to do chemistry again (laughs) (EDP14).

Moreover, it is useful to mention that from the analysis of the questionnaire data, it was observed that 82% of the students indicated that they had not had a career counselling session. The majority (68%) of the students requested a career counselling session to enlighten them about career opportunities in chemistry; as this would help them decide on what to do with their degree, and make an informed decision on the career path to follow at postgraduate level. This is also supported by an excerpt from the interview data:

> It would be nice like when we are doing 2nd or 3rd year, if there can be a career expo just based on chemistry. This will help us to know the places that we can work. Broaden our ideas on the different career options that are available to chemist. And not only becoming academics, because some of us don't want to become academics. So, if were exposed it will really helpful and nice (EDP17).

It is useful to bring in information from the questionnaire to support the point that has been made so far on this discussion of BSc chemistry as a second-choice. One of the questions that were asked in the questionnaire was "When did you decide to major in chemistry?" this was intended to capture information about when participants decided to make chemistry a major course during their academic career. As seen from the responses provided in Table 10, most of the participants made this decision either at the end of Y1 or at the beginning of Y2; which agrees with data from the interview transcripts presented earlier. For some of the students, it was when they were not accepted in their initial preference, for others it was during enrolment. Yet, some other students decided to major in chemistry was when they realised that they enjoyed studying it. All the participants responded to the question, and the responses are reported in the order in which they were entered.

Table 10: Responses to: when did you decide to major in chemistry?

1.	After I got the class medal for it in 1st year
2.	After first year
3.	I decided to major in chemistry and physics towards the end of my first year as I realised then that I had a passion for chemistry and physics. I changed physics and astrophysics because physics major has more opportunities and I had more interest in physics
4.	After I was not accepted for engineering and when I realised Biochemistry and Microbiology had a limited number of students accepted so I would need a course with more security (with no limit of students' intake)
5.	After doing first-year chemistry
6.	High school
7.	First year
8.	2014 (second year)
9.	Grade 11
10.	Chemistry was my second-choice so when I wasn't accepted in my first-choice I choice it
11.	In first year, 2013
12.	11 or 12 years' old
13.	Enjoyed it in high school didn't know what I wanted to do
14.	High school
15.	In 2014, during the end of first year in university
16.	When I wasn't accepted in chemical engineering
17.	Second year
18.	High school
19.	During high school, when it was the subject that most captured my attention
20.	In my second year at UCT, after getting a first class for CEM1009H
21.	In high school, when I still really loved chemistry and I was good at it
22.	In first year, after I got accepted to geology
23.	When I understood how deep the field is

24.	I decided to major in chemistry when I arrived on campus February 2014, I had the choice of Engineering or Science, but the latter seemed more interesting and seeing as my love for chemistry was there, I took the leap
25.	1st year
26.	When I was in Grade 11
27.	On the day of registration
28.	2013 (First year)

5.2.4 Job options

Students' responses to the question 'select one of the reasons why you choose to study chemistry' from the questionnaire, was that it provides more job options. 75% of these students indicated that they decided to study chemistry because they are aware that it would increase their chances of finding a job. Typical quotes from the interview data support this: *"And also it is more generous, so I thought it would give me more options later on" (EDP5)*, "and *"I knew chemistry would open a lot of doors, so by choosing it I knew I would have the chance to go into a lot of other fields "(MS7).* During the conversation with MS3, she said:

> That is actually one of the reasons why I choose chemistry and stuff like that, cos it seems like a very good option to get a job. So, I do not mean to demean people in other majors, but maybe someone like in oceanography, like the job opportunity is relatively not that big […] not great. you know! So yeah so that's one of my reason (MS3).

5.2.5 Criteria used by EDP and MS students in choosing chemistry

Chemistry as first, second and partner-choice

Before unpacking the criteria that EDP and MS students mostly used in choosing chemistry, I will summarize the decision points using the first, second and partner-choice categories. As I explained earlier chemistry was not a first-choice for the majority of students; instead, it was a second option for the majority and a partner-choice for others (Table 11). It is important to note that the data only captures information for the 18 interview participants. I acknowledge that placing some students in either first or second-choice was problematic in some cases. The problem resulted because some students had an interest in a future career that could be entered via more than one route (example biochemistry, chemistry), but realised that it was difficult, and then decided to choose chemistry at a later stage. I decided not to put these students in the first-choice category.

Table 11: Chemistry as first, second and partner-choice

Chemistry choice	Number of students	Example
First-choice	3	*For me it has always been chemistry. I chose it*
Second-choice	11	*[…] so this was my 2nd choice, it was not my original plan*
Partner-choice	4	*So, I applied here for biochemistry. And then when I came here, they said you must have two majors, so I decided to take chemistry*

Criteria used by EDP and MS students in choosing chemistry

Students' career choices can be influenced by more than one factor; hence, a decision was made to place all the factors earlier identified into two broad categories, which are retrospective and prospective criteria (Table 12). The retrospective criteria, as used in this thesis, are associated with past experiences and include perceptions about: past achievement in the subject in high school, prior learning experiences, past interest and extra-curricular experiences. On the other hand, the prospective criteria are associated with the future, and include career aspiration, role models, expert advice and wider job options. The majority of these criteria are well identified in the Social Cognitive Career Theory, and attention will be drawn to these aspects when necessary.

Table 12: Criteria used by EDP and MS students in choosing chemistry (criteria are not mutually exclusive)

Choice of chemistry				
Type of Criteria	**Theme**	**Example**	**Frequency EDP, n = 10**	**Frequency MS, n = 8**
Retrospective Criteria	Achievement	*I did well in chemistry in school.*	7	1
	Prior learning experiences	*My chemistry teacher assisted me a lot, she was good.*	4	2
	Past interest	*In high school I was interested in chemistry.*	1	2
	Extra-curricular	*We went on a science expedition.*	2	2
Prospective Criteria	Career aspiration	*For me it has always been chemistry.*	1	2
	Role models	*[…] ever since I became very fascinated and I'm like 'I just wanna be like them.*	1	3
	Expert advice	*There was a lecturer, who advised me. […]*	1	3
	Wider job options	*I knew chemistry would open a lot of doors, […] have the chance to go into a lot of other fields.*	1	4

5.2.6 Career aspiration - career counselling session (data from the questionnaire)

I will be discussing the data gathered from the questionnaire that addresses aspects of the student journey into chemistry in this section. Other aspects of the questionnaire that address different issues will be presented later.

5.2.6.1 Career aspiration (questionnaire)

The response rate for the questionnaire was 88% (28 out of 32), and the results are reported in this section using Table 13 below as a reference for the discussion that follows in this and subsequent paragraphs. It can be seen that 32% of the students provided a neutral response to question 1, while a greater number of the remaining students disagree. The perspectives of two students on the influence of family on their career decision are expressed.

For question 2, a variety of perspectives exist; however, the views held by some participants are expressed. As seen from the responses, 48% of students (agree and strongly agree) and 48% (disagree and strongly disagree) with this statement, dividing the response into two bands. It is interesting to compare this information with the data gathered from the interview because, while analysing the transcripts it was observed that the majority of students admitted that they chose chemistry when they were denied admission into their initial preference. The difference in responses may be accounted for by recognizing that the questionnaire captures the responses of 28 participants, whereas the interview data only accounts for 18.

For question 3, it can be seen that 63% of the respondents strongly disagree with the statement, while none of the participants strongly agree (0%). Furthermore, the participants' comments showed the influence of high school teachers on their career aspiration.

Still referring to Table 13, for question 4, it is interesting to note that strongly agree, agree, and neutral scored a 0% response, implying that none of the students agrees with the statement. The comment provided by one of the respondents indicates the influence of family on his or her career decision. Nevertheless, this is not captured in the bar chart, perhaps the question was not correctly understood, or the student failed to tick the correct box while completing the questionnaire.

Furthermore, a 0% disagree response contrasts with the data gathered during the interview where one participant's narrative indicated a significant level of parental influence on her career decision to choose medicine. A possible explanation could be that since the decision in question 4, relates to chemistry, the student did not see the need to tick the option. In this case, the parental influence was on a choice of medicine and not chemistry.

Table 13: Students' responses to questions 1-4 from questionnaire

	Questions	Strongly agree %	Agree %	Neutral %	Disagree %	Strongly disagree %	Additional comments provided
1	My family/role model had a significant influence on my decision to pursue a BSc?	7	21	32	11	29	• my family wanted me to get good education that would lead me to getting a job • Since I didn't get in for medicine, they encouraged me to pursue the option that I got, but they told me there were other options and that I could do something else if I wanted to. It was more my decision to come to UCT
2	I registered for a BSc degree because I was not accepted for medicine or engineering	26	22	4	15	33	• initially I applied for a BSc but later changed my first choice to engineering • As a non-South African without permanent residence they didn't even look at my application • I applied at both Science and Engineering, got accepted for both and then preferentially chose Science • I was accepted for both Engineering and Science
3	My high school teacher encouraged me to go to University when I did not think that it was an option	0	11	11	15	63	• I knew going to university would increase my chances of getting a good job • I have always aspired to pursue a degree in higher education • My high school teacher told us that if we needed extra classes for physics in high school, we will not survive a BSc degree • My high school teacher did encourage me to go to university, however I also knew it was an option • I'd always wanted to go to university ever since I got interested in Science, literally from grade4
4	I did not want to study a BSc but did it to please my family	0	0	0	36	64	• See the first comment • My family wanted me to do medicine

Students' responses to question 5 are shown in Table 14.

Table 14: Students' responses to question 5

Question 5: Tick as many options as apply to you to complete the following sentence. I choose to study chemistry because			
		Responses (%)	**Additional comments provided**
1	I love it/enjoy it	75	• Well, I used to be in first year, alot has changed since haha • back in high school I was good at chemistry and especially organic: chemistry • I can't imagine doing anything else
2	I am good at it/best subject	50	
3	It provides more job options (a range of jobs)	46	
4	I am certain I will succeed in it	29	
5	There was no other option	14	

The table above is quite revealing in several ways. In the first instance, 75% of the respondents admitted to choosing chemistry because they 'love it/enjoy it'. However, when this question was further probed during the interview sessions, it was observed that this 'love/enjoy chemistry' was not a strong reason that motivated their movement into chemistry.

On the contrary, it was as students continued to study chemistry especially in Y2, that they realised that they actually love/enjoyed the subject and decided to major in it as seen in a typical quote: *"But as I kept on studying chemistry, I realised it was getting more interesting and in-depth, so I decided to make it my 2nd year major" (MS10).* Likewise, the responses to the question: 'When did you decide to major in chemistry?', previously presented in section 5.5.3 also reveal that the majority of students chose chemistry in Y2. On the other hand, it is arguable that these students were responding to how they currently feel about chemistry at Y3 level, not necessarily how they felt when they initially enrolled for the degree in first-year.

Furthermore, as apparent from the same table, only 14% indicated that they decided to study chemistry because there was no other option. It is a bit difficult to interpret this result in isolation, however, a disparity exists when compared with the interview data,. This is because as presented in the previous section, chemistry was a second-choice for the majority of the students, and most of these students indicated that they only chose chemistry when they were unsuccessful in their initial career preference. It could also be that the participants' definition of a second option was different from what I intended, still implying that they did not understand the question properly. Notwithstanding, it is helpful to remember that this questionnaire captures responses of 28 participants as against 18 interview participants

5.2.6.2 Career counselling for students

Results from the analysis of the questionnaire relating to aspects of career planning are shown in Table 15. The numbering of the questions continues from the previous section to allow for uniformity and easy referencing. Students' responses to question 6 are shown in below.

Table 15: Students' responses to question 6

Question 6: Tick as many options as apply to you. What career plans do you see yourself pursuing after graduation?

		Responses (%)	**Additional comments provided**
1	I already have all my career plans after graduation set out	21	• I applied for honours, however I would like a career that uses chemistry which I do not know where • I will change to Engineering • I plan to do Honours, but have no idea what I will choose to do after that.
2	I DO NOT know what to do after graduation	46	
3	I am planning a career that uses chemistry	36	
4	I plan to study further (Honours)	64	

Table 15 shows that 64% of the respondents admitted to planning to study further (Honours), whereas 46% indicated that they did not know what to do after graduation. The comments provided by three participants suggested consideration of further study. Besides, the comments from two students showed they were uncertain of what honours program to pursue, which indicates a lack of career focus; while a transfer to engineering was also presented as an option.

Following up on this question, students' responses to question 7 are shown in Table 16.

Table 16: Proposed study course

Question 7: If you plan to study further, briefly describe or indicate the course

1. Honours in chemistry
2. I am quite keen to do an online course in nutrition
3. I plan on doing chemistry (honours) or medical physics (honour), followed by master's in computational science/computational chemistry (if I get funding)
4. Material science
5. I will do honours in chemistry and hopefully masters
6. Honours in chemistry
7. I plan to study abroad for a specialization master
8. Planning on doing honours in statistics or chemistry
9. I will be studying masters in fragrance chemistry. That is the reason why I have studied chemistry - to pursue perfumery
10. Honours in material science then master's in chemical engineering
11. Chemistry honours
12. Medicine or (hons) clinical pharmacology
13. Honours in chemistry
14. I plan to do chemistry honours, maybe followed by masters if that appeals to me

15.	Oceanography
16.	Chemistry honours
17.	I am planning to do honours in either chemistry or geology
18.	I want to do my honours in chemistry or material science
19.	Geology

From the data in Table 16, it is evident that only 19/28 participants answered the question. Likely, the remaining 9 participants did not know or have a clear picture of what course or the career path to follow. This claim can be supported by the information earlier shown that nearly half of the participants (46%) do not know what to do after graduation, and may account for the incomplete responses. Besides, the career plans of the students varied greatly, and as seen from table 16 funding opportunities limited some of these choices.

Participants' responses to question 8 and 9 are reported in Table 17

Table 17: Students' responses to questions 8 and 9

Questions		**Responses**		**Additional comments provided**
		Yes	**No**	
8	I had a career counselling session before deciding to study my course	18	82	• However, chemistry was not what they told me to pursue
9	I would like to have a career planning session with UCT Careers Centre	68	32	• That would be interesting • I don't know. While I think it could be beneficial for me, my general lack of direction makes me think it would be a fruitless and frustrating exercise for the one trying to help me

Table 17 shows that the majority opted for their course of study without a career counselling session (82%). The comment provided indicates that the student was not advised to pursue a career in chemistry; how this student ended up studying chemistry must have been motivated by other factors.

Based on students' responses to the previous questions (6 & 8), it was not unusual to see that a high percentage (68%) said 'Yes' to having a career planning session with UCT careers centre. Moreover, the comments provided by two participants capture their views about the anticipated outcome and benefit.

UCT careers service workshop

Based on students' request, a careers workshop was organized in partnership with UCT careers service. Students gave positive feedback after the session as seen from a representative quote: 'thank you very much'. This information was obtained from the

feedback forms that participants filled after engaging in the session. A sample of the feedback form is attached (Appendix 11).

5.3 Discussion

The strategies that students employ in choosing tertiary study programmes have been reported to be based on interest in the subject, extra-curricular experience in the subject area, achievement in the subject at school, interest in the study programme outline, influence of role models, pressure and stimulus from family (Arnold, 1993; Gardner, 1985; Khattab, 2015; Ni, 2012; Woolnough, 1994). Findings from the current study are aligned with most of these categories. For instance, interest, extracurricular experience, learning experiences, the influence of role models, which also reflect an important aspect of the SCCT was identified.

In terms of academic abilities, I found that some students chose chemistry based on their prior achievement level in the subject in high school. This is consistent with earlier studies that students' commitment to either pursue or not pursue a course especially in science and engineering is linked to their academic achievement (Ardura & Pérez-Bitrián, 2018; Hinds & Shultz, 2018; Lubben et al., 2010; Palmer et al., 2017; Woolnough, 1994). Bandura (1991) suggested that past achievement and experiences of individuals can influence students' decisions of pursuing various tasks, and this study agrees with this.

Students' prior learning experiences have a profound influence on their career aspiration (David-Kasco, Haragus, & Roth, 2013; Hinds & Shultz, 2018; Liu, Raker, & Lewis, 2018; Tinto, 2017; Woolnough, 1994). For instance, the study by Hinds and Shultz (2018) showed that prior learning experience influenced chemistry students' course selection. The current study is consistent with this finding, as seen in the case of the student who decided to choose chemistry because of the way his high school teacher taught the subject. It is pertinent to state that learning experience in this context is extended to include extra-curricular experience in the subject area, such as visits to research laboratories, open days, job shadowing, science exhibitions. As noted earlier, it was the encounters from these learning experiences that led to interest development and aspiration. For example, MS11, developed a passion for fragrance chemistry (production of perfumes), during visits to his mother's office, where she worked as a landscape architect.

In agreement with the literature, interest was also a reason that students gave for deciding to pursue a career, which may have been shaped by earlier experiences (Lent et al., 1994; Ogunde et al., 2017). As reported by Ogunde et al. (2017), some criteria for selecting a course such as access to a role model, which may also indicate a strong career focus, hold

for this cohort of undergraduate students. For instance, EDP1 developed an interest in nanotechnology, and decided to pursue a career in this field after exposure to role models and visits to nanotechnology laboratories. This finding agrees with the study by Ogunde et al. (2017), where it was reported that interest was a predominant reason why students chose to study chemistry. This findings also echoes the report by Woolnough (1994) that the majority of high school students made the decision towards or away from a career in science and engineering between the ages of 9 -14 years implying that most decisions were made before or just after leaving high school, and is consistent with the accounts provided by the students in this study.

The criterion of students using pressure from the family to decide on a study programme is recognized. A compelling case was recorded of EDP15, whose parents pressured her into applying for medicine because they felt it would be easier to get a job with a medical degree, regardless of her preference. Although this does not apply to her choice of chemistry, it serves to illustrates how peoples' perceptions of job opportunities associated with a profession can influence their choices, even though they lack passion.

Chemistry was not a first-choice for the majority of the students. Lubben et al. (2010) report that half of the students who chose BSc as a second-choice did so because they considered it a stepping stone into their initial career preference; however, as they continued studying half of these participants found aspects of their preference within the programme. This study agrees with this report, although, it was a small number of students who found a preference for the course. The remaining students in the second-choice category indicated that they were leaving chemistry for their initial career preference.

Additionally, in agreement with previous studies, students in this study also seem to be aware that a degree in chemistry would lead to many career options; only a few chose it as a route to a specific career (Kee, 2013; Ogunde et al., 2017). Similarly, there was an almost equal split between an initial preference for medicine and engineering, also reported elsewhere (Lubben et al., 2010). So how do these findings map into (or not) the theoretical framework? this is discussed in the following paragraphs.

The aspect of the Social Cognitive Career Theory or SCCT model that appeared strongly in my findings are the three social cognitive variables: self-efficacy, outcome expectations, and personal goals, which have been shown to influence students persistence (Ali & Saunders, 2009; Lent et al., 2010). These factors influenced both EDP and MS students' career choice and persistence, and show how self-referent thinking affects behaviour and motivation. The criteria that students used to choose chemistry can be categorized in terms of these variables. Thus, achievement, extracurricular and wider job options reflect

students' outcome expectations, while past interest, career aspiration, expert advice and role models reflect personal goals. In some instances, the criteria can be characterized by more than one variable; thus, achievement and prior learning experiences reflect both self-efficacy and outcome expectation.

The study reveals that the requirement for a second major, which I argue as being a contextual factor, as described by SCCT, was a strong influence on students' choice. Personal factors such as gender and experiential variables such as social pressure did not emerge from the data collected for this study. The SCCT proposes that the independent influence of self-efficacy and outcome expectation on goals, and choice actions may help explain career choice behaviour when opportunities to implement interest are perceived as limited; in this aspect, the findings from my study agree with the model. For instance, when some of the students could not gain entrance into their preferred choice, they decided to select subjects that they performed well in high school, highlighting the role of self-efficacy, in agreement with previous studies (Gałaj, 2012; Lent et al., 1994; Schunk, 2003). Based on this reason, some students, especially the second-choice category, decided to major in chemistry. In terms of outcome expectations, it was also recognized that some students decided to continue in chemistry because of the expectation that it would help them to return to their initial career preference.

SCCT emphasises the significant role that prior learning experience plays in the career choice process, and this is evident in this study, as seen in a typical case (EDP13). This student explained that she became interested in a career in chemistry, while helping her teacher prepare for laboratory sessions, and since that time, she had imagined working in the laboratory. Moreover, SCCT highlights the role of personal goals and outcome expectation on students' career choice, and is well illustrated in the narratives of most of the participants in this study; examples will be provided later. Some students chose chemistry to satisfy the admission requirement of two majors at UCT, which has been argued as a contextual influence on students' choice and, which appeared strongly in this study. The question needs to be raised as to whether this should be a concern. I argue that this might have forced students to choose chemistry in an impromptu manner, and they may have been unprepared about what to expect.

In summary, for those who choose chemistry as a first-choice, role models, interest and extra-curricular had a significant influence on their decision. On the other hand, for those who choose chemistry as a second-choice 'achievement level at school and job options' were influential. Those in the partner-choice category were mostly motivated by the

requirement for a second major at UCT. In terms of retrospective and prospective criteria, as it applies to students' choice of chemistry, this is discussed in the next paragraph

Most of the themes under retrospective and prospective criteria fit aspects of SCCT model, with perceived academic abilities in high school appearing strongly in the decision process; especially after denial in their initial career preference. Outcome expectations and personal goals were significant in helping students to persist in their studies, as seen in the case of MS11, EDP14, and MS9. For those students who chose chemistry as a first, second and partner-choice option, there was a substantial influence of both retrospective and prospective criteria, and so no preference could be established in terms of the criteria employed in most cases.

The difficulty in establishing the criteria may be due to the relatively small sample size that does not allow for the distinction to be made. Additionally, retrospective criteria such as achievement at high school had a significant influence on the choice of EDP students. This finding is consistent with the report by Gałaj (2012), which found that achieving good grades was a major reason why students chose chemistry at high school. The finding also agrees with Pajares and Schunk (2001), who said that individuals tend to engage in tasks in, which they feel competent and confident, and avoid those in, which they do not. With respect to MS students, emphasis on prospective criteria, such as role models and expert advice had an important influence on their decision. The current study also reports that 46% of the participants are unsure of what to do after graduation, and 82% requested a career counselling session.

The literature associates students' career aspiration with academic achievement in their study programme, and by extension, success (Khattab, 2015; Morrow, 1994). For EDP students, the majority had a career aspiration for a discipline outside chemistry, and it was not a strong motivation why the majority continued with their studies. Most of them had a career aspiration in medicine and engineering. During the interviews, some students talked about continuing into postgraduate study in their initially intended career path. This finding was not surprising since chemistry was a second-choice for the majority of students. Others said they would study further in a different field, suggestive of a career diversion. Another category of students was unsure if they would continue into honours, nor were they sure of the course to study at the honours level.

In summary, the majority of EDP students did not have a career aspiration towards chemistry, and it did not play any significant role in their persistence. As will be seen in later pages, these students persisted, based more on their desire to help their family, as noted earlier. The desire to improve or raise their family living standards was pivotal and

significant in their academic persistence. Moreover, because of this they could not drop out or return home without graduating, clearly indicating the role of outcome expectation and personal goals, in agreement with the SCCT model. Furthermore, they also knew that they were acting as role models for their immediate family members and community in some instances. In addition, there was an EDP student who chose chemistry as a first-choice. When she was asked what helped her to continue studying, her reason was closely associated with not wanting to waste the money that her parents had spent on her education, and to raise their living standards.

The majority of MS students also had a career aspiration towards a field outside chemistry. Amongst, the mainstream students who chose chemistry as a first-choice, one of them did so to pursue postgraduate study in a field that he was passionate about, fragrance chemistry (MS11). Thus, it was looking forward to what he would do with the degree afterwards that contributed strongly to his persistence, despite the difficulty he encountered; demonstrating the role of personal goals and outcome expectations. This finding agrees with Bandura's (1986) SCT model, which postulates that personal goals and outcome expectation is associated with academic persistence and success in the career choice process, as also noted by the Lent et al. (1994) SCCT framework**.** Like EDP students', career aspiration (towards chemistry) was not a strong reason why these students continued their studies in the subject.

MS students persisted because they did not want to waste the money their parents had spent on their education. Some of them remembered all the difficulties they had encountered in university, hence refused to quit, even when they were no longer enjoying chemistry as seen in the case of MS7. On the other hand, one student who wanted to be a geologist expressed that he performed better in geology because there were a greater passion and interest (MS16). It was his career aspiration for geology that caused him to perform better, and agrees with earlier studies (Khattab, 2015; Morrow, 1994).

Unlike EDP students, for the majority of MS students, the desire to help their parents was not a motivation behind their persistence. As will be seen in subsequent chapters, the majority, especially the White students, did not mention this as a factor. However, MS2, who is an international student, said that she was studying hard to be able to take care of her siblings. This finding also agrees with Bandura's (1986) SCT theory and supports the role of outcome expectation in her decision process. Similar to EDP students, a greater number of MS cohort did not know what to do after graduation. Nevertheless, a student indicated that she was going to work, since she already has a job, while another mentioned the possibility of studying further abroad since she is frustrated with protests in South Africa

universities. In terms of career diversion, one of the students who initially wanted to study medicine, indicated that she would be continuing into postgraduate studies in drug development. The next section report on students' self-efficacy.

5.4 Self-efficacy: How I saw myself

How did students see themselves? This aspect needs to be given attention, to effectively provide a detailed description of this case of undergraduate chemistry students at UCT. I will begin by presenting the data that emerged from the questionnaire as this captures the self-efficacy of the entire class, and shows the areas where they appear similar. Afterwards, attention will be directed to the interview data and highlights areas where their self-efficacy differed, which helped me to categorise the students into three groups.

5.4.1 Data from the questionnaire on self-efficacy.

The numbering of the questions will continue from the previous section that ended with question 9. Therefore, this section will begin with question 10 instead of 1; as this allows for uniformity, clarity and easy referencing. The data are summarized in Table 18.

Table 18: Data from questionnaire on self-efficacy

Question	Strongly agree, %	Agree, %	Neutral, %	Disagree, %	Strongly disagree, %	Selected comments
10 I believe that no matter who you are, you cannot change or improve your academic ability, it remains the same	4	0	4	43	50	• With the right amount of effort anyone can prosper in their academic work, the only time this does not happen is when you procrastinate or do no work whatever.
11 I believe that academic ability grows as you put in more effort in your studies	52	44	0	4	0	
12 It is possible to change the level of my academic ability considerably	37	56	4	4	0	
13 I believe that academic hard work pays off or is rewarding	39	46	11	4	0	• It does not always pay off. Many people have a degree but are unemployed • It is however rewarding if you achieve your goals after you have put in all the hard work. • But not always. Sometimes you try really hard but you just don't succeed.
14 I am certain I will succeed in whatever career path I choose	26	41	30	4	0	
15 I can figure out anything if I try hard enough	25	36	29	11	0	
16 I am confident I will achieve the goals I set for myself	32	43	18	7	0	
17 I get discouraged when I am struggling to accomplish something and I just give up.	0	21	36	36	7	• Try and try and try again until you get where you want to be. • I learned to differentiate between taking a break and quitting. • Most of the time I'll push through the obstacle in question until I figure out the appropriate solution to it.
18 If I practice every day, my academic ability could be improved.	52	48	0	0	0	

Table 18 shows that questions 10 and 11 are essentially the same but were phrased differently to ensure that students were reading the questions rather than focussing on making a choice. The majority of students believed that it is possible to improve their academic ability, that academic ability grows with effort, that it is possible to change one's level of academic ability (questions 10-12); and that daily practice will improve their academic ability, question 18. Most students believe that hard work pays off and is rewarding, question 13.

The responses to questions 14-16 (Table 18) show a greater spread of answers with more neutral responses than for the other questions. The overall responses to these questions show that around two-thirds of students are confident that they will succeed in their chosen career, question 14. They also believe they can figure out anything with sufficient effort, question 15, with 75% being confident of achieving their goals, question 16. Students' responses to question 17 are less positive than those to question 15, which is interesting as both questions are probing the same idea. The comments offered by students concerning question 17 show that they realise the value of staying on task as reflected in their responses to question 15.

I mentioned earlier; attention is now shifted to the data emerging from the interview. The findings will be reported collectively, and specific references will be drawn from either EDP or MS students as required. Careful analysis of data helped to categorize how students perceived themselves as falling into three groups:

1. Top-students performs poorly
2. Self-confident students
3. Self-doubt and fearful students

5.4.2 Top-students performs poorly

Students positioned themselves as top-students based on their performances in high school and first year, as seen in typical quotes: *"Even in first year I got over an 80 for chemistry" (MS7).* However, some of them later realised that the university system was quite different, as their performance especially first and second year did not match their expectation (they did not anticipate failing a course); as recounted:

> I think the issue is that when you are in high school you feel confident about your abilities and environment. They tell you that you are smart, you are the cream of the crop but when you come to UCT you realise that the whole system is so different and there is that big change (EDP17).

Moreover, the expressions used by these students while describing their disappointment and hurt after failing depicts the impact it had not only on their studies but also on their emotional state as typified: *"…that hurt me bad. It really hurt me bad" (EDP8), "oh No! I am sinking. So*

for me that was the hardest thing" (EDP17). More specifically, an international student expressed the shock, disappointment, and confusion she experienced when she failed:

> So, when I came here, the marks you get from high school, good student, it was very sudden, was shocked when the first decant test came out. And I failed most of them. [...] I don't know my marks were good, I had over 80% average leaving high school (EDP5).

The impact of this failure was significant because she "*was like 'what am I doing wrong?' and everything".* Consequently, she moved into the extended programme, which was "*a very hard decision in the beginning, cos you were like am I going to stay one more year?*". Similarly, another Black South African student, (EDP8), positioned himself as a top student because "*When I was doing matric I managed to secure 1st place in my school, and 3rd place in the entire district*", but faced the same struggle of self-doubt because of failure. In recounting his high school experience, he referred to himself as *"top student whom the teacher will say 'you guys should look up to this person, look up to this man, you should study like him'".* Hence, it was emotionally challenging when he came to UCT, and for the first time in his studies failed a course as reported:

> But when I got to second year I did feel that way because in the 1st semester for the first time I actually failed a course […] that hurt me bad. It really hurt me bad. And now when I told my parents, they were a little bit hurt by that, and that hurt me back (EDP8).

