Investigating the Efficacy of the Bachelor of Engineering Technology Degree in Mechanical Engineering at the Durban University of Technology

By

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Declaration

I declare that this thesis is my original work except where due acknowledgement is made to others. This thesis is being submitted for the Master of Engineering degree to the Department of Mechanical Engineering at the Durban University of Technology, and has not been submitted previously for any other degree or examination.

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Abstract

As of 2018, the Durban University of Technology's (DUT) Mechanical Engineering Department offers a Bachelor of Engineering Technology (BET) degree, as well as master's (MEng) and doctorate (DEng) degrees. DUT subsequently launched a BET honour's qualification in 2022, which serves as a stepping stone from the BET degree to the master's degree. The BET degree was initiated for several reasons to replace the existing National Diploma as part of the aligned process to the newly introduced Higher Education and Qualifications Sub-Framework (HEQSF). The BET degree also constitutes those academic requirements necessary to apply for registration as a Professional Engineering Technologist with the Engineering Council of South Africa (ECSA).

This dissertation investigates the success of the new degree by assessing the academic success of Mechanical Engineering students enrolled in the BET programme. The investigation is not limited to students who have successfully completed their studies, but includes students who have begun their studies and have failed to complete them, or do so in a reasonable amount of time, for several reasons. The primary data source for the research included information from the institution's Management Information System (MIS). Conforming to a positivist paradigm, the research employed mixed methods methodology, comprising five sub-studies to understand student success in the BET programme. The first sub-study involved success rate analysis. Since the commencement of the BET degree in 2018, the success rates of the cohorts (2018, 2019, 2020, and 2021) were analysed to assess programme efficacy. The second sub-study concerned the relationship between National Senior Certificate (NSC) results and students' performance in first-year modules. Students' NSC results were compared to their first-year module outcomes to determine the correlation between NSC Maths, NSC Physics, NSC English, and the appropriate first year engineering modules. The third sub-study relates to Graduate Attributes (GAs) and their implications on student throughput. The concern was that if a student failed a GA, they would also fail the module. An investigation was conducted to determine whether students are failing primarily because of failing GAs. The fourth sub-study related to selected modules offered in successive semesters ('back-to-back' modules). The purpose of which was to determine whether offering Strengths of

Materials I and Mechanics of Machines I in the first semester resulted in higher success rates, and whether this intervention ought to be maintained. The fifth and final sub-study related to the student success in National Diploma (ND) vs. BET modules. Student success rates of BET modules that were deemed similar to modules offered within the ND qualification were compared and analysed. Performing these five sub-studies resulted in insights into the success of the BET Mechanical Engineering programme at DUT, and is anticipated to enable DUT's Mechanical Engineering Department to make informed decisions in addition to placing interventions in the programme to ensure greater student success. The content comprising this dissertation was disseminated into one abstract (Walker, Graham and Sheoratan 2022a), one poster (Walker, Graham and Sheoratan 2022b) and one full conference paper (Walker, Graham and Sheoratan 2023) and one journal article (2024 – still under review). See Appendix D (Publications).

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Subject Name Abbreviations

Engineering Mathematics 1A (Maths 1A)

Engineering Physics 1A (Physics 1A)

Mechanics of Machines 1 (Mechanics I)

Engineering Mathematics 1B (Maths 1B)

Strength of Materials 1 (Strengths I)

Engineering Physics 1B (Physics 1B)

Computer-Aided Draughting (CAD)

Fluid Mechanics 2 (Fluids II)

Engineering Mathematics 2A (Maths 2A)

Mechanics of Machines 2 (Mechanics II)

Strength of Materials 2 (Strengths II)

Thermodynamics 2 (Thermos II)

Strength of Materials 3 (Strengths III)

Mechanics of Machines 3 (Mechanics III)

Thermodynamics 3 (Thermos III)

Fluid Mechanics 3 (Fluids III)

Abbreviations

ANOVA: Analysis of Variation

BTech: Bachelor of Technology

BET: Bachelor of Engineering Technology

BEng: Bachelor of Engineering

BEngTechHons: Bachelor of Engineering Technology Honours

CHE: Council on Higher Education

DHET: Department of Higher Education and Training

DoE: Department of Education

DTech: Doctor of Engineering Technology

DUT: Durban University of Technology

ECSA: Engineering Council of South Africa

ENGAGE: Engineering Augmented Degree Programme

ERT&L: Emergency Remote Teaching and Learning

FAL: First Additional Language

FET: Further Education and Training

FEBE: Faculty of Engineering and the Built Environment

GAs: Graduate Attributes

GPA: Grade Point Average

HE: Higher Education

HEI: Higher Education institution

HEQF: Higher Education Qualifications Framework

HEQSF: The Higher Education Qualifications Sub-Framework

HL: Home Language

IREC: Institutional Research Ethics Committee

MEng: Master of Engineering

MIDFIELD: Multiple-Institution Database for Investigating Engineering Longitudinal Development

MIS: Management Information System

MTech: Master of Engineering Technology

ND: National Diploma

NDip: National Diploma

NQF: National Qualifications Framework

NSC: National Senior Certificate

OBE: Outcomes-based education

PCC: Pearson's Correlation Coefficient

pp: Percentage Point

PQM: Programme and Qualification Mix

S1/S2: Semester 1/ Semester 2

SA: South Africa

SAQA: South African Qualifications Authority

SOTL: Scholarship of Teaching and Learning

TPACK: Technological, Pedagogical, and Content Knowledge

UCT: University of Cape Town

UoT: University of Technology

UTSA: University of Texas in Saint Antonio

Chapter 1 – Introduction

The first chapter comprises the study's background information, followed by the problem statement. The research problem is presented with support from relevant literature. The research questions are formulated. The study's aims, objectives, significance, scope, theoretical framework, and methodology are also addressed. Finally, the study's limitations and delineations are discussed.

1.1 Background

The 1997 Higher Education Act set the stage for the establishment of new higher education institutions in South Africa, requiring a unified, coordinated system. The objectives of these changes were to address the demands of a technologically dependent society (Mtshali and Sooryamoorthy 2019). Additionally, it was proposed that there would be fewer universities and Technikons (similar to UK Polytechnics) as a result of a process of consolidation. Technikons were renamed Universities of Technology (UoTs) in 2003 (Mtshali and Sooryamoorthy 2019). The ML Sultan Technikon and Technikon Natal merged to form the Durban University of Technology (DUT).

The Higher Education Qualifications Sub-Framework Act No. 67 of 2007 (HEQSF) forms the foundation for incorporating all South African higher education qualifications into the National Qualifications Framework (NQF). The HEQSF develops standards and assures quality by enhancing the higher education system's consistency and outlining the pathways between qualifications, thereby increasing the system's adaptability and allowing students to easily transition from one programme to another as they advance their academic or professional careers (South African Qualifications Authority 2013).

In order to expedite the establishment of a single, nationwide higher education system with harmonised courses across programmes and student transfer between institutions, the Department of Education's 1997 plan was the basis for the introduction of a single qualification framework for higher education institutions by the HEQSF (South African Qualifications Authority 2013) (Kapp 2019). Every programme that was already in place had to be aligned with the HEQSF, and any new programmes that were created had to also be aligned.

Prior to the new HEQSF requirements, the path to becoming a Professional Technician and Professional Engineering Technologist required a National Diploma (Ndip/ND) and a Bachelor of Technology degree (BTech), respectively. Due to the new curriculum, the Bachelor of Engineering Technology (BET) degree is now the academic requirement for registration as a Professional Engineering Technologist.

Three-year ND programmes had previously been offered by DUT's Faculty of Engineering and the Built Environment (FEBE), which was followed by a one-year BTech degree. There were additional postgraduate degrees offered, such as a Master of Engineering Technology and a Doctor of Engineering Technology. The postgraduate programmes could be readily aligned, however the ND and BTech were not HEQSF compatible and could not be aligned, therefore they had to be replaced with new programmes.

The requirements of numerous stakeholders and statutory bodies, including the South African Qualifications Authority (SAQA), the Council on Higher Education (CHE), the Department of Higher Education and Training (DHET), and the Engineering Council of South Africa (ECSA), had to be met when creating these new programmes. The CHE is an independent statutory quality council for higher education in South Africa. It oversees and leads quality assurance by keeping an eye on trends, initiating crucial discussions about pressing issues in higher education, and supporting the DHET Minister strategically and politically. To assist the Post-School Education and Training system, the DHET offers strategic leadership at national level. The establishment of standards for educational qualifications, programme accreditation, and registration of professionals are among the primary responsibilities of ECSA.