5.4.3 Self-confident students

As revealed from the analysis of the data gathered, some students expressed confidence in their ability to complete their education as evidenced: *"Yes, I was confident […]" (EDP18), "If I start it I must complete it" (MS4).* A Black South African said that when she arrived UCT, she was confident of her abilities. She considered herself a smart student who would not fail nor move into the extended programme as recounted:

> From the 1st day when I came in, I was like I am going to do this. I'm going to pass this. In the back of my mind I was like you cannot fail. I was like 'NO, I'm not going to decant, I AM SMART' (EDP12).

Things turned around for EDP12 when she encountered obstacles, which created a sense of self-doubt, and then she realised that studying at university for her degree was not as easy as initially imagined. This happening led to thoughts of discontinuation:

> And then we wrote decant test, and I was crying to my mum. I told her mum I want to go home. I was crying and those decant test were the worst […] I was definitely focused on passing, but there were obstacles. You encounter things that makes you realise it is hard. You also encounter shock (EDP12).

Similarly, EDP15, felt *"oh I am good, I am smart, I don't need help",* but experienced difficulties that resulted in her advice to new students:

> You know from high school we tell ourselves "oh I am good […]". And some of us are not used to getting help, we always do things on our own. But when you get to university get every possible help you can. Put your pride aside, put your grades from high school aside. Just get help. And try to stay on top of your work, you can do it (EDP15).

5.4.4 Self-doubt and fearful students

Students' interview data reveal expressions of self-doubt and fear from both EDP and MS students as evidenced: *"I contemplated my options" (MS10), "That is the one part (referring to the transition to mainstream) that dazzles people, and makes you lose your mind at some point" (EDP18), "firstly, I was like am I in the wrong crew/group or what?" (EDP13)*. As an example, a participant said that during his study, there had been issues of uncertainty and self-doubt at different stages:

> There were times I felt some doubt. Cos in the last 3 years there were times that I wasn't really doing well, and I felt like 'maybe, this is not really for me'. And there were times I was doing well, and I feel like this is for me (MS11).

Moreover, other instances caused students to begin to doubt their intellectual ability, especially when they were not able to meet the academic demands of the course. As an example, EDP17 explained that when the academic workload was intense, coupled with the high demand from third-year or Y3 lecturers concerning the level of intellectual expertise she was expected to demonstrate, resulted in intense pressure, and self-doubt.

Another interesting case is MS9 who said that when he enrolled for BSc Chemistry *"there was a lot of doubts*" especially when it got more difficult in Y2; and *"at some point there was the feeling of 'maybe I don't belong to chemistry too much'".* However, having made it to 3rd year, he said: *"But now, I do believe I can make it, especially since I have come this far into 3rd year"* (MS9). Furthermore, his case is interesting because he was one of the few students who chose chemistry as a first-choice and indicated that chemistry had always been in his career plan. Nevertheless, even this student experienced self-doubt especially as the course became more difficult and he contemplated transferring, but finally decided to push on: "*I mean these doubts would happen halfway through the year, and at that point you can't change, so you just have to get it through the year" (MS9).*

Furthermore, another interesting case is EDP13, who explained that when she enrolled at university, one of the major factors that influenced her decision to move into the extended programme was a feeling of self-doubt and intimidation:

> But at that stage I think what mostly went through my mind to choose the EDP programme was a lack of self-worth and self-trust. It wasn't bad, it was just because I was scared, fearing nothing and […] I was very intimidated by people in mainstream who had done well [pause], like they were just very smart, they were like very quick" (EDP13).

Additionally, she said that when she joined mainstream, i.e. CEM2, the feeling of insecurity and lack of self-confidence, which she experienced before entering EDP returned. The feeling caused significant turbulence in her studies, which eventually led to failure:

> It was once again coupled with little feeling of insecurity, little feeling of am I going to be better than mainstream students? Because when one is in the EDP programme you already kind of have a mindset of oh! I might not be as good as the people in mainstream, and like it took quite some time to actually just be Ok. And many reasons are coupled to this as well […].
>
> But I think that year in particular when I transitioned from the 2 years of EDP back to 2nd year mainstream that was quite a difficult year. And also [pause] And yeah! already you have that thing of I am not as good as the people in mainstream and coupled with many factors it led me to failure. Yeah! So, I failed that year. And I had to grow, yeah, I did grow from it (EDP 13).

However, EDP13 explained that one of the ways she handled this issue of self-doubt was by engaging in self-discovery, saying:

> And also, I had to go back and dig deep within myself to learn who I am as an individual and not comparing myself to other people and I started to work on myself, and that working continually on myself has helped me in many regards like talking to people. Just like being motivated by them […] (EDP13).

Engaging in self-discovery eventually helped her to perform better academically. She achieved this by continually listening to and reading motivational messages and books respectively; and applying the lessons learned as seen in the excerpt:

> I think within the working on myself, personal development. The things I have been doing in that regard has been helping me, been reading books in my leisure time, simple books like Life Lessons from Farrier. That's an easy book to read, you read one lessons and you continue with your day. And also watching videos on YouTube, like motivational videos. […] but it is because I listen to them, I listen to their tapes, the words they pen down, and I try to apply that in my life (EDP13).

Besides, she referred to these authors and motivational speakers as "*my friends",* and when she fails to listen to their messages, it affects her personality as narrated:

> And I think along my journey I have gotten to know amazing people like Oprah Winfrey, Jamie Ro, Les Brown, and Maya Angelou. And I think a day when I do not wake up in the morning and listen to these people [pause] […] When I don't listen to a motivational something in the

> morning, I am missing something. I think that is what I do to keep my spirit full. And so, when I don't do that, I don't do that for 2 days or for a week. It's a whole drastic change about me. I am just not the same person (EDP13).

Furthermore, EDP13 explained that she also sought advice from her lecturers, and indicated that although there has been significant personal growth over the years, there still existed moments of struggle, which she referred to as 'downfalls'. Nevertheless, she endeavoured to seek support. Based on the difficulty EDP13 experienced during her undergraduate study, she offered advice to incoming students:

> I think the advice I would give to a person in those shoes, is not only to trust in themselves but to know that they have the potential to actually overcome that. And it is not difficult. It's just a thing of mindset if you put your mind to it and you know there is no easier option, because I think EDP for me was like an easier option. And you don't grow by making life easier for you, you grow by putting yourself in a difficult circumstance and pushing through (EDP13).

Additionally, EDP17 captured the self-doubt she experienced during her undergraduate studies in a different light. This feeling of self-doubt originated from the preconceived impression that people have about chemistry, and comparing this with her actual achievement in the course as described:

> There is a thing of 'oh! chemistry is difficult, oh! You are doing chemistry?' And so, when you tell people you are studying chemistry, they just exclaim! And that begins to make you doubt yourself, especially when you look at your marks also. And you begin to tell yourself chemistry is not for me (EDP17).

Some Black students mentioned the fear or intimidation they felt in approaching a White lecturer to ask for clarification on areas of difficulty. It should be noted that the majority of the lecturers in UCT are White, and this brings into perspective the difficulty these students experienced. For instance, a Black student (EDP8) referred to his lecturers as 'intimidating'.

As a final note, contrary to the cases reported thus far, there was an instance where fear had a positive impact. An example is a Black South African participant (MS16) who mentioned that it was the fear of losing his bursary that helped prevent failure, despite the negative effect his social life had on his studies. More details about MS16 will be provided in the next chapter nevertheless find below his account that shows how fear helped him to persist:

> Cos it is the fear of losing the bursary, which makes me work. […] because if I fail then my bursary pulls out. So that is one thing that helped me to stay on track […] And this is because I am a person of so many friends. So, I have been spending little time towards my studies (MS16).

5.5 Discussion

Students' academic abilities have been associated with their self-efficacy beliefs, and by extension, their career aspiration (Hoppe & Fujishiro, 2015; Li, 2012; Zusho et al., 2003). Students' self-efficacy influences their motivation, interest in a specific task and expected outcome for certain behaviours (Bandura, 1994, 2006). Additionally, the strong influence of self-efficacy is posited to be due to its influence on an individual's intention to either persevere or give up, thereby influencing their future behaviours by increasing or decreasing exposures to new and challenging tasks. Thus, it was not surprising that I found that some students indicated they were confident that they would succeed in the career path they had chosen.

This was especially seen in the case of EDP students whose statements indicated a high level of performance in chemistry in high school. Some of them were top performers in their district and region. Thus, when they initially enrolled, they were confident about succeeding. However, some of these students became disappointed as they realised that they could not meet the academic demands at university; this led to failure, and subsequently, significant self-doubt. At this stage of failing, they began to question their ability to succeed, which resulted in further self-doubt; similar experiences have been reported in the literature (Dweck, 2017; Kelly-Laubscher et al., 2018). It is useful to note that the study by Kelly-Laubscher et al. (2018) also focused on EDP students, who similarly bragged about their academic excellence prior to tertiary education. However, a difference between these two studies in terms of the study sample is that the study by Kelly-Laubscher et al. (2018) only focused on EDP students, unlike the current study.

The case of MS9 is contrary to the accounts above of students who possess a strong sense of self-efficacy. In section 5.3.2, I explained that MS9 chose chemistry as a first-choice and indicated his career aspiration for the course, yet he experienced significant difficulty during his studies, which planted thoughts of discontinuation and self-doubt. This difficulty was worse as he progressed to Y2 as the courses became more intellectually demanding. The scenario in which MS9 found himself brings into perspective the argument that it is one thing to have a career aspiration, and it is entirely another to feel confident about succeeding in the career. Moreover, it is yet another story when one encounters obstacles, in the desired career path such as failure, which could completely alter one's initial preference or lead to a different degree choice. MS9 had a weak sense of self-efficacy for chemistry because when asked 'if he felt he would succeed in chemistry at the initial stage of enrolment', he clearly said 'No'. His response contrasts with what is known from the literature that students tend to pursue a career option based on how self-efficacious they feel, i.e. they have a greater likelihood of succeeding (Bandura, 1986; Pajares & Schunk, 2001; Schunk, 2003). The fact that MS9 chose

chemistry as a first-choice even though he did not feel confident about succeeding could be a pointer that other reasons may have motivated his entry. During the interview, he indicated that his teacher encouraged him to study chemistry because of his interest in the subject. I would argue that this was a strong motivator, and maybe the desire not to disappoint his teacher made him persist in the course because she was significant in his career decisions.

Furthermore, EDP13 also experienced significant self-doubt, and she was also one of the students who chose chemistry as a first-choice. As clear from her account, she possessed a weak sense of self-efficacy, which resulted in academic difficulty and failure. However, despite this, she embraced the failure and was willing to take steps to make sure that she improved. This attitude of taking needed steps to overcome difficulty was not unique to her alone; others were also willing to work extra hard and improve their grades, as will be seen later. All of this shows that the factors that determine student success in a given career path are multifaceted, and different aspects contribute to overall success. Students should be encouraged to have a career aspiration and be confident about their ability to succeed in that field, but they also need to pay attention to their emotional and psycho-social needs. They need to understand or be taught how to view failure differently and confront academic obstacles.

The study by Sfard and Prusak (2005) highlighted the role that collective storytelling by parents and grandparents positively influenced students' academic performance. I can relate this to EDP students who speak to themselves saying: "I am smart, I cannot fail, I will do it, others have done it so will I", which serves to reaffirm who they believe they are, and can achieve, despite the difficulty they were experiencing. Moreover, this can be characterized by Lent et al.'s (1994) SCCT model as a personal factor.

The aspect of Bandura's (1986) SCT that appeared strongly in my findings are the two social cognitive variables, which are outcome expectations and personal goals. These variables influenced participants' career choices and persistence, and demonstrate how outcome expectations and personal goals play important roles in the self-regulation of behaviour. Thus, the following reasons that students gave for persisting such as 'want to help family', 'help me get to back to my initial career preference', and 'be a role model for my siblings and community members' can be classified as outcome expectations. In some cases, these reasons could be characterized by more than one aspect, thus 'help me get to my initial career preference, be a role model for my siblings and community members' reflect both an outcome expectation and personal goal. The study reveals that commitment to personal goals was a strong influence on students' persistence.

On the other hand, Bandura's (1986) SCT framework proposes that competent performance at difficult and challenging tasks generally requires both strong skills, and a strong sense of

efficacy to deploy one's resources effectively. Findings from the current study do not agree with this aspect. This is because when students were asked about how confident they were about their ability to succeed in chemistry, some of them said they were not sure they would pass, this was especially the case for MS students.

Self-efficacy played a role in the persistence of EDP students as the majority were confident of their ability to succeed in their studies when they enrolled in first-year, in agreement with Bandura's (1986) SCT model and previous literature (Ardura & Pérez-Bitrián, 2019)**.** It was not surprising that they possess a strong sense of self-efficacy because their high school grades were good; and some of them were the best (top-performing students) in their district and region, which also accords with Lent et al.'s (1994) SCCT model. As a reminder, one of the students mentioned that his teacher used him as a point of reference for other students to emulate. Additionally, he took 3rd position in a district competition in his region and was among the first students from his home town to attend university. An international student (EDP5) also mentioned that her high school grades were good and believed very strongly in her ability to succeed when she arrived at UCT. However, this strong sense of self-efficacy of these students was misleading; as self-doubt took centre stage when their performance did not match their expectations (poor grades), and some of them failed.

Moving into the extended programme helped to build back their confidence, they started telling themselves "I am smart, I can do it, I still have the brains". In another sense, one could argue that this strategy could also be a way of actually trying to convince themselves that they could succeed. Furthermore, the encouragement and support that EDP students received in the programme also contributed to their persistence. The opportunity to study in smaller groups helped them to build friendships, and get the help needed from tutors and lecturers; and through this process, some of them were able to overcome the difficulty in interacting with their lecturers. They overcame the inferiority complex associated with being 'a Black student' in an HWU, which shows signs of resilience, and became more confident about their ability to engage and complete their studies. The adjustment and increased confidence were helpful, especially in Y2 and Y3, because students were able to reach out to their lecturers more easily. Those who were failing behind took conscious steps to build their confidence by engaging in personal development and speaking positive words to themselves; which provided the necessary motivation to continue studying. Thus, self-efficacy seemed important in the persistence of these students and agrees with Bandura's SCT model.

Self-efficacy played a role in the persistence of MS students who had a strong sense of self-efficacy, which was tacit. They did not need to use words like 'I am smart', 'I know I cannot fail', but statements from the interviews provided evidence that they believed in their ability to

succeed. In contrast to EDP students, when asked how confident they were when they enrolled in Y1, there were few statements suggestive of absolute self-belief. Also, unlike EDP students, MS students did not refer to themselves as smart. There were no statements that indicated being used as a point of reference by their teachers in high school. MS students felt confident about their abilities and did not need to reinforce it by commenting during the interview. Their academic excellence was mostly inferred from their statements while trying to explain something else. For instance, the only MS student who talked about her academic excellence did so while trying to recount her frustration with getting a scholarship. She pointed out that although her grades were good, she was unable to secure a scholarship but did not express it to show academic excellence as observed with EDP students.

I argue that EDP students needed to refer to their academic abilities because this was probably the only way, they knew how to reinforce their personality. It might be the case that this was how they wanted to be seen and so repeating this statement on several occasions was an attempt at reaffirming whom they believe they are. They were building their own story of how they want to see themselves, and I refer to this as collective storytelling as suggested by Sfard and Prusak (2005); this study showed how the collective stories that students' parents and grandparents told them positively influenced their academic performance. Collective storytelling can also be considered as a personal factor according to the SCCT framework. The next section presents a comparison of the data obtained from Chapter 4 and this chapter that compares students on different measures.

5.6 Comparison of students on different measures

To effectively compare the data obtained using different measures (academic performance, career aspiration, and self-efficacy), I decided to divide the two groups (EDP and MS) into smaller sub-groups. These are (1) top versus poor performing students (2) strong versus a weak sense of self-efficacy and (3) strong career aspiration towards versus outside chemistry. It is essential to note that only those students who featured strongly (positive or negative) in the aspect under consideration were included in the analysis. For example, in dividing the students into the top and poor performers, students who were in the middle band (average performers) were not included. In terms of career aspiration only initial career preference statements were considered, there were significant cases of career diversion as previously mentioned. However, for the analysis, the emphases were on the initial career preference, and career values towards or outside chemistry were assigned based on this information. Table 19 shows a summary of how the values for the academic performance, career aspiration, and self-efficacy for the entire class were assigned. In assigning these scores, the

descriptors high, medium and low were used; the corresponding numerical values that I assigned without testing for validity and reliability are also shown in Table 19.

Table 19: Table showing how values were assigned to different measures

Career aspiration	+5 (high)	A career aspiration towards chemistry
	0 (medium)	Signifies that there was no specific career path. Confused about what career path to follow
	-5 (low)	Signifies a career aspiration towards a different discipline other than chemistry
Self-efficacy	1 (low)	Weak sense of self-efficacy
	3 (medium)	Undetermined
	5 (high)	Strong sense of self-efficacy
Academic performance		Calculated using the total score from Y1–Y3 and subtracting the class average. Example, if a student scored 60, and the class average was 55, the student was assigned a score of 5

Note: In assigning the career aspiration values I did not consider the fact that students initially indicated that they did not know what to do (career path to follow) either in high school or just before leaving school. I only considered the fact that they were able to mention the desired career they wanted to be. For instance, I assigned MS9 (+5) even though he initially mentioned that he did not know what to do in high school. However, he chose chemistry because of his teacher's influence and became passionate about a career in chemistry. For those students who were assigned '0', their statements all through the conversation indicated that they were not sure of what career path to follow.

5.6.1 Top versus poor performing students

EDP students

For those EDP students who were the top performers, I observed that they had a relatively strong sense of self-efficacy, and the majority had a career aspiration outside chemistry. While for those who were poor performers, there was a split between a strong and weak sense of self-efficacy, as shown in Figure 31.

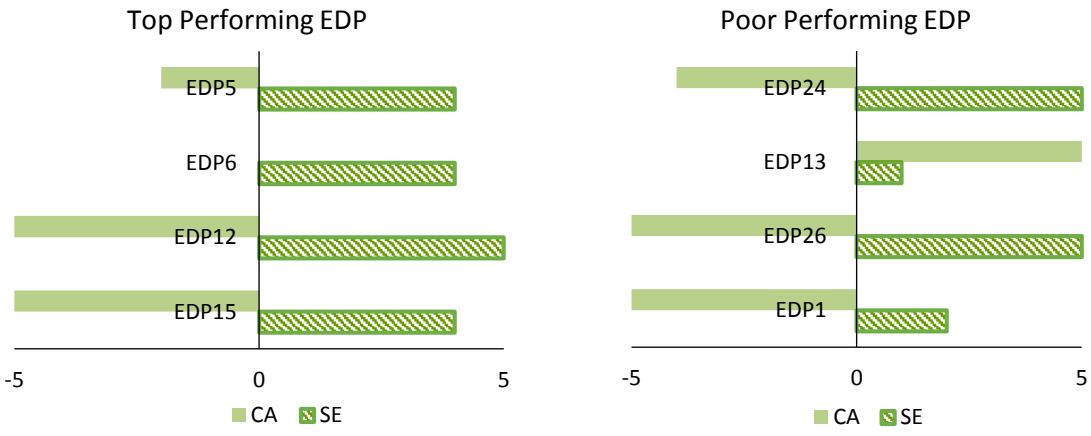


Figure 31: EDP students' self-efficacy and career aspiration (n=4)

MS students

For those MS students who were the top performers, their sense of self-efficacy was not as strong as that observed for EDP students. It is interesting to note that one student did not have a career aspiration. While for those students who were poor performers, one of them had a strong sense of self-efficacy and a career aspiration toward chemistry, as shown in Figure 32.

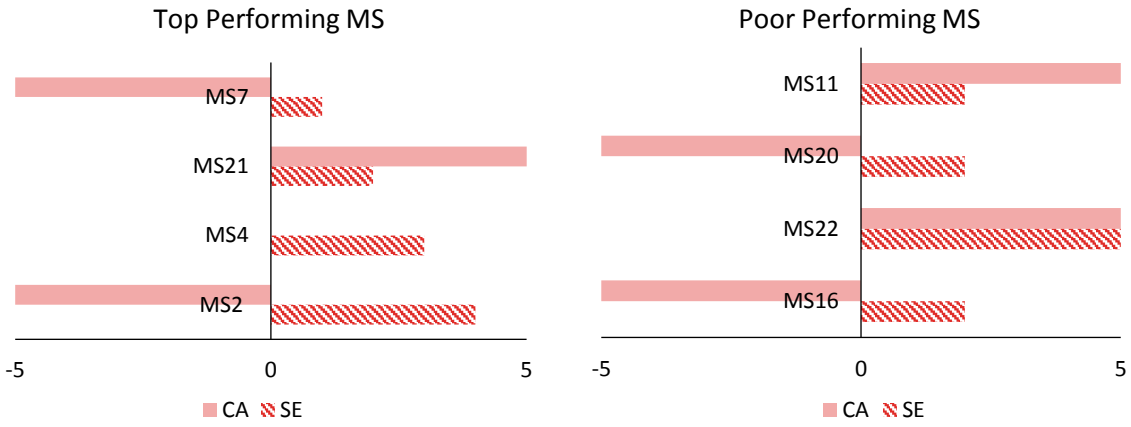


Figure 32: MS students' self-efficacy and career aspiration (n=4)

5.6.2 Strong versus a weak sense of self-efficacy

EDP students

For those EDP students with a strong sense of self-efficacy, there was no positive relationship between this and their academic progression over the years. As a matter of fact, except for EDP12, all students described in Table 20 were below the class average from year Y1 to Y3, and some of these students had to write a supplementary examination in CEM2 before they were able to pass. Thus, there was no significant positive relationship between having a strong sense of self-efficacy and performance, as seen for the group. Additionally, all students within this group had a career aspiration that was outside chemistry, and the majority wanted to be engineers and medical doctors.

With respect to EDP students with a weak sense of self-efficacy, what was rather interesting was the finding that their academic progression was not weak, considering that they were not confident about their abilities. First, I anticipated that their performance would be worse than those who were confident. Instead, I noticed that it was similar to those with a strong sense of self-efficacy; once again, the majority were also below the class average, as shown in Table 20. There were no significant differences in the performances for the two groups. Second, few cases of repeating an academic year were recorded, as the majority were able to pass their courses on the first attempt except for one student who mentioned the significant difficulty she

faced during her studies (EDP13). This finding was interesting because she was the one who desired to be a chemist, while the others had a career aspiration outside chemistry.

Table 20: Comparison of EDP students' self-efficacy and academic performance

Strong sense of self-efficacy and career aspiration					
	CEM1	CEM2	CEM3	Average	Career aspiration
EDP24	-3.6	2.5	-7.4	-2.8	Outside chemistry
EDP8	-9.6	-2.5	-0.4	-4.2	Outside chemistry
EDP12	9.4	8.5	8.6	8.8	Outside chemistry
EDP26	-4.6	-6.5	-5.4	-5.5	Outside chemistry
Weak sense of self-efficacy and career aspiration					
	CEM1	CEM2	CEM3	Average	Career aspiration
EDP1	-14.6	0.5	-6.4	-6.8	Outside chemistry
EDP18	9.4	-4.5	-4.4	0.2	Outside chemistry
EDP13	-1.6	-4.5	-8.4	-4.8	Towards chemistry

MS students

As was the case for EDP students, there was no positive relationship between self-efficacy and academic performance for the mainstream or MS cohort. I noticed that the performance of those with a strong sense of self-efficacy varied and some were above the class average in Y2 and Y3, as shown in Table 21 below. All the students in this category were able to pass all their courses on the first attempt. For those with a weak sense of self-efficacy, it was rather interesting because their academic progression was also like those with a strong sense of self-efficacy. However, unlike the previous group, some students passed their course on the second attempt. In terms of career aspiration, the majority from both subgroups had a career aspiration that was outside chemistry.

Table 21: Comparison of MS students' self-efficacy and academic performance

Strong sense of self-efficacy and career aspiration					
	CEM1	CEM2	CEM3	Average	Career aspiration
MS3	-8.8	11.3	2.6	1.7	Outside chemistry
MS2	19.2	31.7	24.6	25.2	Outside chemistry
MS19	-7.8	-1.3	7.6	-0.5	Outside chemistry
MS22	-9.8	-13.3	-15.4	-12.8	Towards chemistry
Weak sense of self-efficacy and career aspiration					
	CEM1	CEM2	CEM3	Average	Career aspiration
MS11	-8.8	-8.3	-10.4	-9.2	Outside chemistry
MS20	-10.8	-11.3	-16.4	-12.8	Outside chemistry
MS21	17.2	5.7	3.6	8.8	Towards chemistry
MS7	6.2	7.7	7.6	7.2	Outside chemistry
MS9	-3.8	-3.3	-2.4	-3.2	Towards chemistry

5.6.3 Strong career aspiration towards versus outside chemistry

EDP students

The cumulative score (CumScore) represents the average of students' cumulative performances from Y1-Y3 in chemistry, while SE represents self-efficacy (Figure 33). As seen from Figure 33 for the two EDP students who had a career aspiration outside chemistry, the CumScore score was higher than the class average (vertical axis). Whereas for the two EDP students who had an aspiration towards chemistry, the CumScore was below the class average. All students had a strong sense of self-efficacy.

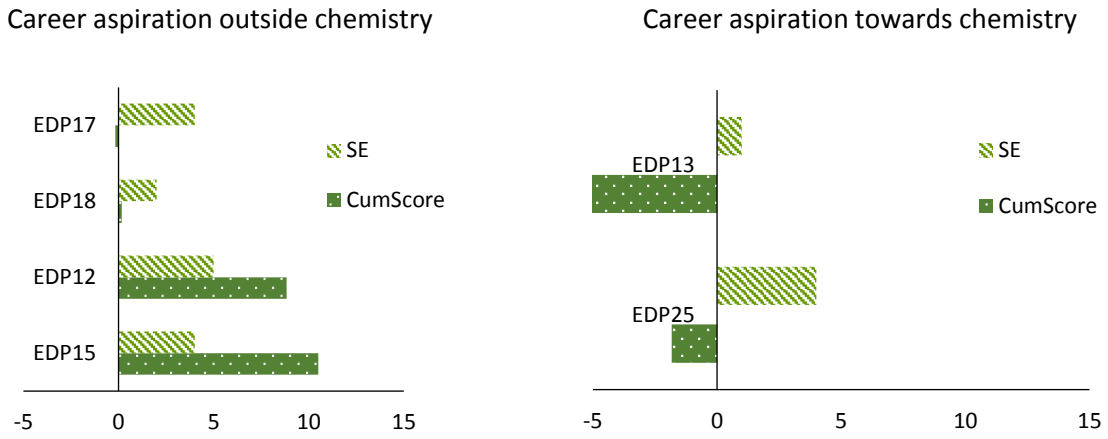


Figure 33: EDP students' career aspiration outside (n=4) and towards (n=2) chemistry

MS students

For MS students who had an aspiration outside chemistry, the chart (Figure 34) does not reveal much, except that two students performed well above the class average (vertical axis). Like EDP students, the majority of MS students who had an aspiration towards chemistry achieved an average performance that was below the class average except for MS22. Once again, all students had a strong sense of self-efficacy.

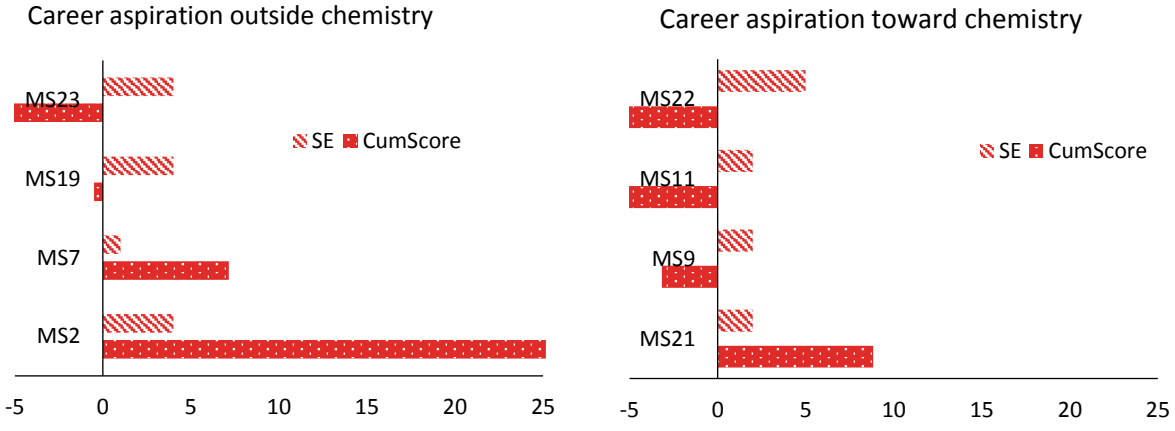


Figure 34: MS students' career aspiration outside and toward chemistry (n=4)

As seen from all the analyses thus far the attempt to obtain more insights by breaking down the class (EDP and MS) into smaller groups did not yield much information in terms of a relationship between their academic performance, self-efficacy and career aspiration. Hence, I decided to do a more focused analysis on some of the students who demonstrated a strong sense of self-efficacy and career aspiration to ascertain if any significant relationship could be established with their academic progression, and this will be provided in the final discussion in Chapter 7.

5.7 Concluding statements

In this chapter, we have seen that the major factor that influenced the movement of students towards chemistry was the denial of their initial career preference. For those who chose chemistry as a second-choice, previous academic achievement in the subject, which reflects aspects of the SCCT model, was significant in the decision process. On the other hand, those who chose chemistry as a first-choice explained that they had developed a long-time interest and passion for chemistry from high school. Interest, role models, expert advice and extra-curricular experience, appeared to have an important influence on students' decision to pursue BSc chemistry as a first-choice. Those in the partner-choice category were mostly motivated by UCT's requirement for a second major. For those students who chose chemistry as first, second and partner-choice option, there was a significant influence of both retrospective and prospective criteria, and so no difference could be established in terms of the dominant criteria employed in most cases.