Professional Engineers, Professional Engineering Technologists, and Professional Engineering Technicians are the three main professional registration categories that are managed by ECSA. The candidates' educational qualifications are the primary determinant of their registration category. ECSA created qualification standards that specified the academic prerequisites for registration in the various categories in order to comply with the HEQSF (Engineering Council of South Africa 2020). 11 Graduate

Attributes (GAs) were included in these requirements; these must be developed, assessed, and incorporated into the curriculum. To graduate, engineering students must be deemed competent in each of the 11 GAs.

The engineering departments within DUT's FEBE agreed to offer a three-year BET degree, followed by a Bachelor of Engineering Technology Honours (BEngTechHons), after consulting with its stakeholders.

There were many approval procedures required before the introduction of the BET degree. First, a basic curriculum framework is sent to ECSA for endorsement. The university Senate's acceptance is then required in order to submit an application to DHET for the clearance of the PQM (Program and Qualification Mix). After this is accomplished, a thorough curriculum that includes prerequisites, module descriptors, programme structure, and entry requirements is presented to the CHE for approval. Lastly, the qualification is added by SAQA to its list of authorised qualifications. A new qualification cannot formally be offered until this last phase is completed.

The BET degree requires two essential alignments. The first is the alignment with South Africa's national higher education prerequisites for a degree, which is associated with the HEQSF and corresponding NQF level requirements. The second alignment is with the nationally ECSA accredited engineering qualification, connected to the Sydney Accord. The Sydney Accord is an international agreement between bodies responsible for accrediting engineering technology academic programmes and its associated GAs. The former ensures that graduates receive a nationally recognised South African higher education qualification, while the latter offers graduates an internationally recognised engineering qualification and the chance to register professionally in South Africa through ECSA.

1.2 Problem Statement

In South Africa, higher education appears to confront difficulties. Due to university enrolments being much higher than that of high school, many students fail their first year. Students are unprepared for the large volume of work and the quick pace of university (Grayson et al. 2014). In both engineering and technical programmes, the throughput rates (defined as time taken in earning a certification) are "poor and slow", where just over half of the first-year student cohort completes their engineering programme (Winberg et al. 2014).

Re-teaching essential abilities that ought to have been learnt at school has now become the task of higher education, therefore the under-preparedness of school leavers places a strain on Higher Education Institutes. Only 25% of the 2005 student cohort who registered for a Bachelor's degree in Engineering (BEng) completed it within the allotted four years. Another 19% did so within five years, and a total of 55% had graduated after six years, according to data analysis by the CHE (Grayson et al. 2014).

In South Africa, lower completion rates of 27-40% for Engineering degrees were reported. South African undergraduate engineering course throughput rates fall considerably below the necessary standard, with students pursuing the National Diploma at universities of technology (UoTs) performing the poorest (Graham 2015). Due to most higher education students failing to complete their courses, the current system remains ineffective. South Africa generates too few engineers to satisfy its demands for development. Despite a population of more than 50 million people, there are still only a few thousand engineers graduating each year (Grayson et al. 2014).

To help alleviate the above problem, DUT introduced the new BET degree to replace the ND and BTech that were previously offered. The BET degree came about due to the HEQSF requirements encouraging course harmonisation and student movement across programmes and higher education institutions (HEIs). The BET degree was also required to enable ECSA-certification for Professional Engineering Technologists. This study explores the success of Mechanical Engineering students who are enrolled within the BET programme. The investigation is not limited to students who have successfully completed their studies, but also includes students who have begun their studies and failed to complete them, for several reasons considered in the success rates investigation. The investigation will make use of readily available information from the University's Management Information System (MIS) and class lists.

The new BET programme is expected to be a great success to DUT and its students. The word 'efficacy' in the dissertation's title was used to investigate the functionality of the new degree and understand factors affecting its success. Consequently, five sub-studies were formed to answer the research questions: the success rate of the BET degree; whether the entrance requirements are appropriate (by comparing NSC results with first year BET results); the effect of GAs on success rates; the effect of ‘back-to-back’ modules on student progression and to compare the success rates of the BET against the ND success rates.

1.3 Research Questions

The overarching question this research sought to address was:

“Is the new BET (Mechanical Engineering) degree offered at DUT successful, and what interventions can be made to ensure its success?”

The following sub-questions guided the research:

1. What is the success rate of the BET programme since its implementation?
2. Are the entrance requirements adequate?
3. Is the implementation of GAs causing students to fail?
4. Has the ‘back-to-back’ offering of the ‘Strengths of Materials I’ and ‘Mechanics of Machines I’ modules been effective?
5. Is the student performance in the BET degree greater than in the National Diploma?

When answered, the research questions will help ascertain if the BET programme can be regarded as successful or not.

1.4 Research Aim and Objectives

The overarching aim of the study is to ascertain the success of the new BET degree since its implementation and to identify interventions to ensure its current and future success.

The objectives of this research are to:

- Investigate and analyse the student success rates of the BET cohorts since its implementation.
- Ascertain if the entrance requirements are adequate.
- Investigate whether students are failing the modules primarily by failing the Graduate Attribute (GAs).

- Investigate whether offering of the ‘back-to-back’ modules (Strengths of Materials I and Mechanics of Machines I) in the first semester has led to greater success rates, and whether the intervention needs to be retained.
- Compare and analyse if the BET is producing greater student success rates than the ND. Further test if the increased entrance requirements are resulting in greater student success rates for the BET first year modules.

Aligned with the objectives, the following five sub-studies were formed:

Sub-study 1: Success rate analysis – There were no extant studies conducted to analyse the influence of the new Mechanical Engineering programme on student success rates after the transition from ND and BTech to the BET degree. The data available on the University’s MIS systems, together with class lists, may be analysed to determine the extent to which the BET programme affects student performance and/or throughput rates. The Department’s goal was to improve graduation and throughput rates. Analysing the success rates gives an indication as to whether the Department is moving closer towards its goals.

Since the inception of the BET degree (2018), the cohorts (2018, 2019, 2020, and 2021) success rates will be investigated and analysed to determine the degree of success of this programme.

Sub-study 2: Relationship between NSC results and success in Mechanical Engineering – At DUT, the entrance requirements into the course are set by the relevant department. As such, the Mechanical Engineering Department set its own entrance requirements, based on students’ NSC results. A matriculant wanting to study Mechanical Engineering at DUT must have obtained a minimum of 50% in NSC Maths, Physics, and English. In addition, NSC candidates will be evaluated based on their combined results in Maths and Physics, with a minimum combined score of 120. The score of 120 was deemed appropriate by the Department based on research completed by Walker and Graham (Walker and Graham 2013).

This investigation serves to determine whether the entrance requirements set by Department were appropriate by first understanding whether there is a correlation between NSC Physics, NSC Maths, NSC English and first-year BET engineering modules. If there is a correlation, the suitable entrance requirements of the NSC subjects can be determined. If the entrance requirements are found not to be appropriate, interventions ought to be put in place.

Sub-study 3: Graduate attributes (GAs) and their effect – According to the unit standard from ECSA, GAs are those learning outcomes that an engineering student must exhibit at exit level to receive their engineering qualification. These activities reflect the student's capacity to meet the educational objectives (Engineering Council of South Africa 2020).

Since the UoTs instil the new BET qualification in their syllabus, ECSA requires that students also pass the GA to pass the year.

All graduates within the Department of Mechanical Engineering must demonstrate competence in the GAs, prescribed by both the University and the ECSA. There is a significant overlap between the University's GAs and those of ECSA. Where the GAs are assessed, they are framed as per the GAs prescribed by ECSA. It is considered that if a student demonstrates competence in all the ECSA GAs, they must demonstrate competence in the DUT GAs.

Currently, the circumstances stipulate that, should a student fail a GA assessment, he/she will fail the module, since the student has not demonstrated competence according to the assessment criteria of the rubric. As mentioned above, all assessments of GAs are externally moderated, to both DUT and ECSA requirements.

The concern is that students may be failing only due to failing the GAs. A student will have a GA assessment for the relevant module. The student may pass all other assessments, and have a qualifying mark to enter the examination. However, the student will not be able to write the exam and will fail the module if he/she fails the GA assessment. Investigation is done to determine whether students are failing primarily due to failing the GA (Walker, Graham and Sheoratan 2022b) (Walker, Graham and Sheoratan 2023). Further information concerning GAs is available in Appendix A.