A major difficulty that EDP students encountered was the notion, 'I am smart'. These students positioned themselves as intelligent students who could not fail because of their past performance in high school. However, they were disappointed with their results in university in Y1, as echoed elsewhere (Bangeni & Kapp, 2005; Case, 2007), because they could not measure up to the academic demand and workload. It was also clear that some students had difficulty communicating with lecturers and reaching out for help. The issue of overconfidence was also evident in the report by (Potgieter et al., 2015); some EDP students in my study developed this attitude because they had never experienced failure and were performing well. These students entered the mainstream system with the same approach and unfortunately came to realise that it was not sufficient for success. MS students, on the other hand, had a strong sense of self-efficacy, which was tacit. The next chapter expands on some of the issues that have been raised in this chapter, and introduces new information on students' university experiences.

Chapter 6: University experiences

This chapter gives an account of students' university experiences as it relates to studying chemistry. The chapter details the transition experiences, difficulties encountered during the transition and coping strategies that students adopted to overcome these difficulties. Moreover, support structures that students employed to help them to continue studying are noted.

6.1 Experiences: my varsity education and how I persisted

Each individual has a unique university experience, and an effort has been made to bring to the fore these experiences as observed from careful analysis of the data gathered. I begin by considering the similarities and differences between EDP and MS students in every possible scenario, especially when addressing the university transition experience as it relates to chemistry. In order to capture participants' responses most effectively and provide a detailed description of the case, I decided to formulate this analysis under the following broad categories: transition, emotional difficulty, time management, obstacles, handling difficulties and support systems.

6.2 Transition experiences in chemistry

It is helpful to remember that in Chapter 4, I indicated that the reason for the wave-like pattern (Figure 28) in EDP students' performance would be explained in this chapter. As will be seen, the transition experiences into chemistry for EDP and MS students from their first to final academic year was different. In order to capture participants' responses most effectively and provide a detailed description of the cases, the discussion will proceed via these sub-headings:

1) Transition into Y1
2) Transition into Y2
3) Transition into Y3

It is helpful to remember the following: Y1, Y2 and Y3 as noted in section 4.4 represent first, second and third academic year; for EDP students Y2 represents their third-year in university as described in section 1.1. However, to allow for uniformity during this discussion Y2 will be used to collectively describe the second academic year for both EDP and MS students, regardless of the number of years spent in university. Where there is a need to refer to EDP students' second-year experience in the extended programme this will be explicitly stated as 'EDP second-year'.

6.2.1. Transition into Y1

The transition experiences into Y1 for both EDP and MS students were significantly different as evidenced from data gathered in this study. The majority of MS students transitioned smoothly into Y1, while it was difficult for EDP students before moving into the extended programme. Afterwards, EDP students described the transition as "good". I will begin by providing a brief description of these two experiences.

The transition of EDP students into Y1

Over half of EDP students mentioned that before they moved into the extended programme Y1 was difficult: "*I forgot to mention this, before moving into EDP. I failed all my tests. It was hard for me at that time" (EDP15)*. Interesting cases were recorded of students who considered themselves bright and intelligent but failed the first class test as shown:

> So, when I came here, the marks you get from high school, good student, it was very sudden. I was shocked when the first decant test came out. And I failed most of them, and I was like what am I doing wrong, and everything (EDP5).

Failure motivated the move into the extended programme, and they considered it a better option because "[…] *that will make it a bit easier to pass it over the next two years" (EDP18)*.

Nevertheless, it is useful to highlight that the decision to move into the extended programme was difficult for the majority of students. For instance, EDP5 explained that when she failed most of her Y1 courses and was trying to decide what to do, a student advisor reminded her about the extended programme. However, the decision to move "*was a very hard decision in the beginning, cos you were like am I going to stay one more year?" (EDP5).* Similarly, another participant (EDP15) explained that she was 'grieved' and wanted to discontinue studying. However, after careful consideration and taking cognizance of the fact that she came from a rural school, and the benefits of the program, she moved; as seen in the next excerpt:

> What I didn't realise was that the programme was actually meant for my benefit. Because I had come from a village school. And so, when you get here there is that big transition. So, I decided, you know what this programme was created for people like me, and it will actually benefit me. Cos if I go into mainstream and I end up failing, it's going to be stuck in my transcript. And it won't look good (EDP15).

These students, who moved into the extended programme, later described Y1 as easy, because they realised that it was easier to deal with the academic workload as cited: "*So my first year done over two years I was cruising through it" (EDP15), "I think that helped me to get better. So, the first 2 years, I did quite well on the courses" (EDP5), "So after decanting that was when I was like now I can breathe and that sort of helped me to relax" (EDP17).* Furthermore, students reported that they received lots of support in Y1 in the form of multiple

tutorial sessions and assistance from lecturers: "*Also in chem, we had a lot of tutorials in EDP programme. We had like 2 tutorials a week" (EDP6)*, *"And we had Dr. DXXX and Dr. GXXX, so they were always hands-on with us, so that actually helped out, it really did help out" (EDP8).* Additionally, if they did not understand any concept, they had the opportunity to ask and receive help from tutors. The multiple tutorial sessions created more learning opportunities as students were able to devote time to their studies and engage with the learning materials.

The transition of MS students into Y1

MS students did not mention any difficulty with transition into Y1, as they described it as basically a minor increase in terms of content to what they had known from high school: *", […] because 1st year was almost like school chemistry, basic stuff" (MS9)*. "*First year was super easy for me. I didn't have much difficulty" (MS11).* In the next section, I will be describing the transition of both EDP and MS students into Y2.

6.2.2 Transition into Y2

Similar to Y1, the majority of MS students transitioned smoothly into Y2, while, it was difficult for EDP students as described.

The transition of EDP students into Y2

EDP students' transition into Y2 was difficult and represented a crucial time on which their persistence was pivoted. After this experience, they convinced themselves that they would survive the remaining years of study. Students indicated: "*the transition back into mainstream was one of the hardest thing" (EDP18),* and "*it was horrible with respect to chemistry (EDP12)"*. Furthermore, *"everything went down in terms of my marks" (EDP12*), and "*[…] it was a jump again. And I'm like 'oh my God and my marks went low" (EDP5),* while some **"***actually, failed chemistry in second year (EDP8).* These students were moving from a system that proceeded at a relatively slower pace and was more supportive than mainstream, and to which they had become accustomed. Hence when they moved into the mainstream system, it was difficult to keep up with the pace as recounted:

> So, in EDP we had this kind of slow and steady lectures […] we were still used to how the courses were like in 1st year. EDP sort of like help you, and give you the support that you wanted, and even the pace was very slow. A pace you get used to over two years. […] EDP18.

Likewise, some students described Y2 transition as an "*emotional roller coaster" (EDP6)*, while others used exclamatory comments like *"oh my God! NO, I am sinking" (EDP17*). A typical case is EDP6, who described her transition into mainstream as tough. She explained that it was hard for students to adjust to the system in mainstream because they had acclimatized

to the slower and relaxed pace in EDP over two years. So obviously going back to a system that was faster coupled with the increased workload was not easy. The salient issues mentioned by this student and others were the faster pace, increased workload, fewer tutorials, and less support, which made the transition into mainstream difficult. These factors will be discussed later, but it is worth recording her thoughts at this point:

> It was very tough [pause], especially coming from EDP that was rather relaxed compared to second year. Also, in chem [pause] we had a lot of tutorials in the extended programme. We had like 2 tutorials a week. Then coming to second year where you only had a tutorial, I think every 4 weeks or so. You don't really get a lot of interaction with the materials, whereas in CEM1009 and CEM1010 you constantly had tutorials, you were constantly interacting, and you know exactly what you knew or didn't know. Whereas with CEM2 you only know what you didn't know like 4 weeks down the line [laughter] (EDP6).

What were the issues that made the transition into Y2 difficult for EDP students?

Analysis of the interview data reveals salient issues that help us understand the factors that made the Y2 transition experience difficult for EDP students. These issues were mentioned by more than half of the study participants and included: faster pace, an increase in academic workload and less support, and insufficient time to study.

Faster pace

'Faster pace' was mentioned by the majority of EDP students: *"And now when you move into the mainstream [2nd year], now everything jumps or very fast" (EDP14), "they are very different especially the pace" (EDP17).* To better picture the difficulty that these students experienced they said that in comparing first and second-year course, it was to be expected that the second-year course would be more conceptually demanding than first-year courses; meanwhile, they were accustomed to a pattern that was slower than the mainstream first-year course. The conversation on faster pace was overlaid with the academic workload as seen in representative quotes:

> Meanwhile it was one module in previous year. So, for me it was quite hectic, cos now you just have to adapt to 4 modules. CEM1 to CEM2 was a big challenge for me […] It was now four modules. Meanwhile it was one module in previous year [deep breath] (EDP14).

> And also, CEM1 is slow compared to CEM2. So, we are used to something that is slower than CEM1 and now we jump into CEM2 and the pace is way too different […] That is the pacing that works only in EDP programme and if you get used to such a pace and then you get to CEM2 and they do 2 weeks of work in literally 3 days. There is literally no way you gonna keep up with that [...] Cos if you were dealing with the EDP programme alone you could cover work in like 3 weeks, which is covered in 1 week in CEM1000 (EDP18).

Still, on the conversation of a faster pace, a participant explained that when she transitioned into mainstream it reminded her of and felt like Y1 (when she failed all her tests) prior to EDP. It was tough, and she emphatically described chemistry in EDP and MS as totally different:

> But when it came to second year that was hard because we moved back into the mainstream chemistry. And for me decanted chemistry and the main chemistry is so different. They are very different especially the pace. So, when I got back to mainstream chemistry I felt like "oh no, I am going back to first year again, when I thought I am over this path, I am over this stress." It was like everything was going back again […] (EDP17).

Increase in academic workload and less support

The next issue that EDP students talked about that made transition difficult was an increase in academic workload and less support: "*The course was just more demanding I guess in terms of everything like pracs, theory, tests. So, I guess that's why" (EDP5).* Tutorials were recorded as a positive aspect of the extended programme. EDP15 remarked that in the extended programme the teaching was done at a pace that she referred to as 'slow', which helped students to understand the basic concepts. Hence, on transitioning to mainstream they were faced with two key issues: content (workload) and pace. Also, she mentioned that students had a lot of support in EDP because the lecturers made the teaching easier, and they had numerous tutorial sessions, but on transitioning into mainstream things changed:

> Yes, I was cruising in EDP [laughter]. Cos they made things easier for us. And I feel that in the EDP, our lecturers like Dr XXX she was very caring. She was for us. She took us through the courses and explains to us in the way that we would understand everything […]. It was a slower pace but we understood. They feed us with small content that went deep […] So that was easy for me […] Then going from there into 2nd year (i.e. CEM2) was not easy. My average even went down [pause]. I think I was not used to the pace of whole year courses especially chemistry. And considering the fact that I was coming from EDP. And also, we were studying things at a whole deeper level (EDP15).

In terms of academic support, EDP students appreciated the friendliness and personal attention from their lecturers. They were drawn by the care, encouragement, and support shown by the lecturers in the extended programme. Thus, it was not surprising that some of them referred to their mainstream lecturers as uncaring or found it difficult to connect with them as seen in a typical quote:

> So, transitioning into 2nd year, which was mainstream course, the lecturers they do care about us, but you don't relate with them. They teach us, but there was no connection. So that was one of the difficulty I faced coming from EDP […] (EDP17).

Insufficient time to study

Insufficient time to study was another issue that made transition into mainstream difficult for EDP students as typified: "*chemistry basically takes up a lot of time (EDP15),* "*it just requires so much time not just only to complete the assignments, but also in making sure you understand everything" (EDP17).* Some students mentioned that because of the workload in chemistry, they dedicated a lot of time to studying and *"sometimes forget that you have other (genetics) submissions to hand in" (EDP15*). In other words, because of the time dedicated to studying chemistry and trying to meet the deadline for submission, their other majors were sometimes given less attention. However, this complaint of not having enough time to study was not peculiar to EDP students, it was also an issue for MS students, especially in Y3; and this will be discussed later.

Finally, before I end this section on the transition of EDP students into MS it is important to mention that three EDP students mentioned that the transition into mainstream was relatively manageable. This was because some of them took a Y2 course while they were still in EDP (2nd year), which provided a "feel" for a Y2 mainstream course. As a result of this experience they were better equipped as indicated: "*But luckily for me, I took archaeology which was a 2nd year course, so by the time I got to 2nd year I already had a feel of what a 2nd year course feels like*" *(EDP12)*. In addition, having a strong network of relationship with students in senior years was another reason that made transition manageable. A typical example is EDP8, who explained that the transition into mainstream was manageable because of the strong network of friendships that he had built with other students ahead of him. These students were his friends in first year but because he moved into the extended programme, they were now a year ahead; so, it was easy for him to get help, advice and study materials from them. Hence, his transition was easier as shown in the excerpt:

> So, like I said earlier, I have a group of people that I work with. There are guys in CEM3 who went ahead of me. So now that those guys were in CEM3, they try to help out with some resources from their previous year. So, they will help out, and that helped. Like if there be something that I don't get [pause], I can ask them like "how do you understand this when you did it?" […] So yeah [pause] it's a matter of the people I had around me (EDP8).

Similarly, EDP12, mentioned that she had built a strong network of friends who were already in mainstream, and they kept her abreast with what to expect in mainstream, which helped. She said she was prepared for the transition because her friends already shared their experiences:

> The transition back to mainstream wasn't easy though. But It wasn't much of a shock anymore. Cos, I knew people who had done the course before me and they kept giving me clues […], So, the transition was very expected (EDP12).

It is pertinent to highlight a point made by some students; they said that before the transition into mainstream, in EDP 2nd year, the pace of programme increases but this was done close to the end of the second-year. This was intended to provide some experience of how mainstream system works, but students explained that the time frame was relatively short and did not give them enough time to adjust nor to acclimatize to the new pace as they were used to the previous slow pattern, as expressed in the conversation below:

> So, in EDP we had this kind of slow and steady lectures. A pace you get used to over two years. Granted they tried to do the transition into mainstream just before the end of the second year, for us to have a feel of how mainstream is going to be. But the issue is 'they only do that towards the end of the year, and you have literally been on slow and steady, chilled for a fraction of a year and six months. so that is a long time to get used to something and now you are given like three weeks to just change it […].
>
> I agree that it is a good choice to try to get people into the transition however that doesn't give us enough time to like get used to the pace. […] So that is a lot hard and you need to develop skills that you will need in CEM2 which are totally different from EDP programme, which is a slow programme […]. So, for the transition, you need to now develop new study techniques which you will need for a fast course. And for you to develop these new techniques takes a while (EDP18)**.**

The transition of MS students into Y2

The majority of MS students described the Y2 transition as manageable despite the increase in academic workload. It also became more difficult compared to Y1, but it was still something they could handle as seen by the following statements: *"So chemistry it was fine, it definitely got more tricky but it was manageable" (MS4), "Second year was chilled" (MS2), "I will say there was the same standard of difficulty, but now just more work" (MS11)*. A typical example is MS2, who explained that Y2 was manageable and relaxing because she was able to organize her schedule and study at her own pace:

> I found that the change from 1st year to 2nd year was very great. I think the transition was lovely. It went from very pressured to low pressure […] 'you have to do this prac, you have to do this tut and then to a place where everything was a little bit of more hands off.' A place where you need to be OK. Do what you need to do [...]
>
> But with that there was also a decrease amount of tut and decrease amount of prac and those kinds of things. You finally get a chance to like [pause] actually I can breathe. And I can focus

> on actually studying and assimilating materials. Rather than just running through everything, trying to get it done. And so I enjoyed the transition from 1st year to 2nd year (MS2).

As seen from the account above, she appreciated the fact that Y2 allowed her to organize her reading, too many tutorial sessions were not a positive experience for her. This finding is a direct contrast to EDP students who appreciated the multiple tutorial sessions in the extended programme. When they moved into mainstream the decrease in the number of tutorials was a major difficulty, as previously mentioned.

In contrast to MS2's experience, two mainstream students described transition into Y2 as difficult. A typical case is MS9 who explained that he enjoyed Y1 as the courses were more like high school topics in physical science, but when he moved into Y2 it was difficult because he encountered harder concepts like integration in physical chemistry:

> Whereas when we got to CEM 2005 it became like menhhhh! (pause). Integrating stuff came into the chemistry, and it was hard to understand some of the concepts. I will say it was the biggest jump that I have done compared to other course I had done, like biology, biochemistry. But the chemistry jump to 2nd year, was probably the biggest jump I have ever seen in my educational career so far (MS9).

The other MS student whose account showed she found Y2 mainstream to be difficult was MS7. She said initially "*It was a very good transition from 1st year to 2nd year in chemistry, because 1st year was almost like school chemistry, basic stuff*" but it became more difficult in Y2 as stated:

> But then 2nd year chemistry was very different from 1st year chemistry, especially because of all the thermodynamics stuff. And so, I had to struggle with that [pause]. And obviously we started seeing the maths and things got a lot harder, like when you have to do those 'derivatives, integration and stuff' […] So yeah, I felt like that whole section was very difficult especially when you are not good at maths (MS7).

Further analysis of students' statements revealed that physical chemistry in Y2 and organic chemistry in Y3 were experienced as problematic modules. Nevertheless, a feeling of a sense of accomplishment in meeting the academic demand was expressed by some students as seen in a typical quotation: *"It actually gave me a nice feeling to get done with a course and pass it" (MS10).*

6.2.3 Transition into Y3

The following paragraphs report the Y3 transition experiences of EDP and MS students, respectively. It is helpful to recollect that EDP students experienced great difficulty when they transitioned into mainstream, whereas more than half of MS students handled the Y1 to Y2

transition well. In Y3, however, opposing experiences were recorded because unlike Y2, it was MS students who described the transition into Y3 as difficult and the most challenging in their educational career, while EDP students handled this transition well.

The transition of EDP students into Y3

The extended degree students said they were more prepared for the transition into Y3 and found the course manageable despite the increase in the academic workload. This preparedness was because they had already experienced the to transition Y2 and this experience built the stamina for Y3, and made them more stable emotionally and academically. So, transitioning into Y3: *"It wasn't much of a shock anymore. Everything was expected. The workload was more manageable" (EDP12)*. While others said, "*But at least since we have done the transition, we now understand how fast we have to move" (EDP18), "[…] we were now more prepared because of the way second year came" (EDP5).*

Furthermore, they described the content as having the same level of difficulty compared with Y2, although it was extensive as noted: *"I feel like 2nd year teaches you how to work efficiently enough. For 3rd year they just pad in a little more work, and that's it. It was easier to handle" (EDP14).* Based on these comments, it would not be out of place to say that Y3 transition was well managed by the majority of EDP students. Additionally, some of them said "*I am glad now cos my average went up in 3rd year. I am doing well. I even want to go into honours now" (EDP15)*. A student explained that she was well prepared for Y3 because she had friends who were in Y3, and they kept giving her clues on the Y3 experience (EDP12). It is helpful to recollect that she was one of EDP students who explained that the transition into CEM2 was manageable because she had friends in mainstream. She maintained this strong link, which proved helpful as detailed in the extract below:

> Everything was expected. It wasn't much of a shock anymore [...] Cos, I knew people who had done the course before me. And they kept giving me clues, hey! 'You got to know that you will be having two practical per week, and two hand-ins'. So, they kept describing everything. And I also kept asking. They also told me they were struggling with organic chemistry. So, the transition was very expected (EDP12).

The transition of MS students into Y3

MS students described Y3 transition as the most difficult and challenging time in their studies as seen in a typical quote: "*2nd year to 3rd year transition was super difficult and the biggest" (MS3).* The content was more complex and there was a very high expectation from the lecturers especially on how well they should understand certain concepts thus: "*It's been pretty tough and they have expected a lot from us this year, compared to 2nd and 1st year (MS4)".* Unfortunately, students felt that they could not measure up with the expectation from the

lecturers, which resulted in immense pressure. One of the interviewees, MS2, who earlier described Y2 as smooth and relaxing complained about the transition into Y3; she described chemistry at a third-year level as "*crazy and too demanding*" and said:

> From 2nd year to 3rd year, that it was VERY high, and very difficult. I found that to be the most difficult jump. It was just crazy because CEM3 was something else. I think number one the content. And number two how deep you are expected to understand things in 3rd year (MS2).

What were the issues that made the transition into Y3 difficult for MS students?

Careful analysis of the interview data reveals prominent issues that need to be described to understand better what made the transition into Y3 difficult for MS students. It is important to note also that these issues were mentioned by the majority of MS students and includes: difficult content, increased workload and high expectation from lecturers.

Difficult content and increased workload

The issue of difficult content will be discussed with increased workload as they show considerable overlap. Most MS students mentioned difficult content: "*I think, number one, the content" (MS2*), *"I don't know how to describe it. But I know the workload triples" (MS9)*. As an example, MS3 described her transition into Y3 as difficult because she struggled with understanding the content of the courses that were taught especially organic chemistry: "*But it was super difficult especially organic chemistry" (MS3).* Other students also commented on their struggle with understanding the concepts in organic chemistry, and referred to it as a general problem, which was facing the entire class as seen in their respective accounts: *[…] but for our class in general people have struggled especially with organic chemistry. I am sure you have heard from the others (MS4):*

> And concepts like organic chemistry was not too big in 2nd year, but now in 3rd year we spend a lot of time on organic chemistry. And it has actually been difficult for a lot of people in my class (MS9).

Organic chemistry was a problematic module to both EDP and MS students as they referred to it several times while recounting their Y3 experience: "*I struggled a lot with organic chemistry" (MS2), "But for this year, organic chemistry has been the problem" (EDP15), "And then transitioning into 3rd year, it's just been organics [pause] just organics [laughter]" (EDP6), "The content was so much harder especially the organic" (MS7),* and this contributed to making the transition into Y3 difficult. This observation was not too surprising given that organic chemistry has a bad reputation as being difficult (Katz, 1996).

Students talked about the increased workload in Y3, and that it was difficult to cope with the daily routine of long hours of lectures, assignments as well as two practical sessions per week,

both of, which required lengthy reports. Additionally, Y3 required a new set of skills to effectively deal with the academic demand, which the majority felt they were not equipped with, and this made the transition problematic. Furthermore, a student said because of the pressure she resorted to memorizing concepts solely for examination without understanding: "*So when it gets to things like this that I don't just understand, I simply cram it especially when I need it for an exam. But I don't just get it" (MS3).*

High expectation from lecturers

High expectation from lecturers on how deep their understanding ought to have been on certain concepts, was also one of the issues that made the transition into Y3 difficult. The lecturers made them feel their background was too weak for Y3 chemistry course, and it resulted in academic pressure and stress as seen in some typical quotes:

> And for me this year one of the other challenge was the fact that I felt a lot of pressure to do well […] And number two how deep you are expected to understand things in 3rd year. But in second year it was very shallow. Like we did quantum mechanics completely for the first time this year, and yet we were expected to have very deep understanding and I was like, this is the 1st time we are doing this. I understand that it is 3rd year but I felt that the jump was very, very big (MS2).

> It's been pretty tough and they have expected a lot from us this year, compared to 2nd and 1st year. They didn't give us a good enough background in 1st and 2nd year, and then suddenly it's like this year, they expect us to know everything [laughter]. And like understand all these reactions and I'm like "NO, I don't" [laughter]. And just like a lot of time. It's understandable it's a 3rd year major now. But it was a big transition (MS4).

It is useful to highlight the two quotes shown above were from the top-performing students in this class of third-year students. So, if these students found this expectation onerous, it helps us to picture how others may have perceived it. Thus, it was not out of place for some of them to have referred to it as a general problem facing the class as seen in an earlier quote. As a final point on this aspect of increased expectation from lecturers, it is important to note that this issue was also mentioned by an EDP student (EDP15). She explained that the expectations were difficult to handle and caused a lot of pressure. She went on to suggest that it would be better if the level of teaching and pressure at all levels remains relatively smooth as this would make the movement from one level to the next easier. The skills developed in previous levels would then find a useful application in subsequent levels, rather than placing students in a situation where they would have to start developing a new study pattern at final year; at the stage of almost concluding their studies as recounted:

> So, if they make the system the same i.e. the teaching-learning system should remain the same, the amount of pressure should be relatively close, or almost at the same level […] But if you want me to change to XXXX method when I am already in 3rd year, when I already have so much pressure and work on me, it's not gonna work out [...]

These sentiments are echoed by EDP 17 who said:

> They are like 'you ought to know this, you ought to know that'. And you are like 'but I am not prepared, I have not been prepared for this'. And you are like how am I am supposed to know all of this? So now you end up catching things from second year. And you also have to start changing all of your learning system and that is a lot of work honestly. And it can drain you emotionally, physically and mentally. And you end up not performing well in your academics […]. And you begin to ask yourself 'what do I know?' what exactly do I even know. When everything they say is 'you ought to know this, you suppose to know this by now.' And I am like I don't know none of that. And that is really so sad, you feel sad (EDP17).

6.3 Emotional difficulty

In presenting these findings, there will be no need for categorization as both groups experienced significant levels of emotional difficulty at different stages. Hence, the discussion will be presented collectively, and specific references will be drawn from either group as necessary and applicable to illustrate important points. The majority of the students said that the "*[…] emotional part was the hardest" (EDP17),* and this will be discussed in detail under the following headings:

1. "Hurt me bad"
2. Difficult time
3. Disappointment
4. Dislike

It is important to note that financial difficulty was also identified as a stress factor that affected students' mental health and caused great distress. However, this will not be addressed in this section but will be discussed later under obstacles.

6.3.1 "Hurt me bad"

"Hurt me bad" is an expression that was used by a student in describing the emotional difficulty he experienced during his tertiary education, especially when he failed (EDP8). I created this category because it captures students who experienced extreme emotional hurt that nearly resulted in the discontinuation of their studies. I will bring in other cases that fall under this category; although the expression 'hurt me bad' may not have been used by these students.

For instance, EDP8 experienced considerable emotional difficulty and hurt when he failed a course; this pain was exacerbated by the hurt, which his parents felt when he told them:

> […] And then for the first time I now failed a course, that hurt me bad. It really hurt me bad. And now when I told my parents, they were a little bit hurt by that, and that hurt me back (EDP8).

The emotional struggle for this group of chemistry students ranged from dealing with the feeling of hurt or sadness to the extent of the hurt affecting their academic studies; where they begin to fear that they would fail or to anticipate failure: "*But there have been times when I felt stressed out. I felt like the workload is too much I'm not gonna pass" (MS11).* In some instances, this fear of failure led to failure as shown: *"I failed all my tests. It was hard for me at that time and it was hard" (EDP15).* Typical cases will be used to describe the categories above. The first category of students who experienced emotional hurt and sadness is illustrated in the narrative of EDP1, who at some point feared that she had not met the minimum requirement for the course as reported:

> As an example, in 1st year I failed all my test, except that one and obviously that was really very emotional for me, cos I used to cry. I cried very much, because I felt like I wasn't gonna get my DP[1] (EDP1).

The second category consists of students who were emotionally hurt to the extent of it affecting their studies, where they began to fear that they would fail. A typical example is MS10 who explained that when he was not performing well in his studies, he was emotionally disturbed, and this affected his academic work because he was worried about not satisfying the minimum requirements for postgraduate study:

> And at that point I wasn't doing so well in tests, and I wasn't sure that the grades I have will be able to take me into honours. So that was one of the things that weighed me on my mind. I was also thinking it might probably impede me in my future (MS10).

6.3.2 Difficult time

Accounts from students during the interviews depicts the difficult time they faced that made university education challenging. A careful distinction must be made at this point because this section describes 'difficult time' in the context of emotional difficulty for this cohort. Other contributory factors or situations unrelated to emotional aspects, such as finances that had a negative impact on students will be discussed later (section 6.5.3). Emotional difficulty, such as stress constituted a difficult time that challenged students. For instance, EDP12 explained

[1] *A Duly Performed, DP, certificate is issued when a student has met the minimum attendance and work requirement for a particular course and is required to write the final examination in a course.*

that stress had been one of the most challenging issues that she had to deal with; which at some point impeded her optimal academic performance:

> Specifically, within my studies, I think 'stress' is the most difficult. Stress doesn't allow you to get to your optimal level. Cos sometimes when everything hit you all at one time, that's a challenge. There are some weeks where you have tests, submissions, and everything just hypes up. And that stress just hypes up. And you get so drained, almost like I AM DONE [laugher]. So that was challenging. And you just start telling yourself, I just want to go home, I don't want to study anymore (EDP12).

Also, an international student (EDP13) explained that she experienced a mini-breakdown due to deep emotional drainage, which was difficult to handle. Subsequently, she opted for support from her family by travelling home, which proved valuable.

Moreover, another issue that constituted a difficult time emotionally for students was when they had worked hard but did not achieve the desired results as seen from the perspectives expressed: *"And it is very emotionally draining to know that you work hard on something and then you don't get the result. It is really emotional draining" (EDP17).*

> So, in chemistry, I always felt like my marks didn't go according to my passion. Everyone else will look at my marks and say 'why are you still studying this? you are obviously not good in it'. This is because my marks were REALLY BAD. Even in 2nd year I cried a lot […] So I never felt like 'oh, I worked hard and this is the fruit of my hard work' (EDP1).

6.3.3 Disappointment

Some students expressed disappointment and regrets in deciding to study chemistry because, first, the course did not turn out the way they wanted as quoted: *"It is very different from what I originally thought it would be" (MS7).* Second, students had unrealistic expectations about chemistry course as clear from the perspective shared: *"I literally thought most of the time I will be in the Lab, combining chemicals and doing experiments of my own choosing [laughs]" (EDP18).* Third, others misjudged tertiary level chemistry by comparing it with high school chemistry; based on their academic achievement in the subject during high school. As earlier recounted some students decided to choose chemistry based on their high school performance in the subject, however, they later came to realise that they could not measure up with the academic demands of the course at tertiary level. This realization resulted in shock, disappointment and regrets. Students could not measure up to the academic demands as most of them described the workload in chemistry as too demanding and difficult. Hence, they were "*always on a catch-up game, which is not nice" (EDP6)*, and this resulted in discouragement *"because […] honours will be worse" (EDP17).* A typical case of a student

who expressed great disappointment and regretted her decision to study chemistry when she was unsuccessful in her initial application to medical school is reported:

> […] And then yeah [deep breath], this has been the hardest year of my life. And now I am doing 3rd year chemistry which I don't enjoy. It is very different from what I originally thought it would be. […] And I just think, if I could go back I will make sure that in 1st year I really understood the foundation of all the concepts because I feel like now in 3rd year I have so much gap in my knowledge (MS7).