Sub-study 4: 'Back-to-back' modules – Since the implementation of the BET degree in 2018, Strengths of Materials I (Strengths I) and Mechanics of Machines I (Mechanics I) in the Mechanical Engineering programme have exhibited poor student success rates. It was decided that it would be effective to also offer both modules in the first semester, to afford repeating students the opportunity to repeat it the following year in the first semester. This is done to facilitate students graduating in the minimum possible time. Initially, both modules were offered in the second semester only. Since 2020, Mechanics I and Strengths I were offered in both semesters and are consequently known as the ‘back-to-back’ modules. This study investigates the effect of the ‘back-to-back’ modules on student success rates in the Mechanical Engineering department at DUT and is important in determining whether the intervention needs to remain intact.

Sub-study 5: National Diploma vs. BET – The student success rates of modules in the BET that are deemed similar to modules offered under the ND qualification are compared and analysed to ascertain if the BET degree is producing improved student success rates. Further, to ascertain if the increased entrance requirements from the ND programme to the BET programme had a positive impact on first-year BET modules.

1.5 Significance of the Study

This study is anticipated to assist the department of Mechanical Engineering at DUT to understand the impact the new degree is having on student success rate and student throughput rate. It will further assist by providing interventions that would promote a greater student success rate and throughput rate of DUT Mechanical Engineering students.

1.6 Scope of the Study

This study was conducted at DUT within the department of Mechanical Engineering in the Faculty of Engineering and the Built Environment. Even though this investigation focused on DUT, the study could have relevance to similar institutions elsewhere, especially other African and South African UoTs.

1.7 Theoretical Framework

A theoretical framework is a logically established and interconnected set of concepts and premises derived from one or more theories to scaffold a study. To construct a theoretical framework, the researcher must describe any concepts and theories that will serve as the foundation for the research, connect them logically, and relate these notions to the study being conducted (Varpio et al. 2020). Research philosophy might be positivist, phenomenological, or a hybrid of the two. Each has their own strengths and shortcomings (Khumalo 2018). The research design for this study includes qualitative and quantitative components. Consequently, this study adheres to the positivist paradigm, which aims to uncover the truth through verifiable, quantitative data. Further evidence is gained using qualitative data.

1.8 Research Methodology

Quantitative and qualitative (mixed method) methodology was utilised. Quantitative data was gathered through MIS and class lists. For the qualitative data, ethical clearance was obtained for focus group sessions held with certain lecturers who taught the relevant modules in the BET Mechanical Engineering programme. The qualitative data analysis followed the four stages reported by Ravindran (2019) as recommended by Mayan (2016) and Polit and Beck (2020): (1) Data preparation, (2) Reading and reflecting, (3) Coding, categorizing and memoing and (4) Developing themes/conceptual models or theory. Each of the four steps successively refined the data, such that it could be used to provide greater insight into the quantitative data obtained from the study.

1.9 Limitations and Delineations

The current study was undertaken at DUT, which limited its reach. The study focused on the 2018, 2019, 2020 and 2021 cohorts only. More information could have been extracted if further cohorts were included. Furthermore, the study suited to most quantitative research methodologies due to the nature of data collecting. More qualitative research could have been performed to gain greater inferences from the quantitative data.

1.10 Conclusion and Chapter Overviews

This chapter provided an overview of the dissertation and contextualized it. It offered a rationale for the research, elucidating the research goal and objectives, and detailed the approach employed to attain the intended results. A detailed literature review is provided in Chapter 2, while the methodology is outlined in Chapter 3, followed by the Results and Discussion, and Conclusions and Further Research in Chapters 4 and 5, respectively.

Chapter 2 - Literature Review

Chapter 2 provides an in-depth review of the literature related to the study. It describes the education system in South Africa and filters into basic and higher education. It further goes on to elaborate on scarcity of engineers in the workforce. These topics have been included to show the importance of needing more engineering graduates in South Africa. The Chapter also provides further insight into the HEQSF, NQF and ECSA. Finally, research in higher education is discussed.

2.1 Introduction

This chapter aims to review and critique the current trends of engineering education in three parts. The first part deals with a contextualization of South African engineering education, quality frameworks and the influence of ECSA on engineering qualifications, while the second part encompasses a review of studies concerning the evaluation of learning programs and strategies, the effect of the NSC qualification on engineering students' performance, and analysis of student success rates, globally and at DUT. The third part examines two critical factors that could have influences student success rates during the timeframe of this study: the effect of class size, and the effect of online teaching and learning during the lockdown. Several literature publications were reviewed, analyzed, and critiqued to provide pertinent details in relation to the topic of this dissertation. A "funnel approach" was used to gradually narrow the research categories until the categories directly relating to this study were reached (Hofstee 2006). This approach enabled the identification of literature gaps to be filled by this study and enabled the study to be situated in the existing body of knowledge.

2.2 Part A: Contextualizing South African Engineering Education

2.2.1 An Overview of the South African Education System

Under apartheid South Africa imposed different education systems for each of the designated 'race' groups in the country. Since the advent of formal democracy, this has been amended to become a non-racial education system. The central government controlled system devised a complexity of highly unjust educational practices, where all learning institutions (universities, colleges, and schools) were separated according to government-designated racial group. Tasks, services, and responsibilities were replicated, and vast discrepancies in per-capita funding between the various learning divisions. Today, education departments fall under a sole national Education Department. Since 1994, South Africa has been in the process of political, social, economic, and educational change, directed at growing an equal and healthy society (Lomofsky and Lazarus 2001).

According to Spaull (2013), compared to all the average-income countries that take part in cross-national assessments of learning achievement, including many low-income African countries, South African performs poorly. The annually reported statistics from the NSC matriculation exam are somewhat deceiving, as they do not account those pupils who did not make it to grade 12. Research also conducted by Spaull (2013) shows that, out of 100 pupils that begin school, only 50 will make it to matric, 40 will pass, and only 12 will qualify for tertiary education. 18 to 24-year-olds who do not obtain some sort of tertiary education are at a significant economic disadvantage, and do not just battle to find full-time employment, but are also at the greatest risk of being unemployed for lengthy periods of time, if not permanently.

The South African education system is described by Spaull (2013) as extremely inefficient, largely underperforming, and unfair, where, although there have been some recent improvements in student results and some policy improvements, the situation is urgently in need of repair. When calculating student performance, whichever standard is chosen, most South African pupils fall substantially below where they ought to be (in terms of the curriculum), and have not achieved substantial numeracy and literacy milestones.

Poor language proficiency in English tends to spread over into other learning areas and it is important to take cognisance of the powerful and complex relationships between language, socio-economic status, and the way a school functions in South Africa. According to Lomofsky and Lazarus (2001), South Africa’s poor performance, measured in local and international tests, is largely due to language disadvantage. He emphasises that a vital factor in learning mathematics and science is not only a student’s financial status, but also their fluency in English. This prompts investigation of the correlation between NSC English results and first year Mathematics (hereafter Maths) and Science results. It is also stated by (Lomofsky and Lazarus 2001) that those who do not learn in their native language have a lower socio-economic status than those who do. Furthermore, second-language students are likely to attend institutions that are governed by weak management, poor accountability, poorly performing academic staff, amongst a plethora of factors. Van der Berg *et al.* (2011) corroborate that, on average, students who speak English as a second language perform significantly poorer than do first-language English students. The reasons for this could be institution-level factors, home background, linguistic disadvantage, or a mixture of these factors.

According to Spaull (2013), critics have pointed out that the NSC pass requirements fall below the usual standard. Widespread dropout prior to reaching Grade 12 constitutes a severe problem, which as time proceeds, causes students to tend to opt for less demanding exam modules. For example, the number of students taking Mathematics, as opposed to Mathematics Literacy, over the four-year period between 2008 and 2011, has dropped significantly from 56% to 45%.

The Global Competitiveness Report 2018 (Schwab 2018), which was constructed by the Word Economic Forum, evaluates the competitiveness landscape of 140 economies, thereby giving insight into the motivators of their prosperity and efficiency. The report shows a bleak picture, where it refers to the South African education sector. The extent of staff training is ranked 55th in the world, while the quality of vocational training is ranked 98th in the world. The skillset of graduates is ranked at an alarming 85th in the world.

2.2.2 The Current State of South African Higher Education

According to Badat (2010), racism and patriarchy were essential characteristics of colonialism and apartheid in South Africa, which have affected many aspects of social life, including higher education. In the case of academia, this has resulted in deleterious racialisation and gendering, leaving South Africa with a primarily White and male academic workforce. South African universities have had to promote restitution and social equality for Black and female South Africans since 1994, in line with new constitutional and social imperatives, and higher education goals and strategies.

Simultaneously, due to the interaction of many variables, it has become obvious that South African universities ought to focus on developing and maintaining a new generation of academics.

According to Winberg (2006), many academics, both in South Africa and globally, create information inside certain disciplinary areas. Efforts in academic development have switched to helping engineering educators by implementing a more holistic and long-lasting Scholarship of Teaching and Learning (SOTL) approach to their pedagogical practices to fulfil the multi-faceted demands of engineering education (Wolff, Blaine and Lewis 2021). Students are traditionally initiated into the "living worlds" of the fields that they have chosen to study in undergraduate universities. Disciplinary knowledge, together with its related living world, may be regarded as a specialised subset of fundamental human knowledge, where ‘disciplinarity' refers to mastering its ‘world-specific' knowledge and skills. Traditionally, discipline-based academic knowledge is increasingly seen as insufficient to solving pressing challenges faced in South Africa. This is concerning, as one of the most essential functions of higher education in a developing country – when just 1% of the population has a degree – is to educate graduates to make substantial contributions to social and economic rebuilding. Learners may believe that the role of education is to perfect a compilation of factual information, fundamentals, and abilities that have been pre-selected for inclusion in a specific subject area, rather than learning how these can be used to inform greater, real-life purposes (Winberg 2006).

Although Black South Africans made up around 89% of the total population in 1994, they only made up 17% of academics in South African universities at that time. Likewise, while women account for slightly over half of the population, they only make up 31% of the academic staff in South African universities in 1994 (Badat 2010).

Further research by Badat (2010) shows that the academic workforce in 2006 remained primarily White (62%) and male (58%), although there were substantial improvements in the proportion of Black academic staff members, particularly Black South Africans (24%), and women (42%) in 2006. Even though there were improvements during that time (1994 to 2006), the numbers still reflect those inequalities. By 2006, while Black South Africans made up nearly 91% of the population, they only made up 38% of academics; Black South Africans made up only 24% of the academic labour force, despite accounting for 80% of the population; and women, who made up 51% of the population, only made up 42% of academics.

The more recent study of Ranchhod and Daniels (2021) adds insight into the labour workforce in South Africa. Estimates for African/Black and White respondents are 45.8% and 16.09%, respectively. So, the (general) unemployment rate for Black/African respondents is nearly three times that of White respondents. Similarly, 58.1% of males are employed, whereas just 40.7% of women are. In connection with this, women have a general unemployment rate of 50.7%, while males have a rate of 34.9%. Hence, the unemployment rate for women is around 45% greater than that of males (Ranchhod and Daniels 2021).

Specific to the academic sector, a study conducted between 2005 to 2015 at the University of Cape Town (UCT) reported that there was no substantial difference between times to promote Blacks, Whites, Coloureds, and Indians. In all the staff groups studied, there is no substantial difference in time in promotion between men and women. This is not to say that there isn't cause for alarm at the university. Although the number of Black, Indian, and Coloured professors at UCT has increased from 4 to 24 in the previous ten years, and associate professors from 8 to 24, they still account for just 21% of all professors and 28% of all associate professors. When it comes to representation, the university's professoriate (full and associate professors) remains predominantly White and male (Sadiq *et al.* 2019).

The Department of Higher Education and Training (DHET) aims for a nationwide success rate of 80% in higher education (Department of Higher Education and Training 2022). This, however, seems unrealistic for engineering courses, as research done by (Pocock 2012) notes that non-completion rates of 50-65% for four-year degrees and Engineering degrees are recorded, with first year leaving rates of 15-35% reported in a wide range of subjects, including Engineering.

According to research conducted by Leibowitz and Bozalek (2014), stress on the higher education system is produced where financing for public higher education in South Africa turns out to be significantly lower than in nations at similar stages of economic growth. South Africa spends only 2.7% of its GDP on higher education, compared to the 3.3% spent by the rest of the globe.

Leibowitz and Bozalek (2014) note that, according to a five-year cohort study conducted by (Scott, Yeld and Hendry 2007), graduation rates for bachelor's degrees within the regulation three years for White students ranged between 43-52%, while for Black students these ranged between 11-13% across the Classification of Education Study Matter (CESM) fields. This is a rudimentary assessment of the issue, based solely on race as a comparative criterion. Only 28% of students experiencing hardship graduate, as evidenced using the National Student Financial Aid Scheme of South Africa (NSFAS). By median, 70% of the households of higher education dropouts questioned were classified as having poor economic status. This finding reinforces the idea that race and class or economic position constitute factors that ought to be considered when addressing learning difficulties in South Africa (Leibowitz and Bozalek 2014).

Internal factors impacting student achievement include self-confidence, mindset, capabilities, and external factors, such as methodology, instructional quality, and programme (Leibowitz and Bozalek 2014). The very first steps in improving student performance should be to concentrate on variables outside of the Department's control, such as the curriculum and how it is delivered, rather than internal characteristics like motivation and attitude, which lie predominantly outside departmental control. Programme modifications, educational expert appointments, preserving the quality of incoming students, enhancing the learning atmosphere, strengthening staff teaching abilities, and providing effective student assistance are all cited as external variables, and are suggested. Modifications to the Engineering curriculum, such as updating the syllabus to better incorporate reading and numeracy and increasing the amount of Engineering applications in entry-level courses, have also shown to be effective (Klingbeil 2004).

2.2.3 The National Qualifications Framework (NQF)

Research by Allais (2007) indicates that the NQF was established as a fundamental tool for reforming the apartheid education system, which was racially segregated and unequally oppressive. This was enacted as the first reform to educational law passed in South Africa after the country's democratic transition. The NQF was designed to overhaul the disjointed education and training system, according to the SAQA, which was formed to administer it. The NQF had widespread political backing, and under democratic transition, served as a sign of the creation of a national education system for all South Africans. The South African NQF was intended as a highly coherent programme, covering the entire education system at all levels, and across all sectors. It was also created to emphasise the importance of learning goals, according to the idea that learning outcomes should drive all parts of the educational system.

Education programmes were to be planned, taught, tested, and assessed against nationally mandated objectives. Allais (2007) refers to this as an outcomes-led qualifications framework, due to its fundamental design element. The South African NQF is a particularly fascinating case study, as it exemplifies a complete outcomes-driven qualifications system in an obvious (and potentially over-determined) manner.

The NQF was first designed to address specific challenges in the industrial sector, however it quickly expanded to embrace all aspects of education and training. To understand how the NQF was intended to function, its internal logic, and the opposition that has since been launched against it, it must be examined from the perspective of the industrial training sector. The South African NQF was created with the goal of integrating education and training to increase skill and productivity levels, encourage greater economic growth, and address equity and social justice concerns (Ensor 2003). The narrative furthering the skilling of the workforce in this way will contribute to personal development, and to social redress, equity, and the development of a globally competitive national economy (Luckett 2000). All qualifications at the higher, further, and general educational levels, including those pertaining to crafts and vocations, are included in the South African NQF (Walters, Watts and Flederman 2009). The NQF was created to remove formal institutional control over determining what constitutes skills and knowledge, where they would no longer be the final adjudicator of that which was important to know, or that which learners were required to accomplish. It was believed that the establishment of standalone result statements would boost educational provision, because any provider would be able to provide learning programmes based on the type of responses, allowing for the emergence of new suppliers. Increased educational supply would result in increased competition, which would necessarily improve quality. Goals appeared to be a tool for increasing quality, since they would establish criteria for all educational services, and all educational institutions would be required to satisfy the requirements, guaranteeing that all students received equivalent academic excellence. Furthermore, due to the competencies being openly stipulated and made available for public criticism, it would be relatively straightforward to determine which competencies were relevant in other courses or programmes that a student wished to pursue, resulting in reduced redundancy and maximum educational efficiency (Allais 2011).

Allais (2007) claims that, despite widespread support and great expectations for the NQF across the political spectrum in South Africa, the Framework has failed to live up to the claims made on its behalf, and has been the topic of lengthy Education policy review since its implementation.

Close to the end of 2008, legislation was introduced to make significant modifications to the NQF, dividing it into three connected frameworks, namely: higher education, general and further education and training, trades and occupational education and training. For each, a quality council was established. The authority of SAQA to create standards has been delegated to these respective councils, each of which appears to be working in ways that are not just distinct from SAQA's outcomes-based qualifications, but also distinct from one another (Allais 2011).