6.3.4 Dislike for chemistry

As captured in a participant's statement: *"Yeah, because it is difficult to continue to enjoy something that you struggle so much to understand" (MS7).* This feeling of dislike holds for some of the participants who expressed great disappointment in opting for BSc with a major in chemistry and said, *"I don't like chemistry" (EDP12*). It is relevant to note that these students who expressed a dislike for chemistry clearly stated that they were leaving chemistry and they were not interested in pursuing further study in the subject. For example, EDP17 remarked that she is not interested in pursuing postgraduate honours in chemistry:

> So, for me my experience with 3rd year chemistry made me realise that I actually don't want to do chemistry honours. Cos my thought is that [pause]: if it is like this in 3rd year then how much more in honours and postgrad? Then I told myself there is no way I am going to continue with chemistry. So, I am running to engineering [laughter] (EDP17).

6.4 Time management

During the conversation with this cohort of undergraduate chemistry students 'time management' was identified as a factor that helped about half of them to manage the academic workload as shown: *"I also learned about time management" (EDP1).* For instance, EDP12 mentioned that she learned time management skills, which proved very useful when she transitioned into MS. She also emphasized the need for students to work hard from the beginning of the semester to avoid panic as best described in her own words:

> I will stress that it is important to manage your time properly […] So, I had to plan on how to split (manage) my time right from the beginning, and I also knew I had to work hard right from the beginning […] I think doing your work consistently throughout the week is good. Studying in bulk gives you a sense of panic. You just start panicking cos everything looks a lot […].
>
> If you have tutorials just start working on it. If you have a submission just start working on it, instead of leaving everything to do by the weekend in bulk […] cos chemistry basically takes up a lot of time, and you sometimes forget that you have other submissions to hand in. But I think splitting up my work helped me (EDP12).

At the other extreme, poor time management proved to be a problem for some students. As an example, a student's inability to effectively manage his time adversely affected his studies: *"I started making friends I started slacking, and then that reflected on my marks also" (MS16).* The social environment in university has the potential to either positively or negatively affect a person's studies as the majority of the participants in this study acknowledged: *"In first year there is a lot that goes on in our mind apart from academic pressure, like social pressure and stuff" (EDP17).* This statement matches the experience of MS16, who explained that one of the problems he faced in his studies was time management. He was unable to find a proper balance between his studies and social life. He spent more time socializing and this affected his studies negatively as described:

> I still do enjoy studying chemistry although my marks may not reflect it […]. And I haven't had the right balancing, that is how to be able to balance my social life and academics […]
>
> I think it is a matter of the whole process of growing up in varsity as well. Especially when you include the social sphere in varsity. This has had quite some effect on my academics [pause]. And I haven't had the right balancing (that is how to be able to balance his social life and academics). And this is because I am a person of so many friends. So, I have been spending little time towards my studies (MS16).

As a result of his experience, MS16, gave a word of advice to incoming undergraduate students: *"Prioritize time. I will say do whatever you want to do ONLY AFTER your school work is done" (MS16*). He went further to explain that he has a younger brother in high school, whom he is already mentoring on how to handle social pressure in university; because he does not want his brother to find himself in the same situation as cited:

> […] cos I have a younger brother and I have started drilling that in him already. And he is a top student now right from his primary school. So, through my failures, I will rather see someone else succeed. That's it (MS16).

6.5 Obstacles

In this section, I will be discussing amongst other issues the issues that made the academic experience of students difficult, which I refer to as 'obstacles.' These obstacles, as revealed from analysis of the research data, included long practical sessions leaving insufficient time to study, protests, financial issues, language barrier, failed course and loneliness. Each of these obstacles will be discussed in the following pages.

6.5.1 Long practical sessions leaving insufficient time to study

Long practical sessions will be discussed together with insufficient time to study as they show considerable overlap. Students said it was difficult for them to keep up with the demands of attending lectures, practical, tutorials and engaging in personal study. Hence, they were always struggling to catch up as is well described in a typical quote:

> So, you see you are always on a catch-up game, which is not nice. Cos, you are left behind on a lot of things. You get to lecture and you are lost because you didn't have time to read before coming. You are lost, you are not listening and everything becomes a big cycle (EDP17).

Students cited the two practical sessions per week in chemistry in Y3 as one of the things that made it difficult because *"the pracs in chemistry definitely consume a lot of time. Especially organic chemistry pracs" (MS16).* Additionally, *"the pracs took more than 3 hours, and it usually takes 3-4 hours to do each write up. And now we've got two of them in a week" (MS11).* Hence, on a weekend *"I spend 6 hrs to write a report […] That's not even studying, but just only writing up the report" (MS3).* Thus, the combined effect of the two practical sessions per week, the long hours for the laboratory sessions, and the time required for completing the reports had a considerable effect on the time available for study as best captured in the excerpts below:

> And now we've got two of them in a week. So you go home on the weekend, and you spend about 8 hours doing each of these pracs. Whereas in earlier (previous year) you could have just spent 4 hours on it. And then use the other 4 hours to be studying your materials. So imagine what happens when we have other papers to submit or a test coming up the next week! This makes you not to prepare properly for it. So I think pracs took up too many hours (MS11).

> But then we had to arrive at 1 pm for organic pracs and then at 5 pm we still weren't done. And they were just long. And then you'd have to come back the next day and finish, and still have to do the report. But then at the beginning they must set out more time for it. Because like when you are running out of time and the demonstrators are rushing you, and that not so nice (MS4).

Accordingly, a student (EDP17) explained that she could not follow the advice by lecturers to read and reread notes because of insufficient time. The inability to do so was made worse by the fact that she also had two practical per week in her second major: *"I have two practicals per week for geology and chemistry. For geology, sometimes you have to stay till 7 pm in order to finish the practical" (EDP17)*. Thus, she basically completed four practicals per week, and was expected to write and submit reports on each, which left her with less time to study as narrated:

> They advise us to study pre-read and after the lectures re-read again, but then where am I getting the time to do that? And again, I still have to do the write-up. So during the week you

> are trying to study so you can be on point for lectures but then you during the weekend all you are doing is writing report. And honestly when you have a test, YOUR LIFE STOPS and it is all about the test […] (EDP17).

This issue of insufficient time to study was a major issue, especially for those who had a second major in geology or genetics. These majors also had two practical sessions per week and a student said:

> The only reason I found it to be quite a problem is because I am doing two courses and both of them have two practicals in a week. That literally made life difficult [pause]. I just couldn't face the week (EDP18).

Consequent on this overloaded calendar when students get home, they have no time to study nor engage in other activities as described in the respective quotes:

> This is because I have two pracs per week for geology and chemistry. So, I am on campus till 5 o clock every day of the week except for Monday. And then both [practicals] needs write up, so I have a report that I have to write essentially every single day of the week [...] That doesn't give me time to go look at my school work […] And so that has also been a challenge (MS16)

> So, you travel and we only realistically get home at 6 pm. And we live by ourselves and so you have to go to shops to buy food, you have to cook food, you have to clean your house and then you have to shower. And all these normal activities take time, it's not like you get home at 5 pm and you are going to immediately start working at 5 pm […] So, there are other stuff that also take time. For example, if you want to exercise that takes 1 hour a day. If you want to go to gym, drive and come home that may take like 2 hours. So, by the time I get home and I also have to do laundry and the other stuffs it's like 10 pm. And by the time I have to spend an hour making a graph on excel to do a write-up and that takes till 11 pm […] And then I have to go to bed cos I have to be back here the next morning (MS7).

It is essential to highlight that, one of the issues students complained about concerning the practicals in Y3 was that in most cases, the schedule was not aligned with what they were learning in class. As a result, this made it difficult to understand the concepts that the practical sessions were meant to reinforce as is evident in these extracts:

> And also the problem I have with it, is that it didn't coincide with what we were learning. So we do a particular prac in the beginning of the year and we get to learn about the actual thing in class at the end of the year. So we are doing this practical as an example, and I actually don't understand what is happening (MS11).

> And only in 6 months later was I able to say 'oh, that practical make sense'. But then it was useless to me cos I am not going to go back and read the practical I had done 6 months ago (MS7).

In terms of aligning the practical session and theory taught, MS11 remarked that the practical should follow the concepts being taught, and not the reverse. The following statement supported this view:

> I feel like it will be better, if we learn this week, and do the practical for what we have learned the next week. Then that will be very good. So, doing a practical in January and learning about it in September is not useful (MS11).

> I think they should make sure the practical is concurrent with what we learn in class. Cos many pracs this year we did before we have done it in class, so then it doesn't make sense. For example, we did CXXX session recently but I have learned that theory like in February this year, and so we didn't understand (MS7).

These statements and suggestions are consistent with the study by Southam et al. (2013) who found that alignment of theory and practical sessions enabled students to gain a positive experience of the laboratory sessions and to maximise both conceptual and technical benefits of the experiement.

As a final note on this aspect, some students gave suggestions on how the issue of long practicals coupled with insufficient time, could be curbed or tackled. For instance, MS7 and EDP15 mentioned that it would be better to have fewer lectures and one practical rather than just rushing over many concepts, which did not allow them to learn properly:

> I would rather prefer there were two chemistry lectures a day, once you do the content then in the next day you would walk through it slower and with examples on what you have learned. Than just rushing and tapping on so many things different things but you don't actually understand any of it […] (MS7).

> But because they are so long. You don't spend your time doing them trying to understand, you just do them trying to finish. The emphasis was more on finishing and not really understanding. So, in a way you don't get to learn much (EDP15).

Additionally, MS11 said "*I personally think that chemistry should be a major by itself"* because combining chemistry with other majors makes it difficult. Moreover, EDP6 also expressed her perspective on learning in the Faculty, as shown in the respective accounts below:

> With all the lectures and two practical per week, and tutorials and test, I think that's enough. There shouldn't be something else added […] [pause] I think organic chemistry should maybe be a course, and inorganic should be its own course (MS11).

> I think the biggest issue with university generally, especially the Science Faculty because we have pracs and tutorial which are compulsory. So, for example first year you start at 8 am, cos you have maths. You have classes until about 1 pm cos you like have 4 classes and you have an hour break between [during the morning]. And then you have tuts or pracs from 2-5pm. So

> by the time you get home, you haven't even looked at what you've done for the whole day (EDP6).

Furthermore, MS11 explained, "*I had to choose environmental science because I needed to choose something that will NOT BE too time-consuming, in order to concentrate on chemistry"*. He also suggested that it would be better if chemistry was divided into two courses, one per semester; because since it is a whole year course it makes it more difficult that *"you have to study stuff from the beginning of the year" (MS11).* Besides, MS3 shared her experience on the choices she was forced to make:

> And you have to like sacrifice your other course [laughter] for like another one, and on it goes. So I left my physics test for my chemistry test [...] That is just to show to you how the time is so short, and you have to compensate for your one course with the other" (MS3).

Moreover, (MS10) suggested that if the two practical per week in Y3 needs to be retained, then it should be for only the first semester as this will free some space for the students in the second semester as described below:

> It will be better if we did the double pracs per week for just one semester, instead of having all through the year. This will actually give the students an opportunity to at least breathe. Cos sincerely combining everything the way it is, is strenuous and very demanding (MS10).

It is pertinent to state that not all the students were dissatisfied with the practical sessions. Some students saw them in a positive light and acknowledged that "*it helps us to master how to write up efficiently and manage time efficiently" (MS9).* While others said:

> I think that's like a very relevant part of our course. Cos sometimes you don't understand the stuff they teach during class, but when you actually get to see it and do it yourself, you get to understand and appreciate it more better especially organic pracs, but for physical chemistry, NO. (MS4).

For instance, one of the students explained that she did not have issues with the practicals because*: "If you want to go further in your career in chemistry like research, this will be like your every day. It will be practical. Obviously, you will do some theory, but mostly it will be practical" (EDP5).*

On the other hand, few students disagreed with the sentiment expressed by EDP5: *"This is because you are spending your time sometimes on pointless things in the laboratory, and you not having the time to actually engage with the information" (MS7).* This sentiment was closely linked with the long hours required for the laboratory work and completing the report, as seen:

> I feel they should reconsider the time spent on it. That's not to say I don't like Labs. I do. I do enjoy being in the Lab, but I feel they are too long. And the output I don't see. In essence, what

> I'm saying is that the output from the practical session doesn't measure up. I wish and I think it will be better if those times were spent on consolidating my theoretical knowledge or getting deep knowledge in chemistry (EDP1).

6.5.2 Protests

One of the obstacles that students identified that adversely affected their studies were the protests for free education tagged 'fees must fall' as seen in the following quotes: *"So, the couple of years was challenging with fees must fall" (MS3).* They explained that *"the uncertainty in the university was just too much" (MS3)* because of the protests, and this made learning and studying difficult. Thus, there was increased emotional stress in the form of panic, anxiety, fear, depression, which affected their mental health and made it difficult for them to focus on their studies as stated:

> Here is, one big issues that I faced. Over the years there has been protest. And I can't really study well when things are uncertain. I try as hard as I could but I can't Yes, it is one of the things which makes my studying a little harder than it is supposed to be (EDP18).

Some of the students indicated that they contemplated discontinuing their studies because of the uncertainty caused by the protests, while others described the environment as not being 'nice' or "friendly" anymore. This is best described in the students' own words:

> Wow! [pause] 'FEES MUST FALL' [deep breath] Fees must fall was also a problem. I get the reason for fees must fall and I definitely support it, but the uncertainty was a lot. It was like do I study, do I not study? [...] The space was not nice, the campus felt like it was a war zone. And you don't just feel right. Like last week I felt so bad for the protesters and I felt like I just want to go home.
>
> Cos you tell yourself I support the protest but at the same time, I also want to study. So, you are split in half. And you just start telling yourself, I just want to go home, I don't want to study anymore (EDP12).

Moreover, MS4 mentioned that the unrest on campus triggered by the protest caused significant emotional difficulty such that she was no longer motivated to study. While she understood the struggle for free education, she said that protesters needed to recognize the disruption their activities were causing in the university. As a result of the protests, she had become discouraged about studying further in South Africa as narrated*:*

> And also cos of the current students protest it affects your motivation. Your brain is just switching off […]. So, I just want to say that like I understand the struggle, and people cannot afford to be here. But at the same time, it's a disruption of other people's education […].

> But I don't have any interest in staying to study more in South Africa, because of the situation and what happened. For me it has just made me more negative about South African education. If I want to do honours, then I wanna go overseas, because I am over the drama in South Africa. Which is a terrible thing to say, but with this, I just don't want to stay. That's how I feel (MS4).

Furthermore, she expressed the need for a learning institution to be able to maintain good teachers; otherwise, the nation's educational system would be negatively affected:

> And I am really fortunate to be here, but it's not like it's easy for my parents to send me here, there are still sacrifices they are making for me to be here. What my parents are paying for me is definitely a driving force that I will pass this year. For me higher education is a very big privilege. So like if my education is now compromised, it's not gonna move our country forward.
>
> I mean it's a learning environment so you need good teachers, in order to learn properly. Because we can't learn from people who don't know how to teach properly. And if they can't afford to pay like the good staff, what is it gonna be? What is it gonna come to? (MS4).

6.5.3 Financial issues

Both EDP and MS students faced personal issues of financial challenges, which placed enormous stress that made it difficult for them to study properly. It emerged from the data that financial difficulty was a stress factor for the majority of Black South Africans and international students, and sometimes overlapped with family issues. Some of the participants explained that financial pressures resulted in depression. I will continue by addressing the financial issues experienced by Black South African students, international students and White South African students, respectively, using typical cases as examples within each category.

In the first category, a Black South African student voiced that it was difficult to focus and study when one is unsure of how to cater for tuition and living expenses:

> […] there were also financial issues for some people, so you could be in the lectures and your mind is on 'I don't have funding'. So, you keep asking yourself 'so even if I pass how am I going to come back next year?' It is a lot. You just feel overwhelmed. Sometimes you could be studying for a test and then you don't understand anything (EDP17).

In agreement with the statement made above, EDP15 mentioned that even though she managed to do well in her studies she kept asking herself how she was going to pay her fees for the next year, but what helped her not to become too worried was her religious background. She had internal peace because "*Cos I know God is gonna provide*", and fortunately, she received a bursary as best described in her own words:

> It is actually a stress factor especially when you don't know how you gonna pay your school fees […] First year I didn't have any bursary. So even though I did good, it was always at the

> back of my mind that I still need money to pay my fees. Although it didn't affect me that much. I just had that peace on my inside […] But fortunately, the next year I got funding, and everything has been fine (EDP15).

On the other hand, some of the Black South Africans indicated that they either had or later received a bursary in Y2, which helped to alleviate financial stress. For example, a Black South African mentioned that he was awared a bursary in grade 12; however, had issues with his initial sponsors but finally *"got to UCT and I got NSFAS [National Student Financial Aid Scheme] funding and that kind of made life easier as it is currently. But I was also able to get some UCT scholarship and that really helped" (EDP18).* Likewise, another Black student (MS16) indicated that he had not experienced any financial issues because "*I have a bursary that is paying for my school fees. So, there was no financial stress".* On the contrary, another Black South African student remarked that she, unfortunately, did not qualify for financial aid, hence had to pay for half of her fees; this caused major stress and anxiety, as narrated:

> I am in the missing middle; the people who don't qualify for financial aid. So, I have to pay half of my fees, and that has been stressful. That has been a problem because I am asking myself where is the other half that I am supposed to pay going to come from? (EDP17).

On the discussion of the financial difficulty experienced by international students studying at UCT, I will use M2 as a typical case. MS2 explained that the major obstacle she faced was a financial exclusion. According to her, she worked very hard to achieve good grades that would make it relatively easier to secure funding, but this did not yield the desired results. She preferred to use the term 'exclusion' because she feels the only reason for not securing any funding was that she was an international student, as reported:

> But one of the main obstacles that I faced was financial exclusion. Because as an international student there isn't really a lot, and I worked so hard to be able to get a scholarship or whatever. But it just never ever came I mean I got nineties (90s) in second year and still didn't get a scholarship […] Well I actually couldn't afford to be here, literally the only way I was actually able to come to University was because of family and friends raised money for me to be able to come (MS2).

The statement above suggests the limited funding opportunities available to international students studying at South African Universities; this could be related to the limited funding, which the university receives. It could also be related to the strict government policies around disbursement of funds, which limit disbursement of funds to locals and permanent residents. MS2 said, "*it's tough being an international student.* Furthermore, at the beginning of Y3, she was not able to pay her fees on time, thus was unable to register and attend classes; this placed a significant burden on her. Thus, she decided to get a job to support herself as shown:

> So that helped me pay for like food and stuff this year because my parents haven't been able to like send me money cos of you know restrictions at home and stuff like that. Cos things are tough, so that helped (MS2).

The White South African students, on the contrary, affirmed the awareness of the money their parents were spending towards their education; but it did not reach a level where it caused major emotional stress: *"And I am really fortunate to be here, but it's not like it's easy for my parents to send me here, there are still sacrifices they are making for me to be here" (MS4*). Some of them indicated that there were no financial constraints: *"I went to a private school in Johannesburg. There were no financial constraints" (MS9).* However, an exception was MS11, who explained that his mum was responsible for his education, but he received financial aid in Y2 when she experienced some financial constraints:

> My mother is a single parent cos my father passed away 10 years ago. So it has been difficult financially but I have been on financial aid for the last year […].
>
> My mum works and so she supported me. But the job is kind of unpredictable. She is a landscape artist where she makes like a garden. So, her work is kind of contract based, she gets a job does it, and then gets paid and that's it. Until she gets the next one. So, she gets paid for the job and that's it, we don't know when the next one will come. And she had a very bad year last year, where there were no jobs for her, and that's why we got financial aid for this year (MS11)

Moreover, he expressed a strong belief that those who can afford to pay for their children's education should be responsible, and financial aid should only be for those who merit it:

> But I always strongly believe that financial aid should be for people that really need it. Like if I didn't need it for the first two years of my study then my mum should have paid. Those that can pay, should pay, and not depend on financial aid (MS11).

6.5.4 Language barrier

Careful analysis of data revealed that language was an issue for some participants as clear from typical quotes: "*I also had some problems with language" (EDP15).* Some of these students explained that English was either not their first language or that it was their first time that they were required to study in English, and "*so sometimes you find it hard to understand" (EDP17).* For example, a participant explained:

> I lived in an English-speaking country, but I was in a French High school. So, this was the 1st time […] So, I guess also the language barrier was also a kind of an obstacle for me at the beginning (EDP5).

Additionally, a student stated that she was extremely discouraged in Y1 when she initially arrived UCT and noticed that the majority of the lecturers were White. She tagged the situation as a 'big problem' because of the perceived and anticipated difficulty with communication and understanding the lectures:

> And the major part is ALL THE LECTURERS ARE WHITES, and you are like “oh! My God! I am going to be having big problem here ‘ENGLISH’ [pause] I don’t know how to describe it, but it was discouraging […] I also had difficulty with communicating with my lecturers. I know they are open, but it’s difficult going to a lecturer and be like ‘Ok, I don’t understand what you are saying’. Especially when you are Black. And in some sections, you are blank (you do not understand anything) and the lecturers keeps explaining to you but you still do not understand (EDP12).

As noted in her statement above, she described the fear that Black students feel, which restrains communication with lecturers; this is deeply rooted in the past apartheid experience. This issue that was mentioned by another Black student who said:

> […] cos sometimes it’s not always easy to approach a lecturer and say ‘oh when you said this, I didn’t understand it’. And even though they say ‘you can approach us anytime that you like, we are not like you think’, they are intimidating (EDP8).

6.5.5 Failed a course

The difficulty that most students experienced emotionally has been described earlier during the discussion of “hurt me bad” in section 6.3.1. Nonetheless, it is pertinent to state that they also referred to ‘failure of a course’ as an obstacle, thus informing my decision to include it under this heading. It was recognized as an obstacle because it threatened their decision to continue studying as clear from typical quotes: *“I was very much like should I continue, should I not continue” (EDP13*), *“I failed all my test. It was hard for me at that time to go on” (EDP15), “I failed one course. So that was definitely like a big hurdle” (MS3).*

6.5.6 Loneliness

Some students also struggled to adapt to the university environment. Loneliness was cited as an issue especially for international students and those who were not from Cape Town: *“I was not enjoying school because I was alone” (EDP15, SA), “It was hard at times, it was hard to be alone […] The only moment you are able to reach out to family is through calls” (EDP5 Int’l).* Some participants remarked that the only way they could talk to their family was through phone calls, which was also limited because of the cost involved, as seen in a typical quote:

> My family is really far, they are all back home. I am the only one here, so it’s a kind of hard. I don’t know how to explain, but the only support they can actually give me is call me, talk to me.

> But like it's not like I share every situation with them, because they are so far. It's hard, when you are only speaking for a few minutes in a day, or a few minutes a week. But you can't like talk [pause], and you can't tell then everything that it's going on, because you only have limited amount of time (EDP13).

Others indicated "*I was really so scared of making friends and everything in first year" (EDP6)*. A student said that as an introvert, she could not make friends and had to deal with the challenges of settling in a new environment alone. Thus, she contemplated leaving UCT because she felt she did not belong or was not a part of the community as reported:

> And it is a matter of you not been at home anymore, you are now settling in a new environment, and you are now settling in the res (residence) system, and you have to make friends. I am an introvert and making friends is the hardest thing for me [...] I was coming to lectures and all of that but I was not enjoying UCT it cos I was alone. I was alone honestly. And in March I applied to go to WITS [laughter]. I was also considering the University of Pretoria. I was like 'NO, I made a mistake in coming to UCT'(EDP17).

6.6 Discussion of students' experiences

This discussion of students' experience as it relates to chemistry is closely associated with their self-efficacy; hence, there may be considerable overlap with the previous section. As noted earlier in section 5.1 several of the findings reported in this chapter were spontaneous responses from students, and was not as a result of the line of inquiry in my interview protocol. All the other aspects discussed in the thesis cannot be dissociated from students' experiences, as this was the lens that helped me to understand their stories; and from which relevant extrapolations were made. My statement that the findings in this thesis cannot be dissociated from students experiences agrees with Mavuru and Ramnarain (2017), who said that students socio-cultural background is important in teaching and learning repertoires.

Unlike EDP students, the majority of MS students did not mention any difficulty with the transition into Y1, as they described it as basically a minor addition in terms of content to what they knew from high school. On the other hand, consistent with previous reports, over half of EDP students mentioned that before they moved into the extended programme, Y1 was difficult; and they failed the majority of their tests (Case, 2007; Kelly-Laubscher et al., 2018; Potgieter et al., 2015). Similar to these reports, EDP students found the transition into MS to be the most challenging (Bangeni & Kapp, 2005; Case, 2007; Potgieter et al., 2015). It represented a crucial moment on which their persistence depended because, after this experience, they convinced themselves that they would survive the remaining years of study. Not having enough time to study because of the increased academic workload was an issue

that made the transition into mainstream difficult for EDP students, as also reported earlier (Grayson, 1996; Lubben et al., 2010).

Tutorials were recorded as a positive aspect of the extended programme due to the small size of the groups, which is consistent with previous reports (Burch et al., 2007; Eaton, 2007; Engelbrecht et al., 2014; Lundell, Beach, & Jung, 2007; Schmitt et al., 2007). Small groups facilitated more interaction amongst students and lecturers for students in the extended programme. The finding agrees with one of the main attributes of an effective classroom, which is involvement and engagement as identified by Tinto (2012), who explained that students are more likely to succeed in the classroom when they are academically and socially engaged with academic staff and peers. Furthermore, the finding is also supported by (Lazear, 2001), who reported that students' learning improves when there are more hands-on activities and interaction. However, unlike Lundell et al. (2007) none of the students indicated a dislike for the smaller classes, rather they said it allowed them to interact with others and make friends, which helped in forming study groups as reported by Schmitt et al. (2007).

In contrast with the report by Potgieter et al. (2015), none of the extended degree students in my study reported that their lecturers were not up to standard in terms of academic expertise. Instead, the lecturers helped them to understand the basic concepts properly. The statement suggests that majority found the programme to be beneficial and provided a positive experience which is in agreement with the literature (Carranza, 2007; Efiritha, Nogget, & Nyevero, 2012; Essack & Quayle, 2007; Munn, 1993; Potgieter et al., 2015). For instance, in the study by Essack and Quayle (2007), at a South African institution, the majority of students considered the access programme for humanities, social sciences, and commerce to be beneficial.

Similarly, Munn (1993) in a study on the Scottish Wider Access programme, reported general satisfaction from current and previous access students. The students also explained that the programme helped them to transition better into university, and the current study agrees with this. Also, the study conducted at a Zimbabwean University reported that more than half of the students said that the access programme was beneficial; although a small number said otherwise (Efiritha et al., 2012).

Consistent with the report by Potgieter et al. (2015) this finding shows that the mode of lecture delivery (slow pace) worked well for the majority of students in the extended programme but made it difficult for the students to adjust when they joined mainstream in Y2. Participants in the study by Lubben et al. (2010) also talked about the slow pace of the extended programme; this was seen in a positive light as it allowed students to seek help from academic staff and tutors, which gave them a solid academic foundation for further study.

In terms of academic support, in agreement with previous studies, EDP students appreciated the friendliness and personal attention accorded by their lecturers (Lubben et al., 2010; Lundell et al., 2007; Schmitt et al., 2007). They were drawn by the care and encouragement shown by the lecturers in the extended programme. Thus, it was not surprising that some of them referred to their mainstream lecturers as uncaring or found it challenging to connect with them.

The study by Grayson (1996) reported that some students did not like the approach of compulsory class attendance in the Science Foundation Programme (SFP), while others appreciated it. The compulsory class attendance in SFP was intended to help students acquire time management skills. Although, class attendance in EDP is not compulsory students liked the hands-on experience that lecturers and tutors provided. Additionally, when EDP students transitioned into mainstream they were able to identify the areas where they needed help. For example, EDP18 said he knew he had to acquire new study skills. Moreover, another student (EDP12) mentioned that she had to acquire learn new study skills to cope with the increased academic demands, which resonates with literature (Case, 2007; Davidowitz & Schreiber, 2008).

The current study did not initially seek to identify and report on the general perceptions EDP students have about the extent of preparedness for the transition into mainstream; however, this line of enquiry emerged during the interviews with students. Based on the data presented thus far, the majority of EDP students did not feel well prepared for the transition into mainstream with respect to dealing with the faster pace and increase academic workload. Nevertheless, none of them described the programme as not being effective as reported by Efiritha et al. (2012) where one-third of the participants felt they did not benefit from the bridging programme.

A study conducted at the Nelson Mandela Metropolitan University, South Africa reported that students who complete a foundation year tend to perform better in later years than those with similar academic profile who were admitted directly into mainstream system (Wood & Lithauer, 2005). Suggesting that the foundation programme helped students to perform better. The findings in this study tend to agree with this report because as seen from the data presented thus far, several examples were noted of students who recounted that their average improved. Along the same line, it was observed that all students were attending the same classes in Y3, none of EDP students complained about the transition into Y3. Instead, it was MS students who complained about the transition. This difference in experience with the transition may be attributed to the skills, which EDP students acquired in the extended programme.

Furthermore, consistent with the report by Wood & Lithauer (2005) the foundation experience also had a significant effect on all aspects of students' general well-being and not only their

academic performance. As stated in an earlier argument, EDP students valued the academic and life skills aspects of the programme such as time management and communication skills, which are significant features of the extended programme (Davidowitz & Schreiber, 2008; Schmitt et al., 2007; Wood & Lithauer, 2005).

The study on students' experience of access programmes in South Africa by Potgieter et al. (2015) revealed that students complained about the academic workload, the fast pace of learning and time management issues. The present study is consistent with this report the only difference being that EDP students complained about these issues only once they joined mainstream (Y2). Rather they described the years in the extended programme as slow and steady. On the other hand, the issue of increased workload and insufficient time to study was mentioned by the majority of MS students in Y3. More than half of EDP students stated that they experienced significant difficulty when they joined mainstream, while a small number did not because of the strong network of friendship with other senior students or the fact that they had been able to register for a second-year course.

Similar to the report by Potgieter et al. (2015), the structure and support offered by EDP were positively experienced and appreciated by the majority of the students. Although the majority of EDP students struggled on transitioning to mainstream, suggesting they did not see the immediate benefit of the extended programme; I believe that the programme gave them the confidence and correct foundation required for success in the remaining years of study. As stated by Potgieter et al. (2015), the overlap between the initial phase and the mainstream is considered beneficial. It is quite common to feel initial insecurity on transitioning to mainstream before settling in and drawing the benefits of the extended programme; which surfaced in Y3 as the majority of EDP students did not experience a difficult transition. Thus, the extended programme provided a good learning experience for the students; and agrees with the Bandura's (1986) SCT and Lent et al. (1994) SCCT model, which highlights the role that good learning experiences play in sustained behaviour and persistence.

As shown in the research by Carranza (2007) this study also reports the significant role that commitment to achieving a personal goal played in the persistence of this cohort and this is in agreement with SCT model. Several instances were recorded, where students reflected on the reason why they came to UCT and subsequently refused to quit. Some students remembered their commitment to helping their family, and being role models for their siblings and community members. These could be viewed through SCT model and demonstrated the role of outcome expectation in students' engagement and persistence.

Both EDP and MS students complained about not having enough time to study due to an increase in academic demand, as noted elsewhere (Bangeni & Kapp, 2005; Case, 2007;

Grayson, 1996). Some students mentioned that it would be better if they had fewer lectures and one practical per week in Y3 rather than just rushing over many concepts, which does not allow them to learn or engage properly as reported (Case, 2007).

This observation was also reported in the study by Potgieter et al. (2015), where one of participants shared the view that some of the practical components were a waste of time; and indicated that the time could have been used in studying. Amongst other factors, the discussion thus far highlights the point that the long hours spent in completing the practical tasks in Y3 was the major source of frustration for the participants in this study as they feel they could have used the time in studying.

Also, concerning chemistry consuming too much time, a student's statement in the study by Potgieter et al. (2015) supports this claim: "*I worked hard, I dropped all the chemistry modules and took GGYS (geography) modules* (S13, p. 121)". This clearly showed that the student dropped chemistry and chose another major, probably to free up some time to engage in other academic tasks. It supports the comments that have been made by the majority of the participants in my study that chemistry is time-consuming. This finding raises a question and suggests that there is a need to look at the chemistry curriculum. Could this issue of an overloaded curriculum be the reason why some students are leaving chemistry?

Studies have shown that the majority of students complain about insufficient time to study (Case, 2007; Grayson, 1996; Potgieter et al., 2015). The issue of insufficient time is arguable because students tend to use the same study methods from high school to approach university work. They fail to realise that a new set of study skills are required for HE, which is most likely responsible for the complaint about insufficient time. Nevertheless, consistent with the literature some students in the current study considered this an opportunity to improve their time management skills and acquire relevant coping strategies for dealing with the academic demands (Grayson, 1996; Schmitt et al., 2007).

Both EDP and MS students faced personal issues of financial challenges (Lubben et al., 2010; Potgieter et al., 2015) and the language barrier consistent with studies reported in the literature (Bangeni & Kapp, 2007; Kapp & Bangeni, 2011; Kelly-Laubscher et al., 2018). A student described the fear that Black students experience and which hinders communication with lecturers. This experience is deeply rooted in the past apartheid experience (Bangeni & Kapp, 2005, 2007). As reported, many factors have been identified as preventing epistemological access for students from disadvantaged background into HWU such as UCT, including the discontinuity between high school and university curricula, the so-called "articulation gap" (Council on Higher Education, 2013; Kelly-Laubscher et al., 2018)

Morrow (1994) described the ‘democratization of access’ and said it was not merely about increasing the number of students from different backgrounds in the university but creating some spaces where they feel they belong. In other words, access is all about creating spaces which students can occupy to the extent that they can refer to it as home; space where they do not need to feel like strangers or foreigners but one which gives them a sense of belonging. As reported earlier in my study, a student contemplated leaving UCT because she felt she did not belong or was not a part of the community, a similar finding has been reported elsewhere (Mann, 2001; Potgieter et al., 2015). This calls for an effort from all those involved in higher education to seek out effective ways to close the articulation gap. In addition, failure was an obstacle that both EDP and MS students experienced; and as suggested by Mann (2001) students need to be equipped with knowledge on how to handle failure; so that it does not lead to alienation, which may give rise to discontinuation tendencies

The findings thus far have shown that the emotional difficulty that students experienced varied significantly. It progressed from emotional hurt, which mostly originated from failure, which resulted in further difficulty, especially with respect to academic achievement. Consequent on this, students became disappointed with their choice of chemistry, and expressed regret about their choice, and dislike for the subject. According to Mann (2001), students’ experiences, especially when it results in failure, contribute significantly to a feeling of alienation. So, what were the coping strategies and support systems that students employed to overcome these difficulties? This will be discussed in the next section.

6.7 Handling difficulty and support systems

This section explains how students handled the difficulties they experienced, and the different support systems that were engaged. In reporting this finding, there will be no need for categorization as the experiences were similar for both EDP and MS students; hence, references will be drawn from either group to illustrate relevant points. Participants also mentioned that one of the factors that helped them to handle difficulty was reaching out to others whom they felt could help them. This included friends, course mates, tutors, lecturers, and building a network of friendship with students ahead of them in their degree, which will be described later.

6.7.1 Handling difficulties

How did students handle the difficult and challenging times they faced while studying? Analysis of the interview data helped me to categorize how students handled difficult and challenging times during their studies under the following broad headings:

1. Taking responsibility and determination
2. Non-complacency

6.7.1.1 Taking responsibility and determination

Analysis of the interview transcripts revealed how students developed coping strategies to handle difficult times; among these were strengthening the resolve to succeed and changing their study method. Students expressed their resolve to take responsibility for their studies, using terms like 'deal with it', 'put yourself together', 'work hard', 'self-discipline', 'compare textbooks', 'consoling myself', 'learned organizational skills', ' continuous practice', 'get help', 'manage time', 'stay on top of game' and 'work on myself' while describing what they did.

Taking responsibility

Students described what they did at different levels to persist in their study programme and used different terms to describe similar events. However, I decided to place all the descriptions provided into two broad groups, and typical cases from either EDP or MS will be used to illustrate relevant points.

Group 1: Strengthening the resolve to succeed

In this category, we have the students who took responsibility for their studies by strengthening their resolve to succeed. Stated differently they told themselves that there was no other option left, other than to press on and pass: "*I had to study everything by force, there was no time to play"* (EDP18). These students were determined, and told themselves "*there was no other option, I just have to pass" (MS11).* For instance, a participant (EDP14) explained that he was determined to finish his studies because he kept reminding himself that he did not want to return the following year:

> So, I just had to push, no matter how hard it was. I had to keep pushing [...] I knew it was challenging and a lot of pressure was there, but I never saw giving up as an option. It was never in my thought. The only thing that was like HEY! BUT I NEVER WANT TO COME BACK NEXT YEAR (EDP14).

Additionally, EDP12 explained that at some stage in her studies, especially when the workload was difficult, she decided to stand up for herself by learning time management skills and working hard. MS10 also mentioned that at some point during his studies, he decided to take responsibility for himself; this became necessary because his younger sister would soon be attending university, as detailed:

> And I have to be very honest at this point in time, as I need to show appreciation to my parents, who have supported me this far in my studies […] So I am so grateful that my parents were able to assist me financially in this time. […].

> And also at this point I feel like I should be able to stand up for myself, cos my mum is now thinking of sending my sister to university, who will be finishing high school in the next two years. So she has to now put attention on her. And I have to be able to stand up for myself later on […] I just didn't want to be passive about what I wanted to do in life (MS10).

The next category were those students who started consoling themselves and speaking to themselves using positive words such as 'I can do it' as cited:

> I started telling myself, I can make it, people before me have made it, and my peers have made it. I can. I am already looking at my Honours academic year. My mind is already there. Exams are coming I am going to write those exams, I am going to pass them. And I will be here next year to do my honours […] I can do it (EDP15).

Moreover, (MS16) explained that one of the important things that kept him on track in his studies was his Christian faith and consoling himself continually:

> And so, based on Christianity principles which is 'don't give up on whatever you do', that has helped. And that is the reason why I am still here till today […] And also, generally just consoling myself helps. Cos even in first year there were times when it was hard, but I consoled myself. And now looking back I just ask myself "what were you even crying about? The same thing applies to me in 3rd year, the exams is just 3 weeks away. But in a couple of weeks you will look back and say 'wow! so I am now done with undergrad' [laughs] [...] So that's it, consoling myself helped (MS16).

Likewise, EDP17 expressed her agreement to MS16 statement above: *And God helped me and I got back to me again, and I started telling myself "I know who I am, I can do this. I also pray and that was most helpful (EDP17).*

Group 2: Changing study methods and exercising self-discipline

The next coping strategy that was adopted was to change their study methods, which included: changing the textbook, using more online resources and forming study groups. A participant explained that she decided to take responsibility for herself by changing her study patterns, reading more textbooks and keeping abreast with lecture notes:

> I just decided to sit on top of things and change my way of studying from 2nd year. I just decided to be more involved at the beginning of the year. Just like I said last year wasn't really a good year academically, so just before entering 3rd year, I said I need this year to be a bit nice year. I need to sit on top of things. So, I wasn't like all perfect all year round, but most of the time I try to sit on top of my academics (EDP5).

Likewise, how another student took responsibility for her studies is captured below:

> Practice. Do your tutorials. Do whatever that will give you practice. Also knowing the expected level of how you are supposed to push. And also be on top of stuff, try to be on top of your lectures and notes […] Cos, it is more difficult when you are approaching an exam and you then need to study right from the beginning. I try as much as I can to do what I am supposed to do. And also "get help". Get some friends, tutors or ask the scientific officers […] And determination (EDP15).

Others became more disciplined and acquired *"more organizational skills" (EDP6),* "*self-discipline" (MS10),* and *"time management skills" (EDP1).* Besides, personal development was sought in order to become more confident in some instances. Specifically, EDP13 mentioned that she took responsibility for herself by deciding to engage in personal development to build her confidence as earlier described, and this was a major factor that helped in dealing with the difficult time she experienced. Additionally, some students explained that when they experienced extreme academic pressure, one of the ways they relieved stress was by sitting down with friends to talk. For example, EDP18 explained that one of the ways he relieved stress was by deciding to sit with friends and talk:

> Like when stress overwhelms me, I take my time and sit with a friend and just talk. Not much of a talk, but I have learned to do that over the past three years and that has helped me to keep stress level as low as they can be (EDP18).

In addition, MS10 explained that one of the things that helped him to persist was the decision to reduce emotional pressure. He did this by telling himself to relax and enjoy the course:

> But in terms of the course itself, I tell myself 'ok, the first time, I was in this course I was stressed, right now I am just going to relax and redo it'. So that has helped, as I just try to enjoy the course now instead of stressing. So, I just tell myself, well I am here, so I am just going to do this and make sure I get that high marks that I need to do my honours (MS10).

Determination

Students stories revealed that they were determined to complete their studies. The reasons they gave for not quitting their studies are discussed under two broad groups below.

Group 1: Remembering my family and why I came to UCT in the first place

Students further strengthened their resolve to succeed, and persisted by remembering their families and reflecting on the reason why they came to UCT in the first instance as illustrated: *"But I think the major thing was just the thought of not disappointing my mother basically"* (MS11), "*It was my career motivation, because I ask myself, in the first place why did you decide to study this?" (EDP14).* As revealed from careful analysis of data gathered, the thought of either not wanting to disappoint or waste the money spent on their education was a strong

reason for persistence: *"And I didn't want to disappoint my parents, cos it will be a big disappointment if I go home without finishing. So, I just had to push, no matter how hard it was" (EDP14).* For example, EDP1 explained that *"quitting never seemed like an option for me". Because my parents are there, I can't just disappoint them*". This thought helped her significantly, especially when she failed most of her tests at the beginning of her first year and received negative remarks from other students because of her poor grades. Nevertheless, she was determined because she did not want to return home without a certificate, coupled with the fact that both parents were educated as narrated:

> I cried very much. Everyone else will look at my marks and say, 'why are you still studying this? […] My mum and dad both have degrees, and so quitting just didn't seem like something that was ever on the card for me. I never considered giving up, even when it was hard and I failed (EDP1*)*.

The desire to be able to provide financial support or help families back home was a strong motivation for most of the participants who cited the desire to financially support their families as a reason for them to continue studying: "*I think of my parents back home, I want to help them out and that is a strong point for me to keep pushing" (EDP18)*.

An international student, (MS2), mentioned that a major motivation that kept her going despite difficult times was the desire to be able to provide needed financial support for her family. This is best described in her own words:

> So for me 'my family', because I am the eldest in my family. And my brothers and sisters are very young. My brother is 10 and my sister is 14. So they are babies [laugher]. So basically, I'm setting up the platform for them to be able to carry on. Because my parents are quite old. And they started quite late with having children, so basically at some point, I am going to take over taking care of my brother and sister. So that's kind of pushing me to do better and make sure that I can make enough money. So I can be able to lay the ground for them to be able to go to university without struggling. You know that kind of a thing (MS2).

It seems like it is the financial difficulty that MS2 had experienced that contributes to the reason why she does not want her siblings to go to university without sufficient financial means. As noted earlier, she is an international student who said that financial exclusion was the biggest obstacles she faced while studying.

EDP8 remarked that one of the things that kept him in school was the thought of not wanting to disappoint his family since they have worked so hard to cater for his education. His parents did not receive a university education, and being the firstborn, and also the first in the family to attend university, there exists a sense of responsibility which became a strong motivation because he needed to set an example for his siblings as narrated:

> It's home. Where I am coming from, because both my parents did not get that much of education. I think my mother has highest grade 8 and I am not sure about my father if he ever went to school. So they worked hard as to put me here in school. And being the firstborn, I feel like it's part of my responsibility to like to pave a way for my younger brothers. Cos I have 3 more siblings that are younger than me. So, I need to be that role model. Show them that even if it's hard, you can make it. So that's what has kept me going (EDP8).

Additionally, there was also a sense of responsibility to his community, being among the first few community members to attend university. So, he was acting as a role model not just to his immediate family members but to other children in his community at large, he described it as *'paving way for other kids'*; this will be discussed later.

It was observed that the desire to help the family was mentioned more often by Black and international students than their White counterparts. It is arguable that socio-economic status was a contributing factor. The White students recognized the need not to disappoint their parents but did not emphasize the desire to help parents or siblings financially as was apparent in the statements by the Black and international students. For instance, a White South African participant, (MS9), indicated that he knew that his parents would be disappointed if he did not complete his studies, but this was not a motivating factor as illustrated: *"No not really. I spent 3 years in school already, and my parents will probably be angry if I come home without a certificate, but that is not really a driving force for me" (MS9).* Furthermore, it was observed that none of the White participants mentioned becoming a role model for siblings as a motivation to continue studying.

Still, on the theme of determination, some students started reflecting on all the difficulties they had encountered and the reasons for enrolling in university, which was to get a degree. So, they told themselves they would not leave without the degree as described in the following quotes:

> I think it is the thought of knowing that I am so close to the end. The thought of all I had gone through keep me going. It kept me from quitting. Especially this year, I had to think about all the challenges that I have had to go through to get to this point, and so giving up was not in me. I had to think about all I had suffered up till this point, and I am almost at the end. And so that kept me going. But I mean it has been really hard (MS7).

> I persevered through all these even when I felt like quitting, and as such time I had to reflect back on why exactly I came here in the first place. The reasons are plentiful and when I think of just one at any point in time that gives me the courage to continue (EDP18).

Group 2: Shame of incompletion

Some students mentioned that it would be a disgrace for them to go home without a certificate. It would be difficult to face their friends and people in their communities who knew they were "in school". An example is EDP 14, who said:

> I had to keep pushing. Quitting from my study was never an option. Cos it will be a big disappointment if I go home without finishing. So, I just had to push, no matter how hard it was. Because you can just imagine, what your friends will think? I mean like that will be a very difficult one for you, cos you will never be able to face anyone of them (EDP14).

Moreover, another participant explained that most of her mother's family members are educated, and so it would be shameful for her to go back home without a certificate as seen:

> Well, my mum didn't finish high school [pause], not academically inclined so is my brother. So I am kind of the first one to go to university. So I had to study intensely […] I think what could have also helped me to stay in the degree is because, my other uncles, cousins and all those on the other side were also very academic**.** The rest of the family is. So, you don't want to be that one not doing anything for yourself (EDP6).

Likewise, as seen in the case of EDP8, one of the factors that motivated him to keep studying was because he could not face the shame of incompletion, since he was acting as a role model for his immediate family, and by extension, the community. He could not afford to go home without a degree because it would be too shameful and disappointing as he needed to set an example for other kids and be a source of motivation: "*I'm trying to pave a way for the other kids and show them that it is possible. If I did it then they can" (*EDP8).

Fear of losing their bursary

Before I end this discussion of determination and not quitting, it is relevant to bring to the fore the case of MS16, who mentioned that he did not have any financial issues while studying; however, one thing that helped him to continue studying was the 'fear of losing his bursary'. This fear was what enabled him to perform well. MS16 is the student who earlier recounted that his social life negatively affected his studies, and he knew he could perform better in his studies but was not bothered about improving his grades as long as he passed as quoted:

> And this is because I am a person of so many friends. So, I have been spending little time towards my studies […] And I tell myself 'why stress yourself, when you can still move on with 50s? And so you see it becomes like 'I am having fun, and I am still having the marks required to move on, so why bother or stress myself?' (MS16).

However, he made a salient point during the conversation about the role that 'the fear of losing his bursary', played in his persistence. This fear was what prevented him from failing and is well captured in the conversation below:

Interviewer: So, was there any form of financial constraints that affected your studies?

MS16: No, this is because I have a bursary that is paying for my school fees. So, there was no financial stress.

Interviewer: So apart from the religious background as you have mentioned, what else helped you to persist in your studies?

MS16: Although I may leave work for last minute, I don't leave anything undone. I still complete. So, anything deadline I deal with it. And the moment anything begins to threaten my marks I act. So what makes me work more is deadline, because if I fail; these then my bursary pulls out. So that is one thing that helped me to stay on track.

6.7.1.2 Complacency

Some students decided to become complacent about their studies, as they made less effort to obtain better grades. Some of these students were passionate about pursuing careers in other fields; hence, they decided to keep their expectations low to pass the course. For instance, MS16, who is passionate about becoming a geologist to earn good money to take care of his family, explained that he decided to keep his expectation low in chemistry to pass. He recognized he could perform better in his studies but was unconcerned as illustrated: *"I don't think much has changed since then. Cos, I have become comfortable with getting 50s. It's not really like I don't want to score higher, but I would still say I have just become comfortable" (MS16).*

Similarly, MS11, who identified his passion in fragrance chemistry, acknowledged dissatisfaction with his grades but was not ready to improve it as inferred from his statement:

> I mean I have passed everything. I have actually set my standards pretty low as I just want to pass […] I probably could do better, but I think it's fine. I am content. Not happy, but I am content (MS11).

Still on the conversation of students becoming complacent is the case of EDP8, who explained that in Y1, when he realised that he was having difficulty with the course, he was unconcerned. He attributed it as a general problem since he observed that other students were also experiencing the same difficulty; consequently, he did not put in the effort required to achieve better grades:

> The main thing you realise when you get here is that as you are struggling with the courses, you are finding that these things are new, you are not exposed to them. There are also other people that are like you […] I will say it kind of affected me a bit negatively. Because when I got here, I started telling myself, 'OK, you know I am not the only one struggling with this, there are also other people. And that kind of made me to relax even more, than I was suppose (EDP8).

6.8 Support system: factors that helped me to remain in my studies?

What helped students to remain in their studies? I refer to the factors identified by students, which helped them to continue, especially when they experienced challenges as 'support systems'. Specific references will be drawn from either EDP or MS students as required during the discussion. Careful analysis of interview data helped to categorize the support systems under the following headings:

1. Family
2. Friends
3. Resources and study groups
4. Religion
5. Mentors
6. Exercise and sleep

6.8.1 Family

Family provided support and sympathetic ears to students' struggles as well as advice, which helped the majority of the students to persist as seen in a typical quote: "*A lot of it has been my family" (MS9).* A typical case is EDP13 who opted to spend time with her family when the emotional pressure was extreme as captured:

> I remember this year in particular, I was having a mini-breakdown as well. I was just so tired emotionally drained. And just like mentally I guess. And due to the emotional drainage, I called my mum, and I was like "I just wanna come home, and without questions she said yes you can come home. I feel like that has been very supportive, that was very supportive on her part. Like we have financial issues as well, and she said its Ok, just come. Regardless of our financial situation just come […].
>
> I was going to stay the whole year alone, but the fact that I went home was also very reviving. I got the chance to rest a bit. And come back with a fresh look. They've [family] been very supportive (EDP13).

A different scenario to the account above is EDP12, who mentioned that her family was supportive but also added extra stress because she knew that the entire family was looking up to her to study hard and get a good job; so that she could alleviate their financial burden. So, whenever her mother called, she encouraged her to study hard, but this added extra pressure because her mother was unaware of the difficulty she was experiencing in university as best described in her words:

> They just add extra stress. Only my father does a part-time job and earns some money but it's not much, like R5000 per month. And my mum doesn't work […] And so every time my mother

> calls she says 'study'. And that's a lot of pressure cos you know that the whole family basically is depending on you. And then you are out there and struggling with chemistry, but they don't know what's going on. So that also adds stress (EDP12).

Furthermore, she explained that knowing that her whole family depended on her, kept her in a constant cycle of panic on how she was going to make more money in the future. The obstacles that further present themselves are described:

> Cos you are always thinking of things that you can do that will give you the most amount of money at the end of the day. So now you are studying chemistry, but you panic almost throughout the year. Cos you keep telling yourself I don't like chemistry, and I don't even know where I am going with this chemistry, and you still have people who are back there at home depending on you. So that becomes so stressful. So even though I know my family wants the best for me, they are now placing me under so much pressure. Cos now you have to tell yourself I have to study.
>
> The next thing you ask yourself is [pause] "Ok, without Hons will it be easy for me to get a job" of course we know it's hard. But now in order to do honours you also need money and where will the money come from? And the next thought is Ok, I will end up being someone's Lab assistant and that doesn't give a lot of money. And you ask yourself, ok do I now study another degree? But I don't have money for that also. So, it all becomes very depressing (EDP12).

6.8.2. Friends

Both EDP and MS students treasured the friendships they made in class and cited this as one of their reasons for persistence in the programme. A participant referred to her flatmates as *"a big blessing because they helped me through a lot of stuff that was going on then*" (MS2)**.** Some students indicated that talking with friends helped them to release pressure, build better relationships and support groups: *"There are also other people that are like you. So, it was based on the group of people that I had around me, that's how they helped out" (EDP8).*

> Having friends, it does help cos you realise that you are not the only one going through the stress. You are not the only one who needs to put in extra effort, you are not the only one who doesn't understand the lectures immediately but needs to go back and read again (EDP15).

Furthermore, some participants explained that because of the relationship that has been established with course mates, they were able to easily approach them for help: "You can tell yourself, '*Ok, I can ask TXXX for help, I can ask LXXX for help' So yeah that helped*" (EDP12). For instance, MS10 mentioned that *"one key thing that kept me levelled was having a good Lab partner"*. Besides the laboratory sessions, "*we also started studying together, to make sure we help each other*". Furthermore, he highlighted the benefit of reaching out to his course mates for assistance:

> And another thing that helped me not to completely crash to the ground but helped me put myself together was interacting with other people who were intelligent in the class. […].
>
> And you will be surprised at how much assistance you can get from others, when you are able to reach out to them. Let them know I am having these issues, I don't understand this, and they may not be able to solve all the problems but they will help. And at least you can work together and you get better that way… And also, through interaction that you also come to understand what other students are going through. And you are now able to work together better (MS10).

He further advised on the need for universities to encourage interaction amongst students, which he referred to as 'people management' as recounted:

> One thing which academics or university sometimes fails to emphasize is the fact that we are humans, and we still need to interact with one another. So even when it is necessary for us to work to the extreme to be good in our academics, we also need to be able to manage interaction with others. […].
>
> We need to have some sort of guidance or information at home or school, on how to manage ourselves and also others. We need to be taught that people management is an important skill, not just in chemistry but in other fields as well, generally speaking (MS10).

It is important to point out at this stage, the significant influence of having a strong network of relationships had on the transition of some EDP students to MS. These EDP students mentioned that they transitioned into Y2 mainstream relatively well because of the strong network of relationships they had with senior students who gave them advice and assistance. Another EDP student acknowledged the significant help he received from classmates: "*In maths I had a friend who was a quick learner. So, whenever I had difficulty he would help me" (EDP14).* Even an MS student (MS10), who was repeating the course did not express any difficulty with learning with the new cohort students whom he was previously ahead of. When he was asked how he was coping in the class he stated clearly that he has received a lot of help by interacting with them. Similarly, another student said*: "And I would also approach my classmate whom I feel understood better" (MS9)*

6.8.3 Resources and study groups

Students explained that when they encountered difficulties in their studies, they decided to engage more proactively in their studies by using more "*online resources" (EDP13)*, and "textbooks" (MS10) and creating platforms like "*WhatsApp group where we can ask questions freely (EDP12*)" and *"studying in a group" (EDP12).* I will use the following pages to discuss each of the points mentioned above namely, online resources such as videos, textbooks, creating study platforms and study groups, respectively.

Online resources

The use of online resources such as videos helped students to take charge of their studies and perform better as reported: *"I used a little of Khan Academy as well if I get stuck. I used it on YouTube. The textbook was good, but the online resources made it better" (MS9).* EDP8, who earlier explained that his transition from EDP to MS was more manageable because of the strong network of relationships he had established with senior students also highlighted the major role that online resources played:

> And we started studying together, and he also introduced me to online resources. Cos I had the textbook, so whenever something will confuse me I had to check the textbook. And still it would not make much sense. And so supplementary we started using some online course materials […] And you can also get like a 10 mins video on the things that you are doing in the lecture. Although it doesn't go as in-depth as the lectures. But at least when you come with that into the lectures, then you have more to gain (EDP8).

He further suggested that: "*It would have been better if the first-year students are told more about the online resources like Khan Academy, even though we know there are textbooks" (EDP8).*

Textbooks

Students also indicated that they engaged more with their textbooks, especially when they realised, they were struggling with understanding the lectures. For instance, EDP1 explained that when she failed in Y1 it was emotional and difficult. One of the ways she overcame this was by using more than one textbook, which proved valuable: *"I also started using more than one textbook to study, so it was easy for me to compare them with my lecture notes […]" (EDP1*). Similarly, EDP13 statement below captures the value of reading textbooks:

> And also I never really use to read my textbook and I found out that reading your textbook really helps. Like I am fortunate enough to have a tablet so every lecture I take all my books with me to the lecture theatre. And before the lecture starts I have already compared in which section the material we are about to do falls. So as he [the lecturer] is speaking, I can relate and if there is a gap in his note, I can see it. I can remember it from the textbook, I can just quickly reference it and go to my textbook […] So that has helped me (EDP13).

Creating study platforms

"*We have a study platform like WhatsApp, where everyone is free to ask questions*" is an extract from a conversation with students during the interview. For instance, if a student was studying alone and encountered difficulty, the person could immediately pose the question and get assistance. The platform was created to accommodate everyone because some people were either shy to ask or approach others for help as described:

> And some of us are not used to getting help, we always do things on our own […] we have a WhatsApp group where we can ask questions. We created this space so that everyone can be free to ask questions. Even though people study alone, you have this opportunity where you can still ask anything freely. So yeah that helped (EDP12).

Still, on the conversation on creating platforms for interaction, MS16 pointed out that in the geology department they have a pizza day, which creates an opportunity for all members in the different tiers of the department to interact. This act of creating spaces proved helpful as it allows students to get advice and help from their fellows, whom he described as *"people who understand their struggle*":

> There is a lack of interaction between the different tiers in chemistry. But in geology it is a complete different story because once a semester we have a pizza day in the whole department where we get together. And through networking like that we are able to meet a lot of people, also get past questions papers and that's a game changer[...].
>
> Yeah, so you get the chance to always ask questions or get advice from someone who is not in academia (not asking lecturers only). You can get to ask and talk with other students who actually know and understand your struggle (MS16).

Study groups

Studying in groups was beneficial to students as revealed from careful analysis of the data. Participants highlighted the benefit of studying together, getting help and providing motivation for each other:

> And also studying in group helps because I live with my friends. We basically live in the same flat. So, whenever I have a problem I literally just go next door and tap on their door and ask […] So, we study together and just push each other (EDP15).

Moreover, EDP8 explained that tutorial sessions in the extended programme were beneficial because they helped him to form study groups with his course mates. Hence, it was easier for them to study freely and support each other, as seen in the narrative below:

> Yeah, cos those tutorials also actually helped out for the formation of study groups and getting people to study together. Cos we are there to study together, and we know each other's weaknesses and strengths. So it's easier for us to get together (EDP8).

On the other hand, an MS student referred to study group as a waste of time since he finds it challenging to work with other people. He explained that he achieves much working alone than with others because people learn at a different pace:

> I find it difficult to work with other people […] I hate wasting time. So being with other people […] [pause] cos not all of us work at the same pace. Some may work faster than me or others

> may work slower than me, so ideally, I am misbalancing my character to accommodate both parties. Yeah, when I could just go straight work on my own and get things done (MS16).

6.8.4 Religion

Religion has been used in this context to cover all form of religious beliefs and practices such as Christianity, Islam, and African Traditional Religions. Some of the students indicated that the teachings and principles that they received from their religious organizations helped them greatly. Furthermore, some students affirmed that it was their religion that helped them to remain in their studies. For instance, EDP1 identified religion as one of the major support mechanisms that helped her to remain in her studies as expressed:

> Also as a Muslim as well one of our main tradition is based on scholarships learning, and also learning to be inspired by the teachings of the great teachers. So that also provides inward motivation and drive [...] So, studying is also encouraged in our Muslim religion, so there was also of spiritual link (EDP1).