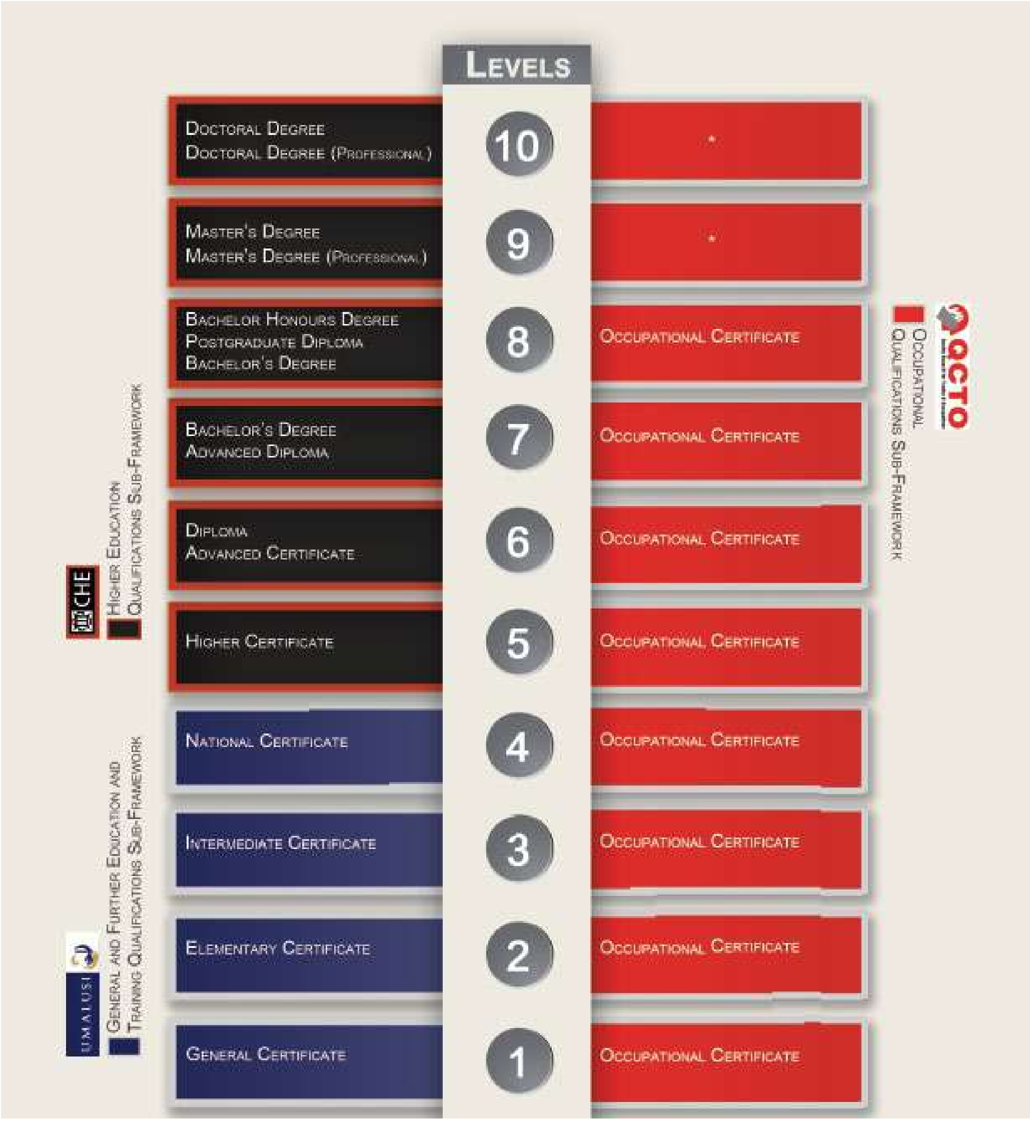

Figure 2-1 A chart depicting the National Qualification Frameworks (NQF) and how it connects to various educational alternatives available in the South African educational system (South African Qualifications Authority 2013)

2.2.4 The Higher Education Quality Sub-Framework

The attraction of faculty programme offerings to potential students, and the vested interests of private companies in curricula and student assistance, form two of the cornerstones to institutional success.

According to Kapp (2019), all Higher Education Institutions (HEIs) were asked to apply the new HEQSF by 2020 by the CHE and DHET. The Higher Education Qualifications Sub-Framework Act No. 67 of 2007 (HEQSF Act) (South African Qualifications

Authority 2013) established a single qualifications framework for HEIs, as envisioned by the Department of Education's 1997 strategy. This programme aimed to hasten the creation of a single nationwide coordinated higher education system. The main goal of this strategy was to encourage course harmonisation and pupil movement across programmes and HEIs. Structures were then split, resulting in parallel qualifications, implying that traditional universities would offer the same programmes that they historically offered, whilst Technikons (now known as Universities of Technology) would have to develop new ones.

Since January 2009, all new programmes were required to comply with the HEQSF's requirements. Despite HEQSF robustness, the CHE informed the Minister of Higher Education that several issues still needed to be addressed. These reservations stemmed from the HEQSF's aim and number, and the nature of the many sorts of qualifications available. Furthermore, the certifying procedure revealed many inconsistencies in the HEQSF, which harmed the achievement of national policy aims and priorities.

The South African HEQSF (2013), according to (Kapp and van Wyk 2018), has resulted in Universities of Technology (UoTs) undergoing curriculum modification and growth for the past several years to ensure that revised and new UoT qualifications correspond with the new structure. As a result of this revision, UoTs have been entrusted with developing new programmes, to provide an academic pathway from diploma to doctorate levels. DHET decided to change the HEQSF to encourage cross and intra-institutional articulation. Considering the variety of curriculum revisions of current qualifications and curriculum creation of new qualifications to conform with the updated framework, the HEQSF (2013) had far-reaching implications for UoTs.

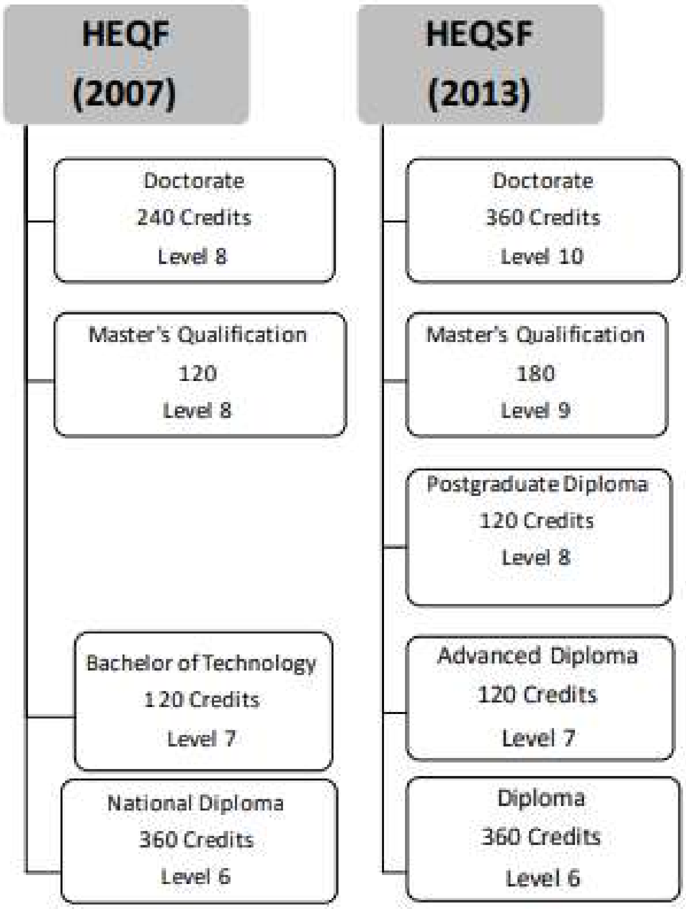

Figure 2-2 HEQF (2007) and HEQSF (2013) (Kapp and van Wyk 2018)

After the introduction of the new HEQSF, several university departments are reconsidering their programme and qualification mixes (PQMs). Choosing a suitable PQM for a university department is a difficult task, impacted upon by a variety of factors, needs, and restrictions. Many other considerations, such as market demands, commercial feasibility, path dependency, articulation, mode of instruction (online learning vs classroom-based education), and university type (e.g. comprehensive, research-intensive, or technology-focused), must be evaluated with respect to the HEQSF requirements.

The amalgamation of Rand Afrikaans University and Technikon Witwatersrand to form the University of Johannesburg, and the former University of South Africa (Unisa) with Technikon Southern Africa to form the 'new Unisa', has resulted in these extensive institutions being able to offer the BEng degree. Competency requirements authorised by ECSA are the most essential criteria to consider when deciding on a PQM for departments providing engineering-related programmes. The inclusion or removal of work-integrated learning (WIL) is another significant HEQSF-related provision that university departments are required to examine (Nel 2014).