Similarly, MS16 explained that his religion is instrumental in keeping him together to persist in his studies because he has been taught as a Christian to never give up:

> I will be honest with you, one thing that keeps me together or keeps me sane so far is my religion. I am a Christian. And so, based on Christianity principles which is “don’t give up on whatever you do”, that has helped. And that is the reason why I am still here till today. Had it not been for that, I would have been long gone. It gives me the push me of 'don’t give up, this is only the beginning of good things that is to come, get it over and get it done with'(MS16).

Moreover, EDP17 said “*I am a very spiritual person and so that helped me to get through that feeling of loneliness"* as well as tough times because she prayed about the difficulties she was experiencing, and this provided the inner strength and peace:

> My spiritual relationship with God, that helped me a lot [...] And God helped me and I got back to me again, and I started telling myself 'I know who I am, I can do this’ […] And because I am a spiritual person, such things are easier for me to deal with, this is because I pray a lot. I tend not to worry a lot (EDP17).

In addition, a student mentioned that home cells (small Christian gatherings) provided “*the space for us to be able to place God first regardless of our academic workload. And at that point you forget all the pressure*” (EDP 12). Furthermore, the home cell provided the opportunity to form a fellowship with other students, to pray and talk with the student pastor about difficulties as best described in her own words:

> It helped, cos I have like home cell. Where you meet other students, who are also Christians and you get to encourage yourself. And pray. Cos everyone is going through the same

> challenges so it is easier for us to support each other […] It is a very nice space. It's a nice space to breathe as well. […] So yeah, church is very supportive.
>
> We have a student pastor, we have student leaders who you can talk to, and they can pray for you. So, church is nice. And very supportive (EDP12).

6.8.5 Mentors

The term 'mentor' in this context refers collectively to teachers, lecturers, and tutors to simplify the discussion. This decision was made because students used these terms during interviews to describe the various roles academics played; as seen in typical quotes some of them used the term lecturers "*I enjoyed talking with my lecturers" (EDP1),* teachers "*My chemistry teacher assisted me a lot" (MS10*), *"My chemistry teacher was one of the people that made me to love chemistry" (EDP14)* and tutors "*And in 1st year there was this tutor he really helped" (EDP12)*.

In terms of support and assistance, appreciation was expressed across the board for the support from mentors and tutorial sessions. Students gave a positive rating to the availability of mentors (tutors) at Help@Science, which is run by the Science Faculty as an after-hours consultation service. Senior students are available to provide support for a variety of first-year courses. Besides, a student explained that she enjoyed talking with her mentors (lecturers), and this allowed her to get clarification on topics she did not understand. Furthermore, some students talked about the caring nature of their mentors (lecturers) and the help they received from tutors, as seen respectively in the quotes below:

> And I feel that in the EDP our lecturers like Dr. DXXX she was very caring. She was for us [smile] She took us through the courses and explains to us in the way that we would understand everything (EDP15).
>
> And in 1st year there was this tutor he really helped with physics a lot. He would opt out his time even late at night to help us with submissions that we had to hand in. so he helped us basically in physics perspective (EDP12).

Other students indicated that having conversations with mentors (lecturers) afforded the opportunity to express themselves freely: *"There was a meeting that we had with Dr. GXXX where we just go to talk with him and express our thoughts, feelings" (EDP12),* and share issues that were of concern as shown:

> I remember going to Dr. VXXX and I was like 'Is chemistry really cut out for me'? Should I continue in this? I also remember going to CXXX […] And yeah the fact that Dr. DXXX is not really my lecturer, but she was and still is open to me just coming into her office and crying about my life. Oh I feel like that helped, it really helped so much. And I know one can't expect it from all the lecturers, but like it is really something that helped (EDP13).

As a final note, I end with the advice from a participant to new students: *"When you get to the University, the first thing you need to realise is that the resources that you have are your lecturers" (EDP8).*

6.8.6 Exercise and sleep

Exercise and sleep also helped students to deal with difficult times, and maintain the right state of mind as seen from representative quotes: *"if you want to exercise that takes 1 hour a day" (MS7),"So, I also spent a lot of time training" (MS9).* For instance, the statement by MS11 captures the useful role exercise and sleep played: *"One thing that has helped me however, is that I make sure that I manage to sleep every night. And keep healthy. Exercise" (MS11).*

6.9 Discussion

In accordance with earlier studies, students from both study programmes described coping strategies that revealed the development of their academic competence and the application of appropriate study skills (Case, 2007; Lubben et al., 2010; Potgieter et al., 2015). Responses revealed strategic thinking about (1) time management, a commitment to work hard and applying extra effort (2) making wise choices of courses, keeping up with the work by studying regularly and strengthening their personal resolve to succeed, consistent with previous studies (Lubben et al., 2010; Potgieter et al., 2015). The feeling of the shame of incompletion was also reported in the study by Lubben et al. (2010), where some students mentioned that their friends left science and moved into humanities to at least obtain a degree with which they could return home. This movement or transfer was undertaken because they could not face the shame associated with incompletion that would come, especially from family and friends at home if they dropped out. Also, in the study by Carranza (2007), it was reported that commitment to achieve an academic goal was an important factor that students identified as instrumental to their success. The current study agrees with the finding because the major reasons that both EDP and MS students gave for persevering as already described included: commitment to helping their family, commitment to their goal to obtain a degree and being a role model for others to emulate, the latter was strongly emphasised by the Black students.

Family was a strong support mechanism for the majority of students, as reported in a similar study carried out by Case (2007). Both EDP and MS students treasured the friendships they had in class, and cited this as one of their reasons for persistence in the programme consistent with other reports (Case 2007; Schmitt et al., 2007). Carini, Kuh and Klein (2006) reported that at-risk students' interaction with more able students did not correlate strongly with their academic development, this study reports otherwise as seen from the students' statements presented thus far. In terms of study groups, Case (2007) reported that engineering students

had a clearly defined small group of students whom they worked with, even after regular class hours and activities, and the current study agrees with this. As seen from the findings from the current study, the support provided by the church was strongly echoed, as noted by Bangeni and Kapp (2005). In terms of support and assistance, appreciation was expressed across the board for the support from mentors and tutorial sessions consistent with the report of by Potgieter et al. (2015).

Academic support provided in the extended programme was positively experienced. In contrast to the report by Potgieter et al. (2015), all EDP students in the study actively sought academic assistance from lecturers, tutors and classmates. Some students initially mentioned they were afraid to approach their lecturers (1st year, prior to EDP as already described) but when they moved into the extended programme the small group tutorials, support from lecturers and tutors alike made it possible for them to get the help needed. The majority of the students mentioned forming study groups for collaborative learning, which is similar to the study by Potgieter et al. (2015). MS students also mentioned getting help from classmates and lecturers. This suggests that getting help was a common theme across the two groups. Unlike EDP students, the majority of MS students stated that they did not participate in study groups. One student (MS16) labelled study group as a waste of time.

Additionally, MS2's statement revealed that she appreciated the fact that Y2 allowed her to organize her reading. For her too many tutorial sessions as was the case in Y1, were not a positive experience: *"you have to do this prac, you have to do this tut to […] and then to a place where everything was a little bit of more hands-off" (MS2)*. This finding is a direct contrast to EDP students who appreciated the multiple tutorial sessions in the extended programme. When they moved into mainstream and noticed there were fewer tutorials, it was a major difficulty, as reported earlier. I argue that it was easier for EDP students to form study groups because of the experience in the extended programme where they studied in smaller classes, attended tutorial sessions together and developed friendships as earlier evidenced. Thus, when they moved into mainstream, familiar faces provided the needed comfort, and the strategy of working in groups continued. Generally, MS students did not consider the care from lecturers or small group learning in tutorials as a strong feature in their persistence, although support from family was recognized.

Students' religious background also played a significant role in their persistence, especially for the Black and international students within this group. For example, MS16, who is a Black student, said:

> "I will be honest with you, one thing that keeps me together or keeps me sane so far is my religion. I am a Christian. And so, based on Christianity principles which is 'don't give up on whatever you do'[…]".

Support structures like student advisors were also positively experienced, consistent with the literature (Lundell et al., 2007; Schmitt et al., 2007). Students' interaction with peers and faculty, especially out of class, have been reported to significantly contribute to their academic and personal development (Kuh, 1995). My study is consistent with this report, as many of the students recounted that interaction with peers, especially outside the classroom setting, as well as connection with lecturers, helped them to handle difficult times. Furthermore, as recounted earlier a student (EDP13) explained that she could go into her lecturer's office and cry about her life; this constituted a stable support system, and she described it as very helpful. Also, (EDP1) explained that she enjoyed talking to her lecturers, and she learned a lot from these encounters. These findings suggest the need to strengthen effort in meeting students' psycho-social needs, which can be strengthened by providing more access to counselling services and advisers. As a way of concluding this aspect, I end with the advice given to new students by EDP15:

> But when you get to university get every possible help you can. Put your pride aside, put your grades from high school aside. Just get help. Get some friends, tutors or ask the scientific officers. And determination. And try to stay on top of your work, you can do it (EDP15)

6.10 Concluding statements

This chapter captured students' transition from Y1 - Y3 chemistry. The transition from Y1 to Y2 and from Y2 to Y3 was the most difficult for EDP and MS students, respectively. EDP students initially felt overwhelmed on transitioning into Y2 as new challenges emerged, and they struggled due to increased workload and pace. The Y1-Y2 transitions is considered beneficial because, despite the initial insecurity, EDP students were able to settle down and later drew on the benefits of the programme. They realised in Y3 that the extended programme had indeed provided them with the required skills for success, because they approached their studies more positively, which led to increased confidence.

Both EDP and MS students faced personal issues of financial challenges, language barriers, protests, loneliness consistent with other studies (Bangeni & Kapp, 2005; Case, 2007; Lubben et al., 2010; Potgieter et al., 2015). Generally, students indicated that it was a challenge to adapt to the larger volume of work, fast pace and increased expectation from lecturers in Y3. Individual students referred to organic chemistry and physical chemistry as difficult modules,

however, some students said that organic chemistry practical sessions helped them to understand their work better.

Moreover, students experienced difficulty and faced various obstacles at different times during their study; however, there is strong evidence of effective adoption of coping strategies in order to overcome these difficulties. The study also revealed that students actively sought academic assistance from lecturers, tutors and classmates. The majority of EDP students talked about forming study groups for collaborative learning; similar to an earlier report (Potgieter et al., 2015), while the majority of MS students stated that they did not participate in study groups

Furthermore, the majority of the students, especially in EDP identified religion as a major influence on their persistence, followed by support from family, friends, and lecturers. In direct comparison, MS students mostly identified support from friends, lecturers, and family as instrumental to their persistence. The next chapter provides answers to the research questions; and a description of four selected cases.

Chapter 7: Conclusion and four selected cases

In the preceding chapters of the thesis, I have taken the time to direct the readers to the major findings as they relate to the aim of the research. In the quest for answers to the research questions, it is important not to lose sight of the primary aim of the study, which was to understand the persistence of a cohort of third-year chemistry students from both the Extended Degree Programme (EDP) and Mainstream (MS) at UCT. The main research question was to investigate how conceptual understanding, career aspiration, self-efficacy and experience in chemistry collectively influence (or not) EDP and MS students' persistence.

The analysis in Chapter 4 helped me to understand students' academic progression before and through university. Listening to the students during the interviews (Chapters 5-6) helped me to understand why they talked about certain things the way they did. Attention will now be directed to the research aim as I answer the research questions posed in section 1.4.

The aspect of the research question relating to conceptual understanding was uncovered by analysing documents, specifically the students' writing project, which focused on chemical bonding; a topic that students find problematic (Tsaparlis et al., 2018). The analysis of the writing project led to the cursory analysis of a question in Y2 exams. The outcome of these two exercises revealed a difference in performance in the writing project and Y2 exams, both of which contained similar questions. As a result, students' academic transcripts, NBT scores, and NSC scores were analysed to provide a measure of their academic performance before and at university. Comparing EDP and MS students on these different measures (writing project, Y2 exams, transcripts, NBT, NSC) presented some differences in performance.

Based on the findings noted above, a decision was made to analyse the qualitative data generated from the questionnaires and interviews to see if these data sources could account for the differences in performance, this was achieved by looking at the experiences of students who were enrolled in EDP and MS. The qualitative data also helped to answer the research questions relating to career aspiration, self-efficacy and experience. The outcome of the qualitative data showed that the majority of the students did not have a career aspiration in chemistry. Their self-efficacy beliefs changed over time depending on their experience in chemistry, especially during the different transitions from CEM1 to CEM2 and CEM2 to CEM3. The transition experiences were different for EDP and MS students. However, it was seen that EDP found the transition into CEM2 to be difficult, whereas it was the transition from CEM2 to CEM3 for MS students. These findings have been comprehensively described in previous chapters.

In this chapter, answers to the research questions posed in Chapter 1 (section 1.4) are provided. My original contribution to knowledge earlier stated in Chapter 1 will be explained in detail here; ending with a conclusion and recommendation section.

7.1 Answering the research questions

Introduction

The centrality of the three sociocognitive variables, self-efficacy, outcome expectation and personal goals as proposed by Bandura (1986) and Lent et al. (1994) is reflected in my research questions (RQs):

> RQ1: What are the students' levels of conceptual understanding and academic performance in chemistry?
> RQ2: What are the students' career aspirations?
> RQ3: What are the students' levels of self-efficacy?
> RQ4: What were the experiences of this cohort of students, as they relate to studying chemistry, and how did they persist?

What follows are four separate sections, each relating to one of the questions above. I have selected themes that match the research questions that each section proposes to provide answers about: Conceptual understanding and academic performance in chemistry (RQ1), Career aspiration (RQ2), Self-efficacy (RQ3) and Experiences in chemistry (RQ4).

7.1.1 Conceptual understanding and academic performance (RQ1)

My first RQ asked: What are the students' levels of conceptual understanding and academic performance in chemistry? The writing project, with its narrow focus on a single topic, namely, chemical bonding, was not necessarily a good measure of students' level of conceptual understanding of chemistry as a subject. However, it was chosen since it was a project that was completed by most of the students and focused on the topic of chemical bonding, which is a key topic in chemistry. Comparing students' marks in Q1 (writing project) and Y2 exams showed a difference in performance. The differences may be because the tasks measured different aspects of the topic, and were administered at different times and under different conditions. Fluctuations in individual students' marks may be explained by other factors in their lives. However, analysis of the data related to performance revealed that MS students performed on average better than EDP students, in every measure. The performance may reflect the fact that EDP students started with a lower NBT score on average.

Additionally, analysis of students' transcripts with a focus on chemistry courses revealed that the average performance for MS and EDP students in CEM1 was similar. There was a drop-

in performance for both groups in CEM2, which was greater for EDP students. There was a marginal improvement for EDP students in CEM3 compared to CEM2, where one student achieved above 70%. This mirrors the earlier argument as seen in the interview data concerning EDP students transition from CEM1 to CEM2, and from CEM2 to CEM3 (EDP students found the CEM1 to CEM2 transition difficult, compared to CEM2 to CEM3 for MS students). Another interesting finding that emerged from the study was the positive correlation between students' NBT and CEM3 scores.

The SCCT model proposes that good academic performance will result in repeated behaviour; which in this case is persistence in chemistry. However, as seen in section 4.6, for the majority of students, there was no apparent consistency in their performances from Y1-Y3, which would have resulted in sustained behaviour (persistence). Their persistence is associated with factors other than good academic performance, which the qualitative data uncovered. The qualitative data revealed the influential role that personal goals and outcome expectations played in sustained behaviour, and agreed with Bandura's (1986) SCT model.

7.1.2 Career aspiration (RQ2)

My second RQ asked: What are the students' career aspirations? The majority of both EDP and MS students had a career aspiration for a discipline outside chemistry, and it was not a strong motivation to explain why the majority of them continued studying. Most of them, as mentioned in section 5.2.3, had a career aspiration in medicine and engineering. During the interviews, some students talked about continuing into postgraduate study in their initially intended career path. The shift was not surprising since chemistry was a second-choice for the majority of students. Additionally, most of the themes under retrospective and prospective criteria reflect aspects of SCCT model, with perceived academic abilities in high school appearing strongly in the decision of choosing chemistry; especially after denial in their initial career preference.

This study reveals that the requirement for a second major, which I argue as being a contextual factor, as described by SCCT, was a strong influence on students' subject choice. The personal factors proposed by SCCT, such as gender and experiential variables, were not observed. SCCT proposes the independent influence of self-efficacy and outcome expectation on goals and choice actions, which may help explain career choice behaviour when opportunities to implement an interest are perceived as limited. In this aspect, the findings from my study agree with SCCT model. For instance, when some of the students could not gain entrance into their preferred choice, they decided to select subjects that they performed well in high school, in agreement with previous studies (Gałaj, 2012; Lent et al., 1994; Schunk, 2003)**.** Based on this reason, some students, especially those who fell into the second-choice

category, decided to major in chemistry. In terms of outcome expectations, it was also recognized that some students decided to continue in chemistry because of the expectation that it will help them to return to their initial career preference.

7.1.3 Self-efficacy (RQ3)

My third RQ asked: What are the students' levels of self-efficacy? Considering the questionnaire findings, all the students appeared to have a similar level of self-efficacy, however, when interviewed, three categories of students emerged, which were top-students, self-confident students, and self-doubt and fearful students. Also, EDP students tended to express their self-efficacy verbally, whereas MS students' self-efficacy was tacit.

Self-efficacy played a role in the persistence of both EDP and MS at different stages during their study, in agreement with Bandura's (1896) SCT model. For instance, the majority of EDP students were confident of their ability to succeed in their studies when they enrolled in Y1, whereas strong-self efficacy played a significant role in the persistence of MS students in Y3.

7.1.4 Experience in chemistry (RQ4)

My fourth RQ asked: What were the experiences of this cohort of students, as they relate to studying chemistry, and how did they persist? The experience of EDP and MS students as it relates to studying chemistry varied, with specific reference to the transition experiences, which have been described in section 6.2. The transition experience from CEM1 to CEM2 and from CEM2 to CEM3 was the most difficult for EDP and MS students, respectively. All students indicated that it was a challenge to adapt to the larger volume of work, fast pace and increased expectation from lecturers. Nevertheless, some students considered it as an opportunity to improve their time management skills and acquire relevant coping strategies for dealing with academic demands, which helped them to persist. Individual students referred to organic chemistry and physical chemistry as difficult modules.

The Extended Degree Programme provided a good learning experience for the students, and thus, the results agree with the SCT and SCCT models, which highlight the role that good learning experiences play in sustained behaviour and persistence. However, the majority of EDP students felt that they were not well prepared for the transition into the mainstream system in terms of dealing with the faster pace and increase academic workload. Considering MS students, they did not appreciate frequent tutorial sessions, especially in Y1; they seem to like the "hands-free" experience that CEM2 provided as earlier noted in section 6.2.3. By the time they reached CEM3, MS students especially, said it was difficult to adapt to the larger volume of work and satisfy the increased expectation from lecturers.

Both EDP and MS students faced emotional hurt, personal issues such as financial challenges, language barriers, protests and loneliness at different times. However, they acquired productive coping strategies like taking responsibility for themselves, and finding support mechanisms that helped them to persist. For instance, the majority of the students, especially in EDP, identified religion, family, friends and lecturers as major supports that helped them to continue studying. On the other hand, MS students mostly identified support from friends, lecturers and family as instrumental to their persistence.

7.2 Four selected cases

The findings in the study come together well in the story of some participants, which can be used to address the main aim of the study. To achieve this, I selected four students: MS4, EDP8, EDP13 and MS7, and describe their experience. These students showed one or more of the following distinct features: good academic performance, a strong sense of self-efficacy and career aspiration, but were lacking in other aspects (Figure 35).

Figure 35: Four selected cases in the study

A summary of the students' respective academic performances in CEM1-3 is shown in Figure 36 below. Those in the positive and negative part of Figure 36, respectively, scored above and below the class average (horizontal axis). Key quotes have been provided for convenience while narrating the students' experiences.

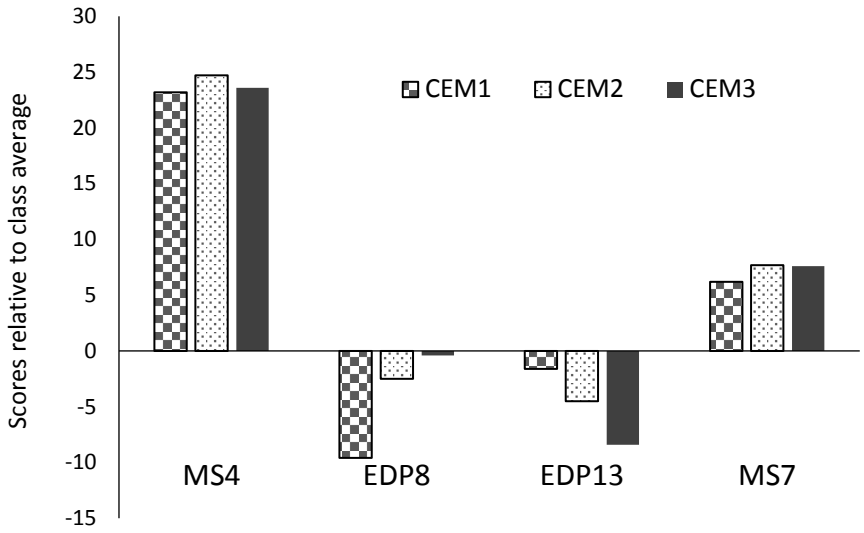


Figure 36: Four selected cases of academic progression in CEM1, CEM2, and CEM3

I begin the discussion with MS4. She is a student who said '*I'm definitely not going into chemistry'* but lacked a career aspiration as illustrated:

> I think the big thing for me was not knowing what I wanted to do when I left school. I just enjoyed everything at school. I never knew 'oh yeah I definitely wanna be this, I definitely wanna do an accounting degree, I definitely wanna do science. I had no idea […] (MS4)

Although MS4 did not know what career path to follow, she possessed a strong sense of self-efficacy as evidenced in her narrative. For instance, during the interview, her statement indicated a strong sense of determination and persistence: "*If I start it I must complete it*". When asked about her career plans, she said: "*And even now, I still don't think I know what I wanna do [pause) I don't think I have any idea of what I wanna do [laughter]".* It was somewhat surprising to view her academic record and discover that she was among the top-performing students in this cohort of chemistry students. Based on this discovery, I decided to return to the data by checking the high school she attended, which revealed an elite private school, with a good reputation of producing students with outstanding academic excellence. I, therefore, argue that this could be a factor for the performance. Nevertheless, I will not underestimate the hard work and extra effort she has put into her studies to achieve excellence. Additionally, during the conversation, she positioned her parents as giving her a "*beautiful school education*" and described higher education as "*a very big privilege*." Also, she said that she would be returning to her previous job, but information about the nature of the job was not shared. On the other hand, she stated that if she later decided to study further, it would be overseas, as she was tired of the protests at South African Universities.

The case of EDP8 is different from MS4 reported above. This student possesses a strong sense of self-efficacy and career aspiration but was not performing well in his studies, and had

come from a public school. In terms of adjustment to the social environment in university his statement clearly indicated that he did not experience much difficulty because *'in first year I had the same friends that came from the same school as I did'* nevertheless "*when it came to the courses and workload, there was just that jump within the workload".* The difference in performance between school and university caused difficulty as narrated:

> When I was doing matric I managed to secure 1st place in my school, and 3rd place in the entire district. And then when I got here, the things shoot around, it was no longer that. It was no longer like 'Ok, you are the top guy, you know everything' […] And then for the first time, I now failed a course, that hurt me bad. It really hurt me bad […]

Analysis of his academic transcript showed that he repeated some courses, and at some point, he contemplated discontinuing because:

> Some of the other kids that I used to compete with back in school, were in universities like CPUT [Cape Peninsula University of Technology], they were doing good. […] something came up again "if you had taken that chemical engineering in CPUT, maybe all these wouldn't be happening, you will be doing good as the other kids are" (EDP8).

Nonetheless, this student was resolute, and his persistence is rooted in the fact that "*I need to be that role model. Show them that even if it's hard, you can make it. So that's what has kept me going".* So, no matter how hard it was he had to push and "*being the firstborn"* and he felt like *"it's part of my responsibility to like to pave a way for my younger brothers*". Similar experiences were reported in the study by Kelly-Laubscher et al. (2018), where the majority of the students also experienced difficulty and self-doubt because they could not measure up with the academic demands in university. In order to overcome these difficulties, EDP8 sought help from "*different groups of people that I would study with"* and had to *"hook up with a new guy in maths",* and used several online resources.

A different scenario is recounted for EDP13, who had an aspiration for chemistry but had a weak sense of self-efficacy, which affected her academic performance. This student imagined working in the laboratory from high school and chose chemistry as a first-choice, but she was "*intimidated by the students in mainstream*." She struggled as explained:

> But at that stage, I think what mostly went through my mind to choose the EDP programme was a lack of self-worth and self-trust [pause]. It wasn't bad it was just because I was scared, fearing nothing, just scared […] (EDP13).

To overcome this difficulty, she had to engage in self- development that has been described in section 5.4.4.

I will end by talking about MS7. This student initially wanted to study medicine but was denied admission hence chose chemistry as a second-choice. She expressed dislike and regret enrolling in chemistry. During the conversation, she said: *"I am not even sure if I will pass my exams"* thus I was surprised to discover that her academic performance was also well above the class average from CEM1–CEM3. Based on this discovery, which was similar to MS4, I returned to the data, which revealed she attended a good private school. The question that I raised was: Why was this student so unhappy and full of regret? I argue that there were emotional issues and unpleasant experiences in the course, which were negatively affecting her motivation in chemistry and causing self-doubts. This experience echoes what has been reported in the literature that negative learning experiences can reduce students' motivation and persistence to complete their degree (Tinto, 2017). It is useful to highlight that I was not able to investigate further why this student was unhappy in chemistry since this was not part of the aim of my research.

The SCCT model proposes that good academic performance is likely to result in repeated behaviour; which in this case is persistence in chemistry. But as seen in the case of EDP8, this student persisted despite a decline in performance from Y1-Y3. EDP13 has a career aspiration for chemistry but was not performing well because of a weak sense of self-efficacy. The qualitative data revealed the strong role that personal goals and outcome expectations played in these students' persistence.

The four selected cases reported above demonstrate that there was no relationship between students' persistence and their academic performance, career aspiration, or self-efficacy. Those students who had strong career aspiration were struggling to persist in the programme, in the same way, as for those who had a strong sense of self-efficacy. On the other hand, a student without a career aspiration was performing well in her studies. This addresses the main research question and demonstrates that persistence depends on a number of inter-related factors that are different for individual students.

So, how does this study contribute to knowledge around students' persistence? Moreover, how can the university translate these findings into efforts in improving the retention of students? What are the implications of these findings for the Department of Chemistry, as it relates to the retention of students? I will use the next sections to make relevant suggestions, and to discuss these points in no particular order, which begins with reiterating my original contribution to knowledge.

7.3 Original contribution to knowledge

My original contribution to knowledge as it relates to students' persistence is that, persistence depends on a number of inter-related factors, which are different for individual students; some students persisted because they wanted to provide financial help for their family, whereas the others did not want the money spent on their education by their parents to be wasted. Furthermore, the study reveals that there was no relationship between academic performance and either career aspiration or self-efficacy for the cohort. This finding means that students may continue to perform well in a course even if they do not have an aspiration or a particular career in mind. Strong career aspiration and sense of self-efficacy may not necessarily result in good academic performance. Students' persistence in a study programme may be largely driven by other aspects such as personal goals and responsibilities, which obtaining a university degree may help them to achieve.

In terms of conceptual understanding, academic performance, career aspiration and self-efficacy other interesting findings emerged. MS students performed on average at a higher level than EDP students in all the measures used to check for the extent of conceptual understanding and academic performance in chemistry. I also found a positive correlation between students' NBT and CEM3 scores. I also found a positive correlation between students' NBT and CEM3 scores. As noted in section 3.2.1, the writing of the NBT is a requirement for admission, but the results are not included in determining acceptance into the Faculty of Science at UCT. A positive correlation between results for NBT and CEM3 is interesting because it suggests that the Faculty of Science could consider including the NBT score as part of the criteria for admission. On the other hand, this might exclude students who would potentially be successful, since we note that all of the sample, even those with lower NBT scores, succeeded in CEM3. The positive correlation described above is useful as it could guide the Faculty of Science and subject advisors to determine, which students should be encouraged to move into the extended degree programme after they have written the first set of class tests.

Furthermore, the findings reveal that some of the students have well-defined, but probably not always realistic ideas of a desirable career. For the majority of the students, chemistry was a second-choice option, and they did not have a career aspiration for chemistry. However, their career aspiration changed over time while studying. The requirement of a second major for enrolment at UCT was a strong contextual factor that influenced students' choice. In terms of self-efficacy, the majority of EDP students possessed a strong sense of self-efficacy that was expressed verbally, while the majority of MS students possessed a strong sense of self-efficacy that was tacit.

My study also surfaced important aspects relating to students' experience. All students had a disheartening experience at different stages in their studies. EDP students found the transition to CEM2 difficult, whereas MS students found the CEM3 transition to be difficult. It was during these difficult times that students began to doubt their abilities; these experiences planted thoughts of discontinuation. Although the syllabus for the two programmes (EDP and MS) is the same, students' experiences differed. I borrow the words of EDP17: "*decanted chemistry and the main chemistry is so different. They are very different […]".* EDP students made significant references to the encouragement and support they received from lecturers and tutors, and referenced this as a major support mechanism that helped them to continue studying. This was not the case for MS students, and I argue that this may be because MS students were not familiar with receiving such support. Other aspects of course design such as the change in structure in terms of the number of tutorials in EDP and MS as well as the faster pace in CEM2 were also problematic for the majority of the EDP students. In terms of study groups, it was easier for EDP students to engage in study groups compared to the majority of MS students who referred to this practice as a waste of time. The study also revealed that a small number of EDP students were able to manage the transition into CEM2 well because they had established friendships with students in senior courses; who provided continuous guidance and support in terms of what to expect in mainstream, and eased the transition process. Also, some EDP students were able to do a second-year science course which gave them an idea of the pace expected in second-year.

In terms of retention, the study has revealed as seen from the overlap between EDP and MS students' performances (Figure 28, p.74) that the extended programme helped the majority of the students in this cohort to be retained, and demonstrates that the programme is helping the Department of Education in achieving the goal of redress; as well as the university's commitment in this regard.

7.4 Implications and recommendations

7.4.1 Implications

Given the issues discussed in this thesis, what does this mean for UCT and the Department of Chemistry? Although the extended programme helped the students to remain in their studies as seen from students' narratives, they still found the transition into mainstream a challenge.

The study suggests the need to strengthen efforts in meeting students' psycho-social needs and highlights that all students need support regardless of the programme (EDP or MS). When EDP students moved into mainstream courses, they referred to their lecturers as uncaring; it

seems they desired to receive the same support from their MS lecturers as they had from their EDP lecturers, which unfortunately was missing. Since students draw support from lecturers, the lecturers must be equipped and well-trained to be able to offer this support. Furthermore, lecturers need to be more aware that their day to day interactions with the students, both within and outside the classroom affects their students' motivation and persistence.

Students complained that chemistry was too time-consuming, and this flags the possibility of an overloaded curriculum. Could this issue be the reason why some students are leaving chemistry? Also, individual students refer to organic chemistry and physical chemistry as difficult modules, which highlight the need to examine the curriculum to ease the transition points for all students.

While students who apply for admission to the Faculty of Science are required to take the NBT tests, these are not used when determining the criteria for admission. Other faculties at UCT use NBT scores in combination with NSC scores to determine admission criteria. The finding of a positive correlation between NBT and CEM3 could be investigated further to see whether it applies to other majors as well as this could provide a starting point to consider using NBT to refine admission to the Science Faculty; as well as the transfer of students from the mainstream to EDP. Additionally, the university requirement of a second major influenced the majority of students' decision to choose chemistry and may have made these students to choose the course in an impromptu manner, and suggests that UCT should consider allowing students to choose a single major.

I noted that EDP students who took mainstream courses while in their second-year of EDP made it easier for them to handle the transition into mainstream. This observation has an important implication for the success of the extended programme. I ask the question "Will the EDP programme be more successful when students take a mix of Y1 and Y2 courses in their second-year in EDP?

The following questions arise from my study: How can the Department of Chemistry accommodate and cater for students who have different needs, and teach them in one classroom in CEM 2 and CEM3? How can EDP programme maintain its distinct features and also assist students to transition better into mainstream courses? What is the required optimum pace for EDP programme, so that EDP students transition more smoothly into CEM2? These are questions that cannot be answered by this research. Nevertheless, I think the first step in the right direction will be to acknowledge that these issues exist.

7.4.2 Recommendations

Based on the findings from the study, I make the following recommendations: The Faculty of Science should seek ways to improve the Extended Degree Programme to help students to measure up with mainstream students academically. One way to begin is by conducting further research on the experiences of EDP students, focusing on a different sample from Mathematics or Biology, as this may reveal other issues. Additionally, I suggest that the chemistry curriculum should be examined by the Department of Chemistry and all those concerned to try to ease the transition points for all students.

Furthermore, I recommend the provision of adequate counselling by the Faculty of Science to steer students on study paths within the BSc degree that may still help them to achieve their initial career preferences; and open their eyes to various opportunities that exist. While it may not be possible to change their initial career aspiration, it is possible to sustain their interest in the course, which will lead to greater persistence and hence, retention. Therefore, an acknowledgement and reinforcing of students' career aspiration are recommended as this may facilitate decisions on progress through their studies.

EDP and MS faced difficulties, which affected their sense of self-efficacy at different times; hence, I recommend that the Department of Chemistry should strengthen effort in providing academic support for students at all levels. Furthermore, some students explained that they enjoyed talking with their lecturers and learned a lot from these interactions; while others said they received support and advice from their lecturers when they felt like quitting, especially EDP students. I, therefore, recommend that the Department should organize relevant training for lecturers that will equip them with requisite skills to support students. Mainstream lecturers should be more aware of the needs of EDP students, and at the same time, EDP students should be advised to recognize the value of the extended programme.

Some students also stated that they benefited from social spaces that allowed them to interact with other senior students. For instance, MS16 said the Department of Geology organises a pizza day for all the different tiers of students within the Department to interact and establish networks. He indicated that such spaces were useful because students have the opportunity to talk and learn from their peers who understand their struggle; and not lecturers. Thus, creating spaces for students from all tiers to interact is essential, and stresses the importance of "webs of development' which will also afford professional development as suggested by (Ngcoza & Southwood, 2019). Thus, I recommend that the Department of Chemistry should encourage and create spaces for students at all levels to interact, as this will help to sustain their interest and persistence.

In agreement with Social Cognitive Theory, personal goals and outcome expectations played an important role in students' persistence. I, therefore, recommend that lecturers and the Department of Chemistry should always remind students of the reasons why they are at university. Drawing their attention back to their personal goals and expectations will keep them engaged, consistent with the suggestion by Ali and Saunders (2009); SES high school students might benefit from targeted interventions that are designed to increase their confidence and expectations about their future.

Given the positive correlation between NBT and CEM3 scores, I recommend that the Faculty of Science should consider using NBT scores to refine their admission process. Also, the Faculty of Science should consider the possibility of a single major. I hope that the findings in this study will help the University of Cape Town and the Department of Chemistry to promote students' retention.

In Chapter 1, I mentioned that education was seen as a potential form of redress as noted in the new 1996 South African Constitution (The Constitutional Assembly, 1996). I also said that I hope that the findings from this study will help advance the state of knowledge about students' experiences in university and help the Department of Education to achieve their long-time goal of redress.

Although this study does not speak to every students' needs in the South African context, it has contributed to knowledge by bringing to the fore the experiences of this class of third-year chemistry students at UCT. It has also shown that the extended programme helped the majority of the students to be retained and demonstrates that the programme is helping UCT and the Department of Education in achieving the goal of redress. I, therefore, call for more support from all concerned to ensure the smooth running of the extended programme because as more students are retained, it contributes to the developmental needs of the South African nation.

7.5 Reflection on the research design

This study recognizes that the self-efficacy data reported in this thesis as it relates to the interview data is limited by the fact that it did not use standardized measures for self-efficacy. The students' self-efficacy was inferred from students' narratives. However, the aspect of the self-efficacy relating to the questionnaire, as indicated earlier, was drawn from relevant literature, and the questions were modified to suit the research.

The choice of the writing project is also recognized as an intrinsic research design flaw because my analysis focused on a small section of the writing project, which deals with

questions on chemical bonding. As such, it was not necessarily a good measure of students' conceptual understanding of chemistry. If I were to redo this study, I would do it differently by choosing another method to investigate students' conceptual understanding, possibly using a pre-test and post-test method.

Also, it is important to note that although this study contributes to literature around retention in the South African context, the findings in this thesis are not generalizable; emphasising the peculiarity of a qualitative study. Moreover, the data has been analysed with a social constructivist framework. Hence the findings should be interpreted in this light. In the next paragraph, I reflect briefly on the research design and identify areas could be improved; some of which presents an opportunity for future research.

As seen in the study for those students who chose chemistry as a first, second and partner-choice option, there was a significant influence of both retrospective and prospective criteria, and so no difference could be established in terms of the criteria mostly employed. I argued that the sample size could have been a factor why this could not be determined, hence I would work on improving the sample size by incorporating students from CEM2. I would also try to establish why there was such a gap between EDP and MS students' performances in NBT since this could not be investigated in the current study.

I also noted that a student, MS7, was unhappy in the course despite her good academic performance, which I argued that could have been due to emotional issues. This could have been investigated further by incorporating actual measures that would help to describe students' emotional satisfaction or dissatisfaction within the courses, instead of inferring this from their narratives.

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Appendices

Appendix 1: Extract from the Science Faculty 2019 Handbook - information about courses and grades

Extract from the Science Faculty 2019 Handbook about courses and grades

Information about degree requirements and chemistry courses

http://www.students.uct.ac.za/sites/default/files/image_tool/images/434/study/handbooks/2019/2019_SCI_Handbook.pdf

First-Year Courses in Chemistry, page 84

CEM1000W is the first-year full qualifying course for entrance to second-year courses in the Faculty of Science and in Chemical Engineering in the Faculty of Engineering & the Built Environment. CEM1009H and CEM1010H are half courses taken by students who transfer to the Extended Degree Programme, and completion of both courses is equivalent to the full course, CEM1000W.

Level of course	MS	EDP
First year, Y1	CEM1000W, AYOS1	CEM1009H, AYOS 1
First year, Y1		CEM1010H, AYOS 2
Second year, Y2	CEM2005W, AYOS2	CEM2005W, AYOS 3
Third year, Y3	CEM3005W, AYOS3	CEM3005W, AYOS 4

CEM = chemistry AYOS = Academic Year of Study

W = whole year course, 1 credit

H = half year course, ½ credit

First number = level of study, hence 1 for first year, 2 for second year etc., see page 10 of Faculty Handbook.

Duration of degree, 3 or 4 years depending on the programme.

Curricular rules, page 16

The curriculum shall include the equivalent of at least nine full-year courses of which at least six full-year courses must be Science courses. A maximum of three full-year courses or the equivalent may be counted from other faculties, FB7.1

The curriculum shall include the equivalent of at least four full-year senior courses or the equivalent, of which at least three shall be Science courses, and the equivalent of two full-year courses shall be third-year (level 7) courses, FB7.2.

First-Year Courses in Chemistry, page 84

CEM1000W is the first-year full qualifying course for entrance to second-year courses in the Faculty of Science and in Chemical Engineering in the Faculty of Engineering & the Built Environment. CEM1009H and CEM1010H are half courses taken by students who transfer to the Extended Degree Programme, and completion of both courses is equivalent to the full course, CEM1000W.

Chemistry courses in the Science Faculty

CEM1000W Page 85
Course entry requirements:
Students wishing to register for CEM1000W will normally be expected to have passed NSC Physical Science with at least 60% and NSC Mathematics with at least 70%.

Course outline:
This course lays the foundation of chemistry in its context as a central science for scientists and engineers working in the chemical, biological or earth sciences or in chemical engineering. Fundamental concepts in chemistry are covered to illustrate their application to understanding the molecular nature of the world around us. Topics include microscopic and macroscopic concepts, atomic structure, chemical bonding and molecular structure, the chemistry of the elements and inorganic chemistry, chemical equilibrium, acids and bases, solubility, phases of matter, thermochemistry and thermodynamics, colligative properties, oxidation and reduction, electrochemistry and chemical kinetics. The course continues with an introduction to the language of organic chemistry, including structure and reactivity in organic chemistry, describing and predicting organic reactivity and the properties and reactivity of biologically important molecules. Practicals aim to develop essential manipulative and technical laboratory skills, as well as to draw links to interpreting the physical world in terms of its molecular nature.

CEM1009H Page 85
Course outline:
This course lays the foundation of chemistry in its context as a central science for scientists working in the chemical, biological or earth sciences. Fundamental concepts in chemistry are covered to illustrate their application to understanding the molecular nature of the world around us. Topics include microscopic and macroscopic concepts, atomic structure, chemical bonding and molecular structure, chemical equilibrium, acids and bases, solubility, phases of matter, thermochemistry, osmosis and chemical kinetics. The course continues with an introduction to the language of organic chemistry, including naming of compounds, identification of functional groups and isomers. Practicals are designed to develop essential manipulative and technical laboratory skills, to take measurements and handle data, as well as to draw links to interpreting the physical world in terms of its molecular nature.

CEM1010H Page 86
Course outline:
Topics covered at a more advanced level include microscopic and macroscopic concepts, atomic structure, chemical bonding and molecular structure, the chemistry of the elements and inorganic chemistry, chemical equilibrium, acids and bases, solubility, vapour pressure and phase diagrams, thermodynamics, colligative properties, oxidation and reduction, electrochemistry and chemical kinetics. The course includes an introduction to the language of organic chemistry, structure and reactivity in organic chemistry, describing and predicting organic reactivity and the properties and reactivity of biologically important molecules. Practicals aim to develop essential manipulative and technical laboratory skills, as well as to draw links to interpreting the physical world in terms of its molecular nature.

CEM2005W Page 87
Course outline:
This course develops the foundations of a major in Chemistry at an intermediate level and allows continuation to third-year Chemistry for the completion of a major in Chemistry. The theory component features a set of intermediate topics, and the laboratory component develops both experimental and interpretative skills. The course includes the following topics: spectroscopy and modern analytical tools, introduction to inorganic chemistry, organic structure and reactivity, thermodynamics, thermodynamics of solutions, phase equilibria, chemical reaction kinetics and equilibria, reactions of organic molecules (patterns, predictions

and preparation of new products), introduction to coordination chemistry, structures and energetics of inorganic solids and electrochemistry. The practical course covers the same topics and aims to develop manipulative and technical laboratory skills including the application of modern analytical methods to the elucidation of chemical structures.

CEM3005W Page 87
Course outline:
This final course for the Chemistry major aims to develop understanding and integrated knowledge of the core disciplines in Chemistry. Lecture material includes topics in wave mechanics and spectroscopy, adsorption and heterogeneous catalysis, solid-state chemistry and X-ray crystallography, dynamics, inorganic reaction mechanisms, organometallic chemistry, further topics in organic structure and reactivity, organic synthesis and organic dynamic stereochemistry. The practical course covers the same topics and aims to develop integrative and interpretive skills. A further aim is to develop skills in writing within the discipline, as well as introducing students to modern research methods.

Extract from undergraduate prospectus 2020

Information about admission
http://www.students.uct.ac.za/sites/default/files/image_tool/images/434/prospective/ug_prospectus/ug_prospectus.pdf

Admission requirements Page 62
NSC results are the primary guide for admission to the BSc degree. However, all applicants to the Science Faculty are required to write the NBT (Academic Literacy, Quantitative Literacy and Mathematics).

Admission criteria for applicants holding the national senior certificate (nsc)
Besides taking the NSC results into account for admission, other factors including NBT, availability of places and educational or social/home background, will be considered.

Faculty Points Score (FPS) and NBTs
The FPS (a score out of 800) is calculated as the sum of the percentages achieved in the best six NSC subjects, including English but excluding Life Orientation, and doubling the percentages achieved in Mathematics and Physical Science. Admission to the Faculty of Science requires a FPS of 550. Quaranteed admission which is Band A require an FPS of FPS of 660 or above.

DEGREE Benchmark NBTs Performance Levels

Information about performance levels https://www.nbt.uct.ac.za/content/benchmark-levels

Benchmark Levels
Revision and resetting of henchmarks is conducted every three years

2015 DEGREE Benchmark Performance Levels

Benchmark Performance Levels	AL		QL		MAT	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Proficient	68	100	70	100	69	100
Intermediate	39	67	40	69	35	68
Basic	0	38	0	39	0	34

Information regarding grading scheme at UCT

Grade	Range of %
1, First class	≥ 75
2+, Upper second	70 - 74
2-, Lower second	60 - 69
3, Third	50 - 59

Admission to certain postgraduate courses depend on achieving a pre-determined grade set by the department. Funding agencies and companies use the grades as criteria for awarding scholarships.

Appendix 2: The questionnaire

Questionnaire

Why are students dropping out of science (BSc) courses?

Could it be that they are not motivated to study science (BSc) courses? Do they really have interest in these science courses? Would they prefer to be in engineering and medical courses but rather found themselves majoring in BSc degrees? Was studying a BSc degree their only option? Are there issues with students' perceived abilities which is making it hard for them to achieve their career goals?

These and many more questions is what this research seeks to answer.

Introduction:

SCIENCE FACULTIES are either **losing** *highly talented and academically able students* to non-science based courses or experiencing **students' discontinuation or drop out**. These students who discontinue or perform poorly in science courses, are a concern for educational researchers. Literature reveals that career aspiration, self-efficacy and conceptual understanding are major factors that have significant effect on students' academic performance and success.

The purpose of this research is to understand how these factors affect the retention of science students in the Faculty of Science at the University of Cape Town (UCT).

The findings of this research will help UCT and other institutions to take actions that will translate into useful guidelines for the development of effective programs and policies that will **reduce students drop out from sciences**. Considering this, the questionnaire below has been designed to help the researcher learn about your unique experience(s) in the Science Faculty at UCT. Specifically, it will

(1) Help you reflect on your reason(s) for studying chemistry or physics
(2) Help ascertain your career plans after graduation.
(3) Help the researcher to identify the overall pattern with respect to perceived self-abilities in your class

My name is Ibiye Dagogo and I am doing a PhD in Tertiary Chemistry Education. My supervisors are Associate Professor Bette Davidowitz and Dr Dale Taylor. I invite you to participate in my research project by answering the questionnaire below.

Career aspiration and self-efficacy questionnaire

Instruction: please put a tick ☐ in the box next to the answer of your choice or write in the space provided. You can provide additional information using the "others" comment box. There are no right or wrong answers so please be honest. Complete this questionnaire to the best of your ability.

Section A: career aspiration

(A.1) Influence of family/role model on career choice (rating scale Strongly disagree-strongly agree)

1. My family/role model had a significant influence on my decision to pursue a BSc.
2. I registered for a BSc degree because I was not accepted for medicine or engineering
3. My high school teacher encouraged me to go to university when I did not think that it was an option
4. I did not want to study a BSc but did it to please my family

Space to add comment

(A.2) Tick as many as applies to you to complete the following sentence. I chose to study chemistry because

5. I love it/enjoy it

6. I am good at it/best subject
7. I am certain I will succeed in it
8. It provides more job options (a range of jobs are available)
9. There was no other option

Space to add comment

(A.3) What career plans do you see yourself pursuing after graduation

10. I already have all my career plans after graduation set out.
11. I DO NOT know what to do after graduation
12. I am planning a career that uses chemistry
13. If you plan to study further, briefly describe or indicate the course_____

(A.4) Help with career planning

14. I had a career counselling session before deciding to study my course

    YES □ NO □ Others (please specify) _____
15. I will like to have a career planning session with UCT CAREERS CENTRE

    YES □ NO □ Others (please specify) _

Section B: Self-efficacy

(B.1) Believe that one's academic ability can grow

16. I believe that no matter who you are, you **CANNOT** change or improve your academic ability, it remains the same
17. I believe that academic ability grows as you put in more effort in your studies
18. It is possible to change the level of my academic ability considerably
19. I believe that academic hard work pays off or is rewarding

(B.2) Belief in one's ability to meet specific goals and or expectations

20. I am certain I will succeed in whatever career path I choose
21. I can figure out anything if I try hard enough
22. I am confident that I will achieve the goals I set for myself
23. I get discouraged when I am struggling to accomplish something, and I just give up
24. If I practice every day, my academic ability can be improved

Section C: Approach to learning

(C.1) Approaches to learning and studying

25. I usually do not have time to think about the implications of what I read in chemistry, I just want to pass my exams
26. I find it best to understand new topics in chemistry by relating them to real life situations.
27. I usually accept the ideas/statements of my teachers and **ONLY** question them under special circumstances
28. When I am tackling a new idea in chemistry I usually ask myself questions about it; which the new information should be able to answer

Space to add comment

General Information/Demographic data

Name: _____ **Student Number: _____**

Major, please specify _____

What was your first-choice of study? _____

When did you decide to major in chemistry? _____

Age _____

Nationality: __________

Language spoken at home: please specify_____

Past Education qualification

Name of High School: _____

Type of High school:

multicultural ('ex-model C') township rural elite private school
other private school home school other:

Province in which your Secondary School is located e.g. Western Cape**_____**

Western Cape Eastern Cape Northern Cape Free State KwaZulu Natal

Gauteng North West Limpopo Mpumalanga

If outside South Africa, just indicate the Country_____

Sources: (Bandura, 2006; Biggs, 1987, 1999; Ogunde et al., 2017)**.**

Appendix 3: The interview schedule

Interview Protocol Project: Career aspiration, self-efficacy, and student retention

Basic information about the interview

Time of the interview:
Date:
Place:
Interviewer: Ibiye Dagogo
Interviewee:
Recording/storing information about the interview: Phone and audio recorder

Introduction

- ☐ **Introduce myself:** I am an independent researcher. I once again assure you of the anonymous nature of this interview, and all information gathered will be used solely for this purpose of this research.
- ☐ **Discuss the purpose of the study:** To help the researcher understand why you decided to major in chemistry and what has helped you to survive in your studies. The findings of this research will help UCT and other institutions to take actions that will translate into useful guidelines for the development of effective programs and policies that will reduce students drop-out from the sciences.
- ☐ **Provide the structure of the interview (audio recording, taking notes)**
- ☐ **Ask if the interviewee has questions**
- ☐ **Define any terms necessary: Transition, student retention**

Interview content questions

1. Kindly tell me about the journey of how you found yourself to be doing a BSc in Chemistry?
2. Could you describe how you managed the transition from 1st year – 3rd year.
3. Tell me about the hindrances you faced during your studies?
4. What were the things that helped you to persist in your academics?

Closing instructions

- ☐ Thank you for participating in my study
- ☐ I once again assure you of the confidentiality of this interview.

Appendix 4: Sample of interview transcript

INTERVIEW TRANSCRIPTS WITH [redacted]

Majors: Chemistry/ Biochemistry
Interviewer: Ibiye Tonye Dagogo (Name Code ID)
Time of Interview: 9.20 a.m. – 9.40 a.m.
Date: 8TH November 2017
Place of interview: Room 6.11, Level 6. PD Hahn Building. UCT
Editors of the Transcripts: Supervisors
Validation Method: Sent to interviewee for validation
Duration: 19mins 49 sec
Interviewee Name Code: **MS2**

ID	Today is the 8th of November, and I am having an interview with [redacted]. She is one of the CEM3005W students who has also volunteered to tell me about her experience so far in UCT So [redacted] over to you. So I just want to know about your journey, how did you come to be doing a chemistry and biochemistry?
MS2	So initially doing a BSc was my 2nd option, my 1st option was medicine. But because I am an international student I didn't get accepted for medicine. They have a strict policy on if you don't have permanent residence in South Africa, and if your country of origin has a medical school then you can't study at UCT basically
ID	So is it just UCT or all schools in South Africa has this same policy?
MS2	Hmm Yes….. Stellenbosch also has that policy. They didn't even look at my transcript, they just said NO. So yes, that was the reason I started with the BSc. Initially my majors were going to be chemistry and biochemistry and physiology, because I wanted to go over into medicine. And then at the end of 1st year I applied again to medicine and they still said NO for the same reason obviously. And then I decided, actually I like to do chemistry and biochemistry. And hmmm I also had genetics as a 3rd major for second year. And then I realised that I don't like genetics; and I am stuck with Biochemistry and Chemistry. And I dropped Human physiology completely because one of my tutors spoke to me. And she said well, if you are interested in going into drug development and those kinds of things then human physiology is not going to help you. Biochemistry is going to be the one that can actually aid you in doing drug development and stuff like that. So that's why I changed. And I am actually very happy now, I am glad I didn't do medicine [laughter] I am really, really happy where I am, and I am really excited to see……opportunities coming forward **[2.25]**
ID	So when did you start developing interest for drug discovery and development?
MS2	It was in 1st year [laughter] We went on a science expedition, and KXXX was one of the speakers
ID	Oh I see
MS2	And the rest is history; and he spoke to us and he told us bit about what his Lab is doing

	[2.51] And I was like wow!...that's a different take on chemistry. You are not physically helping people but you are in a way, indirectly helping them. I think it somehow makes a bigger impact because doctors are there to give the medicine, and we are there to make it. You know
ID	Exactly
MS2	So it was really cool. That was where it all started.
ID	I can relate with that cos I also had a strong passion for medicine, and I may just do a research related to that. But it may just be a 6months research, not a full degree [laugher] But I relate so much with what you are saying cos my masters degree was also in Drug analysis and Toxicology, so we did a lot of drug development research as well. So you will be surprised that I also had a passion to do medicine [laugher] And it was not like I failed but I didn't meet the cut off. So after several attempts, I said that's enough, and I had to change. So I just moved into chemistry [laughter] **[4.01]** So how was your transition from 1st year to 2nd year like? Any particular thing you want to talk about?
MS2	I found that the change from 1st year to 2nd year was very great. I think the transition was lovely. It went from very pressured to low pressure…. 'you have to do this prac, you have to do this tact to, there is no time to……and then to a place where everything was a little bit of more hands off.' A place where you need to be OK. Do what you need to do. But with that there was also a decrease amount of tut and decrease amount of prac and those kinds of things. You finally get a chance to like actually I can breathe. And I can focus on actually studying and assimilating materials **[4.04]** Rather than just running through everything, trying to get it done. And so I enjoyed the transition from 1st year to 2nd year. 2nd year was actually quite relaxing, it wasn't too hectic.
ID	How were your marks?
MS2	At the end of 2nd year I think my mark for chemistry was 95, and for biochemistry it was semester courses. For the 1st semester I got a 94 and the 2nd semester a 93. And for genetic cos I had to do it for the 1st semester I got a 93 I think. And for second semester I dropped it and I did stats [statistics], and for stats I got 86. Yeah those were my marks
ID	So how was your high school like? Did it aid your background in chemistry?.....
MS2	NO. My high school? So I went to a private school, but it was a very small starting up private school. But I think when I started there it was only like 3years old. So they didn't have qualified teachers. It was very much like self study most of the time. So maybe that did help me in university **[6.00]** But in terms of actual content no, because ……South Africa, I realise how totality different the syllabus is between NAMIBIA and South Africa. So it was quite a jump, but like I pushed, I definitely pushed.
ID	You have answered most of the questions. But what helped you to persist regardless of the refusal and all other things?

MS2	There is one thing that I forgot to say about the Jump from 2nd year to 3rd year. That it was VERY high, and very difficult. I found that to be the most difficult jump. It was just crazy because CEM3 was something else. But we persist. Yeah we persist
ID	So was it the content? What was particularly challenging?
MS2	I think number one the content. And number two how deep you are expected to understand things in 3rd year. But in second year it was very shallow. So that's what I experienced
ID	I think you are right because I am bit familiar with the 3rd year curriculum, and most of the abstract or most difficult topics in chemistry are in 3rd year. So I really understand. It takes a lot of extra effort to……at that level, and to even understand what they are saying. I struggled a little with organic chemistry
MS2	Yes, that also helped me a bit. During 2nd year I read a lot of books for organic and I was fine. But for a lot of the other topics that we have just started. Like we did quantum mechanics completely for the first time this year, and yet we were expected to have very deep understanding and I was like, this is the 1st time we are doing this **[8.08]** I understand that it is 3rd year but I felt that the jump was very, very big.
ID	So what helped you to persist?
MS2	So for me 'my family', because I am eldest in my family. And my brothers and sisters are very young. My brother is 10 and my sister is 14. So they are babies [laugher] So basically, I'm setting up the platform for them to be able to carry on. Because my parents are quite old. And they started quite late with having children, so basically at some point I am going to take over taking care of my brother and sister. So that's kind of pushing me to do better and make sure that I can make enough money. So I can be able to lay the ground for them to be able to go to university without struggling. You know that kind of a thing **[9.05]**
ID	So your parents are back home, you are the only one here.
MS2	Yes, my parents are back home
ID	So any other thing that you will like to share?
MS2	Yeah… I don't know but one of the main obstacles that I faced was FINACIAL EXCLUSION Because as an international student there isn't really a lot, and I worked so hard to be able to get a scholarship or whatever. But it just never ever came I mean I got nineties (90s) in second year and still didn't get a scholarship. So from UCT I got like R15,000 in 2nd year and in 3rd year. Compare that to res fees and university fees that probably only covered one course. Well I actually couldn't afford to be here, literally the only way I was actually able to come to University was because of family and friends raised money for me to be able to come **[11.03]** And because also there is no payment plan for international students You have to pay at the beginning of the year and you have to balance it in the middle of the year. And there is no lieu way, there's nothing I even at the end of second year, I emailed Prof Gammon. I was like is there any way that you as the assistant dean could somehow get them to waive something……..so that I can at least

	start university, and be up to date with the stuff, and then settle the fees later. And even he said there's nothing he can do. I think for me that was the biggest challenge. And for me this year one of the other challenge was the fact that….[pause] I felt a lot of pressure to do well. **[11.54]** And in the beginning of the year I was struggling because of CEM and Biochem and everything was just a lot. And I think I also struggled because I always strive to do the best that I can do. And like in my marks for example I don't want 70%, I want 80% and above. And I think that pressure of just wanting to do well for my family and to be able to help them, that kind of really put a big burden on me And I think because also I couldn't afford a psychologist or anything like that, it was very difficult to kind of adjust
ID	So how about student wellness?
MS2	Student wellness has been over flowing with students this year
ID	And you don't even get an appointment
MS2	And yes, like you have to wait 3 months and in my head I was like in 3months I am either going to be fine or completely crazy. So I just need to make sure that within myself, I need to get myself in gear [you know]. And I think also because I am a Christian it kind of helped me to hold on to my belief. And you know…. yeah I think this year was probably the most struggled year I've had in the past **[13.15]**
ID	I can also relate with a lot of things you've said because as an international student. As a matter of fact I was talking with my husband the other day, and I told him I didn't know it was like this in South Africa. If I had known I wouldn't have signed up to come and do a PhD here. Cos I can relate with the stress, the pressure back home. Especially when my funds were not coming in. where was I supposing to get money? How am I supposing to feed? It was difficult to get a job? So far within UCT I have applied for one or two jobs but I feel they are excluding me because I am an international student. But at the same time, I really don't want to give attention to all these treatments as a limitation because I am also a Christian. And I know that there is nothing that God cannot do. I know that if God has assigned it for me then it will come to me. But if it doesn't come to me then I just have to wait and trust him to bring mine to me. So in all of this, I am really glad that you are here to tell your story Thank God that you have made it this far
MS2	I think also something, now that you have mentioned it that I did. Another thing that I did for myself this year was that I got a job cos I basically did tutoring with help @ science. Which is something that is run by the chemistry [I think she meant science] faculty because it is run by David Gammon. So yeah **[14.50]** So that helped me pay for like food and stuff this year because my parents haven't been able to like send me money cos of you know restrictions at home and stuff like that. Cos things are tough, so that helped. But at the same time because I did that and I was doing tutoring elsewhere, so on average I did about 6-8hours a week. Which is quite a lot if you think about how much other stuff that you have and that also put pressure on me. But it had to be done, otherwise I won't have money. So yeah it's TOUGH BEING AN INTERNATIONAL STUDENT [wow!…laugher] **[16.35]**

ID	So, what other thing helped you to persist? You talked about your family, what other thing helped? Did you get like friends or formed study groups?
MS2	No. I am this kind of person who doesn't do well in study groups. And I prefer to be by myself, so no, I didn't do study group. But definitely my flatmates were a big blessing because they helped through a lot of stuff that was going on then
ID	So from what you have been saying, your hard work has been paying off, as you have been getting good grades right?
MS2	Yeah….
ID	So I am sure that must have been a good consolation for you
MS2	Yeah….
ID	So I think people's lives are shaped by the experiences they have through. And sometimes this is what I tell people; you see people walking on the road you don't know what they've been through, you don't know where they are coming from, but the least you can do is not to judge them. So we all have our experiences from different point, and for us to be seated here is a story. One thing I can also relate with as well is the family. My parents are not also that wealthy. When I was in school I really put in a lot of effort, you know. Cos I really wanted to do well in school in order to get a job. But I am also thankful to God because it worked. By God's grace I got a first class in chemistry. It really did take out a lot of things from me, because I didn't have time to socialise. I didn't have time to make friends. It was always reading …..(inaudible) **[18.27]** The consolation was that God was kind to me I am really glad that you have come this far, and I know that you will do better. You will continue to soar higher
MS2	Thank you…
ID	Thank you so much for your time is there any other thing that you will like to say?
MS2	{pause….} nothing that I can think of
ID	Thank you so much, and I will have to end the interview now [laughter]

An example of an email to clarify some aspects of the transcripts is shown below:

Dear MXXX

Hopefully after your exams, kindly have a look at the attached interview transcript, and confirm that this was the conversation we had. This is a very important validation process for my research.