Curriculum development is frequently prompted by the need for change due to organisational or external pressures. The HEQSF's implementation in South Africa resulted in significant modifications to qualifications in the UoT sector (Scholtz 2020). To assure a straight path to the master's level, the HEQSF required changes to current national diplomas, and the development of new qualifications. The NQF's higher education band consisted of four levels (5 to 8) and was superseded in 2013 by the HEQSF, which has introduced six levels (5 to 10). Certain graduates of the 5-8 Level NQF BTech programme went on to earn a Master of Technology degree (MTech).

When the Postgraduate Diploma (PGDip) is implemented in 2022, BTech graduates will be obliged to complete the PGDip, or possibly an honours level qualification, before moving on to the master's degree. The PGDip's aim is to allow employed professionals to develop their thought, experience, and research techniques in a specific area of speciality as a gateway certification to master's study. Graduates would gain the necessary skills and abilities to proceed to the 180-credit master's degree. The Advanced Diploma and PGDip are new to the Universities of Technology. While the forerunner of an Advanced Diploma is the BTech, the PGDip is a brand-new certification, at a novel level on the HEQSF.

2.2.5 The role of ECSA in South African Engineering Education

The foundation of ECSA's mission is to provide regulations, standards, and qualifications for the engineering field. The Engineering Profession Act (EPA), 46 of 2000, created ECSA as a statutory entity (McDiarmid 2015). ECSA's principal responsibility under this Act is to regulate the engineering profession. Its main responsibilities include the accreditation of engineering programmes, registration of professionals (in certain categories), and control of registered peoples' activities. ECSA is important for the creation of engineering skills, and for the regulation of engineering performance in a moral and competent way, and with the maintenance of proficiencies through ongoing professional development. In South Africa, this ensures the quality of Bachelor of Science (Engineering), Bachelor of Engineering, Bachelor of

Technology (Engineering), and Diploma in Engineering programmes. The accreditation procedure at ECSA is focused on programmes rather than the educational institution, staff, or school. The major factors responsible for certifying engineering education, according to the ECSA, are to verify that the programme meets its primary goal, and that the teaching, learning, and evaluation procedures are successful. Most notably, the Engineering Profession Act of 2000 mandates the certification of engineering programmes (Mutereko 2018).

To improve throughput in the BEng degree, ECSA commissioned an investigation. One of the seven “levers of change” mentioned in the study is curricula that is “flexible enough to provide successfully for a varied student intake” (Fisher 2011) (page 126). Engineering curricula in South Africa are unusually strict, in the sense that, for the most part, courses are mandated, leaving students with few, if any, options for electives within their degree programmes. Aside from the detrimental implications for children from low-income families, inflexible curricula provide little room for creativity and adaptability to 21st-century job needs (Grayson *et al.* 2014).

Research by Mutereko (2018) states that ECSA’s accreditation procedure is designed to guarantee that graduates of its programmes can work and adapt successfully in a globalised society. To that end, ECSA follows the worldwide standards outlined in the International Engineering Alliance’s Graduate Attributes, which are based on the respective Washington, Sydney, and Dublin accords. This shows that, in addition to responding to local and regional requirements, South Africa’s Engineering certification is also subject to worldwide trends, and the concomitant globalisation of the labour market.

The ECSA accreditation model has five criteria which are used to evaluate and accredit an engineering education programme:

1. Credits, Knowledge Profile and Coherent Design
2. Assessment of Exit-level Outcomes
3. Quality of Teaching and Learning
4. Resourcing and Sustainability of the Programme
5. Response to Previously Identified Deficiencies and Concerns, Capacity for Improvement and Programme Review

(ECSA 2018) (page 3-8)

A course must have a clear objective to fulfil the learning demands of an identifiable engineering position to achieve the objectives for Criterion 1. A graduate of an engineering programme knowledge profile, for example, must be well specified. Criterion 2 requires that evaluation techniques verify that graduates of an Engineering programme meet all the programmes exit outcomes. The methods of evaluation must show that the results are met in line with the criteria. Criterion 3, which concentrates on teaching and learning quality along with other needs, guarantees that the specified results are achieved via effective learning and teaching. There must be sufficient employees, students and resources required to achieve the results.

With respect to Criterion 4, which concentrates on the need for resources and sustainability of the programme, the degree of selection of the students that are proportional to the programmes' academic needs ought to be demonstrated. The selection of pupils connected to other institutional responsibilities, such as diversity and equality, ought to guarantee that the quality of the education is not affected by the quantity of students enrolled. The last criterion ostensibly closes the feedback mechanism (Mutereko 2018). It requires institutions to show that the faults and issues that were previously highlighted, have been handled appropriately.

At the faculty level, a number of decisions were made to guarantee that GAs would be developed, evaluated, and recorded regularly. Only at third year level, via exit level modules, or if offered by the department, may GAs be assessed. Owing to the significance of GAs for programme accreditation by ECSA, it was determined that modules provided directly by the Department (rather than serviced modules) would be the sole modules utilised for GA assessment.

2.2.6 Distinctions between Engineers and Technicians

According to Winberg *et al.* (2014), South Africa has a deficit of all engineering experts, with just one engineering professional to every 3,166 people. The scarcity may be traced back to apartheid policy, when the majority Black cohort of South Africans were prohibited from accessing technical careers. There has been an effort in post-apartheid South Africa to boost the number of Black engineers the country graduates.

Engineers, engineering technologists, and engineering technicians constitute the three major categories of engineering professions in South Africa today. The title is determined by the level of post-secondary education achieved. Engineers and technologists often have a four-year bachelor's degree, whereas technicians typically have a three-year diploma.

The engineering profession has expressed concern regarding employment arrangements, which emerge from a scarcity of technicians on the one hand, causing engineers to perform technician-level work; and a lack of engineers on the other hand, causing technicians to have to perform engineering work, which is of greater concern. Much has been accomplished in post-apartheid South Africa in terms of a broadening inclusion in the engineering professions. Black South Africans make up 30% of all professional engineers and 40% of all engineering technicians. Engineers are disproportionately under-represented among women, with just 15% of female engineers, and 85% of male engineers. There is also a significant lack of older professionals, with 13% of engineers being over the age of 50, which has consequences for the supervision of new engineers (Winberg *et al.* 2014).

2.2.7 ECSA's Influence on the New Degree at DUT

Basson (2017) points out that it is a struggle to develop a curriculum for the Engineering degree that prepares graduates after a few years of work experience to become engineering professionals. There are several diverse functions that engineers perform, which implies that a curriculum cannot be tailored to every job, particularly in a nation like South Africa, where the funding available for engineering education requires large class groups to achieve a financial break-even. Curriculum designers must, therefore, establish a compromise suitable for a broad variety of engineering tasks, emphasising the most popular roles, or specific, strategically chosen positions.

In terms of knowledge areas and GAs, ECSA accreditation standards for the content of engineering programmes are specified (Basson 2017). The aim of the accreditation is to build the expertise, understanding, talent, and competencies to become a qualified engineering technician for further education. The aim of a Bachelor's degree in Engineering Technology is to equip graduates with a preparedness for employment in engineering and associated fields, along with technical leadership, to ensure that they may contribute to economic and national development. The educational requirement is needed for certification with ECSA as professional engineering technologist, and to allow the graduate to seek employment in engineering and allied disciplines (Engineering Council of South Africa 2020).

DUT possesses its own GAs, alongside the ECSA GAs. To prevent duplication, DUT's GAs were mapped against the ECSA GAs, where only the assessment of the ECSA GAs is required.

It was also determined that one of the conditions for passing the module would be passing the embedded GA assessment. Put otherwise, a student would not be able to pass the module if they failed the GA assessment, which might not have had any relation with the material covered in the module.

2.3 Part B: Review of Similar Studies

2.3.1 Evaluating Pedagogical Strategies

Several pedagogical interventions may be implemented in higher education classes, typically in response to pedagogical challenges, such as decreased student engagement, increasing class sizes and unsatisfactory student performance (Roopchund and Naidoo 2023). It is important to adequately evaluate such interventions to ensure their effectiveness.

Case and Gunstone (2003) undertook a qualitative study with a group of second-year Chemical Engineering students to examine their learning approaches. The data collection and analysis methods followed a naturalistic inquiry method. The data collection comprised four individual interviews with the purposively-sampled students before and after the release of test results. From the results, three learning strategies were identified: a conceptual strategy, an algorithmic strategy, and an information-based strategy. This study indicated that diverse learning strategies may require diverse pedagogical approaches.

The study Maladzhi (2020) employed the technological, pedagogical, content, and technological pedagogical content knowledge (TPACK) framework to determine academics' knowledge concerning teaching with technology. A quantitative research design was utilised to collect the data through surveys (Microsoft forms) using convenience sampling. The descriptive statistics from TPACK scores were analysed. The findings revealed that the academics lacked comprehension of technology integration in teaching, thus losing teaching opportunities. The lack of technological knowledge by academics can cause a digital divide when young incoming students possess high technological skills; potentially causing students to undermine academics who are less interested in technology, which can destabilize the teaching and learning environment. This study also emphasized the general poor digital literacy and technology uptake of academics prior to the Covid-19 pandemic lockdown.

The study of Inglis, Combrinck and Simpson (2022) investigated students' transition to university during the Covid-19 pandemic. In 2020, while institutions responded to the pandemic, there was a sudden switch to online learning for students, which required most academics to become rapidly acquainted with pedagogical technology tools. The rapid transition to emergency remote teaching and learning practices was also confirmed and documented in the study of Roopchund (2022). Through semi-structured interviews, the study examined how second-year engineering students perceived the influence of the lockdown on their academic performance, and how they believed first-year students may have perceived this influence. Interestingly, this study captured students' perspectives through in-depth qualitative analysis of their interview responses, as previously done by (Case and Gunstone 2003).

Grayson (2011) investigated the first-year results of the Engineering Augmented Degree programme (ENGAGE) a five-year curriculum introduced in 2010 at the University of Pretoria (UP). Reduced mainstream courses and added developmental modules comprise ENGAGE. The developmental modules assist students to form success-oriented behaviours. ENGAGE is an effective strategy for expanding the number of Black engineers. The study used qualitative techniques. The student participants who had voluntarily switched from the BEng to the four-year BSc programme were questioned on their first-semester experiences in the BEng degree.

The study of Khumalo (2018) sought to determine the effectiveness of e-learning to students' academic development at DUT. The study considered how academics encourage students to utilise e-learning, how frequently students use it, and their perspectives of e-learning. Quantitative data was collected from students using a questionnaire and qualitative data was acquired via interviews with selected lecturers from the Faculty of Accounting and Informatics to reinforce the students' replies. This mixed-method research strategy is noteworthy, as it enables the insights of the students and instructors to be captured to provide a holistic understanding. This study is therefore a combination of the positivist theoretical position, which seeks to discover the truth through verifiable quantifiable data, which is included in the phenomenological framework which understands that human knowledge is socially constructed (Khumalo 2018). The findings indicate that some students utilise e-learning and believe that it has greatly enhanced their academic achievement. However, others believe that more needs to be done to ensure that everyone is pleased with the implementation and efficacy of e-learning. It is notable that such e-learning initiatives were implemented prior to the Covid-19 lockdown, which would have enabled a smoother transition to emergency remote teaching and learning during the lockdown.

2.3.2 The Relationship between NSC Results and Tertiary Performance

After the introduction of the new NSC programme in 2008, a few studies considered the influence of the NSC programme on tertiary education results. The study of Collier-Reed, Wolmarans and Smit (2010) quantitatively investigated the impact of NSC mathematics on student performance in Mathematics I in first-year engineering programmes at the University of Cape Town (UCT) between 2005 and 2009. The mid-year results for Mathematics I in 2005, 2007, and 2009 were compared to the results for the semesterised version of the course in 2010. The results showed a considerable decline in first-year Mathematics proficiency among South African matriculants from 2008. However, the 2007 results indicate that this decline has occurred consistently. Hence the NSC programme could not be held accountable for declining tertiary education results (Collier-Reed, Wolmarans and Smit 2010).

Similar to the study of Collier-Reed, Wolmarans and Smit (2010), Wolmarans *et al.* (2010) analysed first-year student performance in engineering Mathematics and Physics at UCT in relation to their NSC results. The authors provided a statistical comparison of the Mathematics and Physics midterm scores over a five-year period.

The results indicated that students' first-year mathematics and physics proficiency has generally declined. However, a comparison with the Mathematics statistics from 2007 shows that the "new" matriculation examinations cannot be held solely responsible for this overall reduction (Wolmarans *et al.* 2010); thus validating the findings of Collier-Reed, Wolmarans and Smit (2010). These findings may imply that each cohort of first-year students have different learning needs, which must be identified and addressed by their first-year instructors, such that their overall learning experience is optimized, thus leading to improved performance.

2.3.3 Broader Analysis of Student Performance

The study of Maurice (2015) analysed the key indicators of student success based on a sample of BCom Accounting students at the CTI Education Group (MGI)/Durban Campus from 2009 to 2011. This study notably documents important markers of student achievement by examining whether matriculation aggregate scores, selected individual matric subject scores (including Mathematics, English, and Accounting) and demographic information (such as gender, race, socioeconomic status, and first generational status) are key success indicators. As applied by Khumalo (2018), qualitative and quantitative data were gathered and included into an econometric model. Qualitative data such as gender, race, and parent education level were used as dummy variables and examined using Pearson or Spearman's correlation tests. Due to the student performance gap, the descriptive econometric model was applied. It is noteworthy that this study suggests several ways in which diverse research approaches are complimentary. During focus group talks, the specific themes included student views of mathematical competency, English, and accounting. This information was examined quantitatively. However, the findings were interpreted qualitatively (Maurice 2015) .

The study of Smith (2009) used statistical analyses to determine the effect of first-year academic development courses offered by UCT’s Commerce Academic Development Programme, on students’ graduation in relation to mainstream students. The results suggest that the academic development programme enables students to out-perform their mainstream peers, and that the positive effect of the first-year courses on graduation performance is conspicuous for African students. This study is notable as its methodology demonstrates the level of statistical rigor required to quantitatively measure the effects of an academic intervention on the success of students within a program.

The study of Cechova, Neubauer and Sedlacik (2019) considered assessment as a tool for enhancing an institution’s quality and informing students about their outcomes and learning opportunities. The authors believe that the hallmarks of a quality assessment are its ability to establish quantifiable student learning outcomes, and analyse and interpret them, thus enabling students to receive feedback to improve their performance. This notion was supported by the study of Roopchund and Naidoo (2023) who quantitatively demonstrated the link between students’ performance and effective feedback. The study gathered empirical data on students´ learning to refine study programmes. A longitudinal study was used to observe students’ outcomes from entrance exams to state exams. The statistical analysis revealed a correlation between the entrance and admission test results and the study results.

2.3.4 Analysis of Engineering Student Performance

Within the engineering context, Marbouti, Ulas and Wang (2020) undertook an academic and demographic cluster analysis of student success using semester grade point average (GPA) to account for temporal factors in student achievement. The novel aspect of the study is that its findings emphasise student success based on demographic status and use of university resources such as financial help. Furthermore, considering the retention and graduation issues affecting higher education institutions, understanding why students are not successful is one method to change this. A cluster analysis was used to understand student groupings based on academic achievement and demographic information. The students were divided into two groups: 1) freshmen and 2) transfers. The datapoints consisted of 32 958 freshman semester data and 18 330 transfer student semester data, for a total of 51 288 student semester data. The findings indicate that despite being qualified, Hispanic, first-generation, low-income students are less likely to apply for financial help. This group also have a lower GPA and take fewer units per semester, resulting in a delayed graduation and increased debt (Marbouti, Ulas and Wang 2020).

The study of Zarreh *et al.* (2019) investigated the factors contributing to student success in an introductory mechanical engineering course at the University of Texas in San Antonio (UTSA). The data was gathered during the 2018 semester from the Engineering Graphics and Practice course. Although the course is aimed for freshmen, upper-division students (juniors and seniors) were present. The study sought to evaluate the influence of several factors on student achievement by determining the most essential association between these variables and their final grades. Analysis of Variation (ANOVA) was used to identify factors influencing the final grade of the lecture segment and their impact on students' grades. Finally, the pivot technique was utilised to show some of these relationships. The results indicate that attendance and homework have the greatest impact on students' overall achievement. Surprisingly, students in the upper division did not outperform those in the lower division. Overall, the results demonstrated that active learning has a bigger influence on a student's total performance than the quantity of credits acquired.

The study of Orr *et al.* (2014) considered student demographics and outcomes across American mechanical engineering programs to inform decision-making using the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) that includes over 90,000 first-time-in-college students and over 26,000 transfer students. The quantitative results show that although males outnumber females in mechanical engineering, matriculation and six-year graduation rates differ by race/ethnicity and gender. Asian, White, and Black students retain more in mechanical engineering than all other engineering majors combined, while Hispanic students do not. While around half of the mechanical engineering starters leave, most are replaced by switchers and transfers. This replacement population is devoid of black males, who are also the least likely to continue with mechanical engineering after graduation. Asian females are the most likely to earn a mechanical engineering degree. Almost half of all mechanical engineering graduates began their careers in other fields. While these quantitative results are insightful, the reasons accounting for these trends could have been obtained directly from the students by including a qualitative research strategy.