I would like you to give me a little more detail about the science expedition, and also the fill in the age of your younger sister (as indicated in the word document attached).

Thank you once again for your time and kind assistance.

We have a winner from the questionnaire raffle draw, I will announce the winner and price on Whatzapp, so you can share with your class.

Keep soaring higher.

Kind regards

Appendix 5: Sample of proof of interview validation

Validation Response from Interview:

From: [redacted]
Sent: 14 December 2017 15:35:02
To: Ibiye Dagogo
Subject: Re: Interview Transcript

Dear Ibiye

I hope you are doing well. Attached is the revised transcript. I enjoyed assisting you, thank you for the oppourtunity to partake in this study, and all the best for its completion. I confirm that this is the conversation we had.

Warm regards

[redacted]

Validation Response from Interview:

From: [redacted]
Sent: 29 November 2017 16:55:30
To: Ibiye Dagogo
Subject: Re: Interview Transcript

Dear Ibiye

I have made some minor adjustment to the transcript but is mainly unchanged and I am in agreement with.

I would also like to wish all the best in your research and in your future work.

Kind Regards

[redacted]

Appendix 6: Sample of Nvivo output

Main Nvivo Analysis project CEM3005W 2017

These are the main codes and sub-codes Ibiye used. The number of cases is the number of students; the number of references the total number of times the code was used, including all the sub codes.

Name	Description	Cases	Refs
Experiences	It is quite good to make a compilation of the students. This describes their difficulties and how they were able to overcome those difficulties	18	560
Conceptualization		18	68
Difficult content-Lack of coherence	Description of how the students described the nature of the courses they were thought	11	24
Intellectually Manageable-knowledge reinforcement	Students complained about the content in chemistry course. Some said it was manageable but it was just that they didn't have enough time to reinforce learning	8	11
Pace	Fastness or slowness of the course	9	17
Emotional Difficulty		18	201
Difficult-time		18	92
Disappointment		9	16
Emotional-cry		15	45
Hate-dislike		6	11
Psychological effect		12	32
Handling Difficulty	This describes the different survival mechanism that the students used	18	103
Non-complacency		3	5
Not-quitting		17	42
Taking responsibility		17	56
Obstacles	This is a compilation of all the different obstacles that the students faced. several expressions have been used by these students	17	75
Discriminating policy		1	5
Failed Course		8	13
Finances-Funds		9	14
Language Barrier		4	4
Long practical		14	24
Protest		4	8
Reflections		11	13
Time Management		11	27
Transition		18	73
Difficult 2nd-year	Some of the students complained about the transition into 2nd year, they noted that it was difficult.	16	29
First year		17	27
Third year		13	17
Journey (Chemistry story)		18	105
Career Aspiration		16	37
Post-graduate study		8	9
Choice of Study		15	39

Name	Description	Cases	Refs
2nd choice chem		15	18
Switch-transfer-indecisive		13	21
Interest-Favourite subject	how students developed their interest in Chemistry	13	22
Favourite subject		0	0
Salary-Job		5	7
Others	This is compilation of the emergent themes. I found this particularly interesting and was unusual. It covers interesting themes such as fear of losing bursary,	17	75
Caring-lecturers-kindness EDP		3	6
Community service		1	1
Communication-white lecturers-No-connection		3	8
Enjoy interview		1	1
Family depending on me		7	10
Fear of losing bursary		1	2
Fees must fall		2	4
How to manage relationships		4	5
Knowledge reinforcement		0	0
Make Parents Proud		12	13
Memorize-cram stuff		2	2
Mental Health issues		5	12
Multiple Choice		1	1
Negative Marking		1	1
Opportunity,-good education		2	4
social life-Academics		3	5
Self-Efficacy		16	73
Doubt-Fear		10	27
Self-confidence		12	19
Top student		8	11
SUGGESTIONS-ADVISE		2	10
Support system		18	103
Exercise-sleep		3	4
Family-Parents	This comprises of all support that the students got from their family, parents, uncles	13	20
Friends-help		12	22
Help from friends		0	0
Talking-lecturers		0	0
Mentor		12	23
Religion	Muslim, Christian, Traditional prophet	12	17
Resources-study group		9	15

Appendix 7: The Ethics approval

UNIVERSITY OF CAPE TOWN

Faculty of Science
University of Cape Town
Rondebosch
SOUTH AFRICA 7701

Tel: +27 21 650-5551
Email: timm.hoffman@uct.ac.za

Ms Ibiye Dagogo
Chemistry Department

29 August 2017

Dear Ms Ibiye Dagogo

RE: *The factors influencing undergraduate student retention and success, a case study of students in the science Extended Degree Programme (EDP) at the University of Cape Town (UCT).*

I am pleased to inform you that the Faculty of Science Research Ethics Committee has approved the above-named application for research ethics clearance, subject to the conditions listed below.

- Implement the measures described in your application to ensure that the process of your research is ethically sound; and
- Uphold ethical principles throughout all stages of the research, responding appropriately to unanticipated issues: please contact me if you need advice on ethical issues that arise.

Please also note that the LR1 form to request recording requires that the persons being recorded provide consent to be recorded, and also detail who may access those recordings. This must be in place.

Your approval code is: **FSREC 53 – 2017**

I wish you success in your research.

Yours sincerely

Signature Removed

Prof Timm Hoffman
Chair: Faculty of Science Research Ethics Committee

Cc: A/Prof Bette Davidowitz

RESEARCH ACCESS TO STUDENTS

DSA 100

NOTES

1. This form must be FULLY completed by all applicants who want to access UCT students for the purpose of research or surveys.
2. Return the fully completed (a) DSA 100 application form by email, in the same word format, together with your: (b) research proposal inclusive of your survey, (c) copy of your ethics approval letter / proof (d) informed consent letter to: Moonira.Khan@uct.ac.za. You application will be attended to by the Executive Director, Department of Student Affairs (DSA), UCT.
3. The turnaround time for a reply is approximately 10 working days.
4. NB: It is the responsibility of the researcher/s to apply for and to obtain ethics approval and to comply with amendments that may be requested; as well as to obtain approval to access UCT staff and/or UCT students, from the following, at UCT, respectively: (a) Ethics: Chairperson, Faculty Research Ethics Committee' (FREC) for ethics approval, (b) Staff access: Executive Director: HR for approval to access UCT staff, and (c) Student access: Executive Director: Student Affairs for approval to access UCT students.
5. Note: UCT Senate Research Protocols requires compliance to the above, even if prior approval has been obtained from any other institution/agency. UCT's research protocol requirements applies to all persons, institutions and agencies from UCT and external to UCT who want to conduct research on human subjects for academic, marketing or service related reasons at UCT.
6. Should approval be granted to access UCT students for this research study, such approval is effective for a period of one year from the date of approval (as stated in Section D of this form), and the approval expires automatically on the last day.
7. The approving authority reserves the right to revoke an approval based on reasonable grounds and/or new information.

SECTION A: RESEARCH APPLICANT/S DETAILS

Position	Staff / Student No	Title and Name	Contact Details (Email / Cell / land line)
A.1 Student Number	DGGIBI001	Ms Ibiye Tonye Dagogo	dggibi001@myuct.ac.za, 061 217 2646
A.2 Academic / PASS Staff No. A.3 Visitor/ Researcher ID No.			
A.4 University at which a student or employee	UCT	Address if not UCT:	
A.5 Faculty/ Department/School	Science Faculty, Chemistry Department		

A.6 APPLICANTS DETAILS if different from above	Title and Name	Tel.	Email

SECTION B: RESEARCHER/S SUPERVISOR/S DETAILS

Position	Title and Name	Tel.	Email
B.1 Supervisor	Associate Prof Bette Davidowitz	Ext 2549	Bette.Davidowitz@uct.ac.za
B.2 Co-Supervisor/s	Dr Dale Taylor	Ext 3367	DL.Taylor@uct.ac.za

SECTION C: APPLICANT'S RESEARCH STUDY FIELD AND APPROVAL STATUS

C.1 Degree – if applicable	PhD
C.2 Research Project Title	The factors influencing undergraduate student retention and success, a case study of students in the science Extended Degree Programme (EDP) at the University of Cape Town (UCT).
C.3 Research Proposal	Attached: Yes ✓ No ☐
C.4 Target population	Undergraduate students in AYOS 1, 2 and 3 as this is a longitudinal study.
C.5 Lead Researcher details C6. Will use research assistant/s	If different from applicant: Yes ☐ No ✓ If yes- provide a list of names, contact details and ID no.
C.7 Research Methodology and informed consent:	Research methodology: The research methodology and consent form are outlined in the research informed consent: proposal attached
C.8 Ethics clearance status from UCT's Faculty Ethics in Research Committee /Chair (EIRC)	Approved by the UCT EIRC: Yes ✓ With amendments: Yes ☐ No ✓ (a) Attach copy of your UCT ethics approval. Attached: Yes ✓ No ☐ (b) State date / Ref. No / Faculty of your UCT ethics approval: 29 / 08 /2017 Ref. FSREC 53 2017, Science

SECTION D: APPLICANT/S APPROVAL STATUS FOR ACCESS TO STUDENTS FOR RESEARCH PURPOSE
(To be completed by the UCT - ED, DSA or Nominee)

D.1 APPROVAL STATUS	Approved / With Terms / Not	* Conditional approval with terms	Applicant/s Ref. No.:
	(i) Approved [redacted] (ii) With terms (iii) ~~Not approved~~	(a) Access to students for this research study must only be undertaken after written ethics approval has been obtained. (b) In event any ethics conditions are attached, these must be complied with before access to students.	DGGIBO001 Ms Ibiye Tonye Dagogo

D.2 APPROVED BY:	Designation	Name	Signature	Date of Approval
	Executive Director Department of Student Affairs	*Dr Moonira Khan*	Signature Removed	*11 September 2017*

Appendix 8: Consent form

DEPARTMENT OF CHEMISTRY

UNIVERSITY OF CAPE TOWN
PRIVATE BAG X3
RONDEBOSCH 7701
SOUTH AFRICA

RESEARCHER: IBIYE TONYE DAGOGO
TELEPHONE: 0632172949
FACSIMILE:
E-MAIL: DGGIBI001@myuct.ac.za
URL:

Informed Voluntary Consent to Participate in Research Study

Project Title: The factors influencing undergraduate student retention and success, a case study of students in the Science Faculty at the University of Cape Town

Invitation to participate, and benefits: You are invited to participate in a research study conducted with students. The aim of this study is to understand how career aspiration, self-image and conceptual understanding work together in student retention process. I believe that your experience would be a valuable source of information, and hope that by participating you may gain useful knowledge.

Procedures: During this study, you will be asked to fill a questionnaire via Vula and may be invited to be interviewed. You may also be asked to participate in focus group interviews. Video-recorded lectures which focuses on the lecturer will also be used to help us understand how the teacher's actions impact on students' understanding of topics in chemistry. We should also like to copy your answers to the writing project and tests which deals with chemical bonding.

Risks: There are no potentially harmful risks related to your participation in this study.

Disclaimer/Withdrawal: Your participation is completely voluntary; you may refuse to participate, and you may withdraw at any time without having to state a reason and without any prejudice or penalty against you. Should you choose to withdraw, the researcher commits not to use any of the information you have provided without your signed consent. Note that the researcher may also withdraw you from the study at any time.

Confidentiality: All information collected in this study will be kept private in that you will not be identified by name or by affiliation to an institution. Confidentiality and anonymity will be maintained as pseudonyms will be used.

What signing this form means:

By signing this consent form, you agree to participate in this research study. The aim, procedures to be used, as well as the potential risks and benefits of your participation have been explained verbally to you in detail, using this form. Refusal to participate in or withdrawal from this study at any time will have no effect on you in any way. You are free to contact me, to ask questions or request further information, at any time during this research.

I have obtained permission from the Faculty of Science Ethics Committee for this project. Please feel free to contact me if you have any questions.

Please fill in and return the reply slip indicating your willingness to participate.

Informed Voluntary Consent to Participate in Research Study

Project Title: The factors influencing undergraduate student retention and success, a case study of students in the Science Faculty at the University of Cape Town

I agree to participate in this research (tick one box)

☐ Yes ☐ No (Initials) _____ (Student number) _____

Name of Participant	Signature of Participant	Date
Ibiye Dagogo Email: DGGIBI001@myuct.ac.za		10/10/2017
Name of Researcher	Signature of Researcher	Date

Please answer the questions by placing a circle around the YES or NO below:

I am willing to participate in the research study as described in this letter. YES / NO

I am willing to participate in interviews. YES / NO

I am aware that field notes may be taken during lectures, tutorials YES / NO

I am aware that researcher may observe the lectures/tutorials YES / NO

I give permission for interviews to be audio recorded. YES / NO

I give permission for documents to be analysed (e.g. tests, tutorials, questionnaires, surveys) YES / NO

I know that I am under no obligation to participate. YES / NO

I know that I can withdraw at any stage. YES / NO

I know that all information will be kept confidential. YES / NO

I know that all research data will be used for this project only. YES / NO

I know that all the research data will be destroyed within 5 years after the completion of this study. YES / NO

Appendix 9: Chemistry Department CEM 3005W Writing Project 2017

DEPARTMENT OF CHEMISTRY

CEM 3005W Writing Project 2017

Title: Carbon monoxide releasing molecules (CO-RMs), a new class of pharmaceuticals

Project designers: Professor T J Egan, A/Prof B Davidowitz, A/Prof A T Hutton and Dr S Ngubane

OVERVIEW

Carbon monoxide (CO) is an odourless toxic gas often produced as a by-product from partial combustion of carbon-based fuels. CO gas is toxic when encountered in large quantities as a result of its competition with the oxygen-binding sites in the bloodstream (*i.e.* Iron in the haemoglobin). Nevertheless, CO can also serve as a therapeutic agent for various diseases if released into the cells and tissues in controlled amounts. Certain molecules can achieve this and are hence referred to as carbon monoxide-releasing molecules (CO-RMs). The writing project for 2017 centres on transition metal carbonyl complexes as a new class of pharmaceuticals that releases therapeutic amounts of carbon monoxide.

The purpose of the writing project is to allow you to engage with key concepts in chemistry as well as to learn how to write a coherent scientific report based on a number of resources. In addition to consulting the references provided, you will have to search for information from other sources. You should use the guidelines in this document as well as the Royal Society of Chemistry (RSC) and Style Manual provided to assist you with issues related to scientific writing e.g. layout, referencing etc.

Part A

In part A, you will need to explain the molecular orbital description of the CO molecule. In addition, you will need to describe and explain the effects of coordination of CO to metal ions on the molecular orbitals of an octahedral complex. For this, you should consult your inorganic chemistry textbook, Inorganic Chemistry by Housecroft and Sharpe. In addition, you should supply a description of the various ways that CO can be released from a metal ion. This information is available in the reviews by Romão *et al*. (2012) and Schatzschneider (2015).

Part B

The two reviews by Johnson *et al*. (2003) and Romão *et al.* (2012) provide an introduction and overview of the origin of CO in the human body, its beneficial and harmful biological effects, current CO-RMs that are under investigation and diseases that could potentially be treated using these molecules.

For this writing project students are expected to present a coherent account of these aspects. You should read the articles a few times while making notes before attempting to write your report. Advice on how to go about this is given below after the questions.

FORMAT OF PROJECT

PART A: Carbonyl complexes and CO release

Your report should address the following sub-topics / themes:

1) An account of CO as a ligand, including a brief survey of binary d-block metal complexes of CO. This section should include:

- A simplified MO diagram for CO accompanied by a written explanation of the diagram (in your own words). [Figure 2.15 (a) in the 4th edition of Housecroft & Sharpe should be used as the basis for your discussion.]
- A qualitative account of the bonding of CO to a metal centre (Dewar-Chatt-Duncanson model). MO diagrams are not required, but you should illustrate your discussion with appropriate orbital overlap diagrams.
- A brief survey of typical d-block metal complexes in which CO is the only ligand (binary metal carbonyl complexes). Your discussion should be based on no more than five or six such compounds.

2) Mechanism of CO release:

- Outline briefly the different mechanisms by which CO can be released from a metal complex. Your report should include a table summarising the mechanisms of CO release.

B Beneficial and toxic effects of CO, sources of CO in the human body, CO-RMs and prospects for treatment involving CO-RMs

1) Describe the sources of CO in the body and relate the colour changes observed in the development of a bruise which leads to the generation of CO at the molecular level.

2) Describe the beneficial and toxic effects of CO in human health. In the case of toxic effects, describe the relationship between concentration and known toxic effects.

3) Provide an overview of CO-RMs and include the structures of at least three metal complexes that are CO-RMs.

4) Discuss three diseases that have been suggested as potentially treatable using CO-RMs.

Use Housecroft and Sharpe and the references by Johnson et al. (2003), Romão et al. (2012) and Schatzschneider (2015) as starting points to write sections A and B above. The topics can also be accessed via Google scholar at http://scholar.google.co.za/.

References

1. T.R. Johnson, B.E. Mann, J.E. Clark, R. Foresti, C.J. Green and R. Motterlini. *Angew. Chem. Int. Ed.*, 2003, **42**, 3722.
2. C.C. Ramão, W.A. Blättler, J.D. Seixas and G.J.L. Bernardes. *Chem. Soc. Rev.*, 2012, **41**, 3571.
3. C. E. Housecroft and A. G. Sharpe. *Inorganic Chemistry*, Pearson Education Limited, England, 3rd Ed., 2008 or 4th Ed., 2012.
4. U. Schatzschneider. *Br. J. Pharmacol*., 2015, **172**, 1638.

Length of the report

The report should be 12-15 pages (typed), excluding figures, diagrams, tables and references.

Assessment of the project

Marks will be allocated as shown on page 8. You are expected to pay attention to the layout of the project including appropriate referencing, correct use of grammar, spelling *etc*. Use the Style Manual provided on Vula, the checklist for report writing on page 6 and the guidelines on page 7.

The Department of Chemistry reserves the right to change the assessment criteria provided any changes are to the advantage of the students.

Submission of reports

Draft due on Thursday 24th August 2017

All students are required to submit a **typed draft** of their report by 14h00 on Thursday 24th August 2017. This should be placed in the practical box near the laboratories on level 5 PD Hahn building. This draft should demonstrate that the student has attempted to address **all aspect of the report**; a few lines will not suffice. Failure to submit a draft will result in a penalty of 30% *i.e.* if your project is found to be worth 70%, the deduction will result in a final mark of 40%.

Report due on Tuesday, 3rd October 2017

The report must be placed in the practical box by 14h00 on Tuesday, 3rd October 2017. **Late reports will be awarded a mark of ZERO.**

In addition to submitting a typed version of the report, each student must submit their report to Turnitin via Vula. https://vula.uct.ac.za/portal Turnitin will be used to check for instances of plagiarism.

To submit to Turnitin you should make a copy of your file used to print your report. Convert the file to a pdf format and submit this file to Turnitin via **Vula.** Name it the following way:

Name_Surname 2017.pdf

Consultants for the writing project

Two consultants will be available during the second semester. Once the drafts have been submitted, booking schedules will be placed on the notice boards outside their offices. Students are invited to make use of the opportunity to visit a consultant. **You may book only one consultation.** Please book early as there are a limited number of appointments available. You should email the latest version of your draft to the consultant at least 48 hours before your appointment. You are reminded that it is common courtesy to cancel an appointment if you are not going to be able to be present at the consultation. The consultants are:

Dr Cesarina Edmonds-Smith	Room 6.05, level 6, PD Hahn building, C.Edmonds-Smith@uct.ac.za.
Assoc. Prof B Davidowitz	Room 5.22, level 5, PD Hahn building, Bette.Davidowitz@uct.ac.za

Note: The role of the consultant is to assist you to improve your report with respect to content and overall coherence. The consultation is not meant to be an editing service; thus **your draft must have been proof-read and be free of spelling and superficial grammar errors**. You must also follow the referencing conventions given in the Royal Society of Chemistry guidelines. Students who present with poorly prepared drafts run the risk of cancellation of their consultation time.

CEM3005W Assessment outline for the Writing Project 2017

Introduction **10%**

	% allocated
• Description of CO and general sources of CO. • General toxicity of CO (CO vs O_2 in the bloodstream) • Therapeutic effects of CO and examples of diseases/occurrences where CO is used for therapeutic purposes.	**10**

Carbon monoxide releasing molecules (CO-RMs) discussion

Part A : **30%**

	% allocated
CO as a ligand and d-block metal complexes of CO	**15**
Mechanisms of CO release	**15**

Part B : **40%**

	% allocated
Sources of CO in the human body and colouration of bruises	**10**
Beneficial and harmful biological effects of CO	**10**
Examples of CO-RMs	**10**
Diseases treatable using CO-RMs	**10**

Language and layout **10%**

	% allocated
Appropriate language, no spelling errors, conforms to suggested layout, A4 page size, 2.5 cm margins, 1.5 line spacing, pages are numbered, references are cited in the text, reference conventions appropriate (Royal Society of Chemistry guidelines).	**10**

Conclusions **10%**

	% allocated
Conclusion is a summary of main ideas	**10**

Appendix 10: Sample of examination paper (Y2 exams)

A student answer is included for the section of the questions included as part of the data set for the thesis.

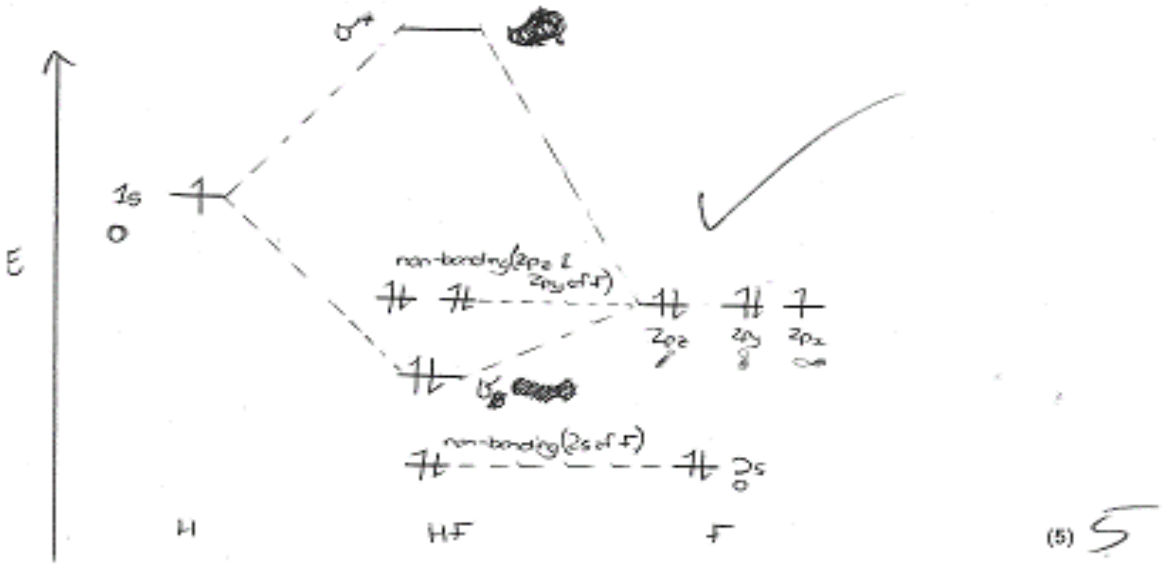
CEM2005W Final Examination November 2016

Question B9

(a) The effective nuclear charge, Z_{eff}, for the single electron in the 1s orbital of hydrogen is obviously unity. Use Slater's rules to calculate Z_{eff} for the outermost electrons in an atom of fluorine.
What does this result tell you about the relative energies of the fluorine 2*s* and 2*p* atomic orbitals compared to the hydrogen 1*s* atomic orbital? (3)

(b) For a molecule of hydrogen fluoride, HF, if the bond is along the *x* axis, illustrate how the *p* atomic orbitals of F can combine with the *s* atomic orbital of H to give bonding, antibonding and non-bonding molecular orbitals (use orbital overlap diagrams and indicate phases by shading). (3)

(c) A key result of the molecular orbital (MO) description of the bonding in HF is that the bonding MO is more concentrated on the F atom and the antibonding MO is more concentrated on the H atom. Use this information, as well as your responses to parts (a) and (b) of this question, to construct a fully labelled orbital interaction (energy level) diagram for the formation of HF. (5)



(5) 5

(d) Use your diagram to calculate the bond order in HF (show your working).

B.O = $\frac{\text{bonding e}^- - \text{anti-bonding e}^-}{2}$

$= \frac{2-0}{2}$

$= 1$

(1) 1

[12]

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CEM2005W Deferred Examination January 2017

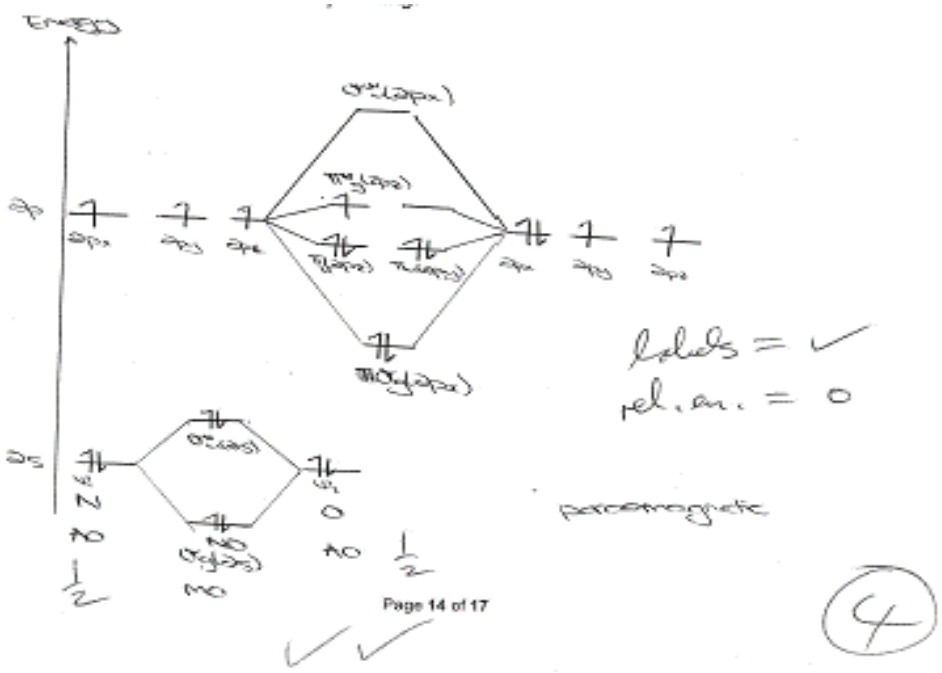
Question B7

(a) Explain what is meant by the terms “shielding” and “effective nuclear charge, Z_{eff}”. What is the connection between the two (how are they related)? (3)

(b) Use Slater’s rules to calculate Z_{eff} for the outermost electrons in atoms of nitrogen and oxygen.
What does this result tell you about the relative energies of the oxygen 2*s* and 2*p* atomic orbitals compared to those of nitrogen? (3)

(c) For a molecule of nitrogen monoxide, NO, if the bond is along the *x* axis, illustrate how the *p* atomic orbitals of N and O could combine to give bonding, antibonding and non-bonding molecular orbitals (use orbital overlap diagrams and indicate phases by shading). Label your diagrams. (3)

(d) Use your responses to parts (b) and (c) of this question to help you construct a fully labelled orbital interaction (energy level) diagram for the formation of NO. You may assume that there is no 2*s*–2*p* mixing. (5)



(e) Use your diagram to calculate the bond order in NO. (1)

(f) Because of its unpaired electron, NO is a highly reactive molecule. From your MO description, does this lone electron reside more on the nitrogen or the oxygen atom? Explain your answer. (2)

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Appendix 11: Sample of feedback sheet from career workshop.

Feedback Sheet: Career Workshop November 2017

FACULTY: SCIENCE **DEGREE:** CHEMISTRY

1. What was the most useful aspect of this workshop for you (highlights)?

Job searching skills, refining knowledge of self to improve CV

2. What have you learnt from this intervention that you did not know before ?

Informational interviewing was really interesting

3. Do you feel that you have the necessary information to take the next step?

I am definitely in a better ~~person~~ position than ~~was~~ before the interview

4. What is the next step for you?

- Continue VAC work and arrange alternative plans if not taken for honours

4. What additional help/information do you need?

5. Would you recommend this event to fellow students? Yes ☑ No ☐

6. Any other comments?

Thank you very much.