2.3.5 Analysis of Engineering Success Rates at DUT

The study of Jackson (2015) investigated the learning styles, teaching techniques, and student performance in Industrial Engineering at DUT by analysing students' preferred learning styles and lecturers' preferred teaching styles at various levels. The Felder and Silverman Model (1988) was intended to identify variations in learning styles among engineering students. The study's target audience was the 200 students registered for the National Diploma: Industrial Engineering at DUT in 2013 using a mixed-methods research strategy in which the lecturers were chosen via convenience sampling. The study included five instructors and 150 students. Questionnaires and semi-structured interviews were used to collect data. Following the interviews with the lecturers, direct classroom observations were conducted to establish their teaching styles. Such a comprehensive mixed-methods research strategy is well suited to providing holistic insights.

The study of Graham (2015) analysed mechanical engineering students' success at DUT. Using data from the universities' management information system, four sub-studies were used to identify potential barriers to student achievement: (1) trends in student success rates during four semesters from 2007 to 2010. A longitudinal study was conducted to assess the success rates of every subject in the diploma and BTech programmes. Raw data was obtained from class lists. (2) Workplace Learning (WPL). Using WPL registrations from 2007 to 2010, this study analysed the average time to complete the WPL components, the percentage of the academic components completed before and during the WPL period, and the dropout rate. (3) Relationship between NSC results and success in Mechanical Engineering. The goal of this study was to determine if there were any links between students' NSC results and their achievement in the programme. (4) Investigation into causes of poor performance in Hydraulic Machines III. Overall, the pragmatic paradigm was used, and while quantitative methods were largely employed, qualitative approaches were used where necessary. The research was conducted within a framework based on grounded theory, with elements of grounded action research incorporated (Graham 2015). It is notable that breaking down the main study into sub-studies provided greater clarity in terms of the research findings, coupled with holistic insights offered by the mixed methods research strategy.

2.4 Part C: Pertinent Factors Influencing Student Success Rates

2.4.1 The Effect of Class Size on Student Success Rates

According to Abizada and Seyidova (2024), smaller classes are generally linked to better student performance. Bourke (1986) and Finn and Achilles (1990) suggest that smaller class sizes are beneficial for student outcomes due to enhanced opportunities for individualized attention and instruction, positively influencing student engagement, motivation, and achievement. Teachers' perceptions of smaller classes include an easier facilitation of individualized attention, and provision of supplementary learning materials (Pedder 2006). Additionally, greater interaction and personal instruction was reported by Blatchford *et al.* (2002) with group work, pair work, open-ended questions, and consistent feedback contributing to student achievement (Harfitt 2013). Notably, such teaching strategies are not possible in large classes, due to limited time and resources.

Other than student performance, class size also affects classroom management, instruction, and academic achievement (Kusi and Manful 2019). According to Taha (2021) and Uhrain (2016), it is difficult to maintain student discipline in larger classes, resulting in more focus on student behaviour than academic performance. Additionally, larger classes often require teachers to utilize class time for management tasks rather than solely for instruction (Abubakar, Diri and Shuaibu 2023).

Despite the reported advantages of smaller class sizes with respect to student performance, Nye, Hedges and Konstantopoulos (1999), Hanushek (1986), Hanushek (1989), and Slavin (1989), suggest limited or non-linear relationships between class size and student achievement. This notion still stands as the more recent research of Abizada and Seyidova (2024) elaborates that no satisfactory relation between class size and student performance has been reached to date.

2.4.2 Transition to Emergency Remote Teaching and Learning (ERT&L)

The mandatory COVID-19 pandemic lockdown disrupted conventional pedagogical procedures, as educational institutions were inadequately equipped with resources and expertise to conduct teaching and assessment activities online and remotely (Roopchund 2022). Many educators had to find alternate means of teaching within limited timeframes. Without the necessary expertise in navigating online teaching and assessment, many education institutions were not prepared for the rapid transition to emergency remote teaching and learning (ERT&L) (Schuck and Lambert 2020).

During the lockdown, each university adopted different solutions, including specific online tools for distance learning, comprising online classes, guidelines and instructions for lecturers to adapt their teaching activities (García-Alberti *et al.* 2021). Despite such support, transforming traditional contact teaching into ERT&L was not trivial for the lecturers or students (García-Alberti *et al.* 2021), as the learning materials, tools used for their production, and the interaction mechanisms with the students had to be adapted. Consequently, students and lecturers were required to rapidly learn how to use new tools and the way they interact with each other. Hence, such stress is likely to have adversely impacted teaching and learning, having a ripple effect on students' performance.

It is notable that the lockdown is one example of a disruption to teaching and learning. Typically, protest actions at South African universities occur annually, causing 'transient' disruptions, which still adversely impact teaching and learning.

2.5 Conclusion

This comprehensive literature review lays the foundation for the study incorporating this dissertation. Part A provides a detailed background of the South African higher education system, its quality frameworks, and the role of ECSA in ensuring the compliance of South African engineering qualifications to international standards (thus forming an objective accreditation framework). Part B considers the manner in which tertiary learning strategies are evaluated, the influence of the NSC qualification on tertiary academic performance, and the evaluation of success rates globally and within the South African Engineering context. Part C presents the effect of class size and the transition to ERT&L during the COVID-19 pandemic, spanning 2020 and 2021, on student success rates.

Collectively, Parts A, B and C provide the theory base needed to effectively achieve the goal of this study: to evaluate the efficacy of the BET Mechanical Engineering programme at DUT. Furthermore, the funnel structure demonstrates where and how this study is located within the existing theory base (Hofstee 2006).

Notably, the mixed method research paradigm was found to yield the most holistic results (Graham 2015; Jackson 2015; Maurice 2015; Khumalo 2018). Finally, the gaps identified in the literature, specifically in relation to DUT’s new BET Mechanical Engineering programme, include a student success rate analysis, the manner in which the NSC qualification influences the programme’s success rate, the effect of graduate attributes on student progression, measures taken to optimize student success rates, and a comparative analysis with the previous ND programme. Consequently, this dissertation seeks to address these gaps through five corresponding sub-studies, which will undergo further discussion in subsequent Chapters.

Chapter 3 – Methodology

3.1 Introduction

The purpose of Chapter 3 is to detail the research design and research instruments of this study. The paradigm and methodologies used are described. The population and sampling utilised for this study is specified. The Chapter then filters into the sub-studies performed and explicitly describes the methods used in the collection, sorting and analysis of data.

3.2 Research Design

A research design is an all-encompassing strategy for linking conceptual research problems to pertinent practical research. It also outlines what information is needed, how it will be gathered and analysed, and how it will answer the research objectives (Khumalo 2018).

This research adheres to a positivist paradigm and employs mixed methods. The research questions rely on the data collection (qualitative and quantitative) and analysis techniques that presents insights into the study. The quantitative methods involve numerical data collection and the corresponding statistical analysis, while the qualitative methods involve focus group sessions with lecturers at DUT (who are involved in lecturing the students in the BET Mechanical Engineering programme) and recording their responses. Additionally, a longitudinal study is used to understand the effect of 'back-to-back' modules on student progress. Finally, a cross-sectional study is utilised to ascertain whether the entrance requirements are appropriate upon investigation on NSC results versus specified first-year module results.

3.3 Research Paradigm

A paradigm refers to a theoretical framework, as opposed to a theory, and affects the way in which knowledge is researched and perceived. A paradigm is comprised of three elements: a viewpoint on the nature of knowledge, a methodology, and a set of validating standards (Mackenzie and Knipe 2006). This study is underpinned by the positivism paradigm, anchored in the ontological belief that truth and reality exist independently of the observer (Aliyu et al. 2014). A positivist stance deems that the universe operates according to constant laws of cause and effect; that complexity can be broken down through reductionism; and that there is a need to emphasize neutrality, measurement, objectivity, and repeatability (Aliyu et al. 2014). Positivism methods include confirmatory analysis, nomothetic experiments, quantitative analysis, laboratory experiments, and deductive reasoning (Aliyu et al. 2014). Positivism, however, does not necessarily rely solely on quantitative methodology. The positivist paradigm is appropriate for exploratory research, using qualitative analysis to examine the effects of a given intervention. Generating explanatory linkages that enable the prediction and control of the phenomenon under consideration is one of a positivist inquiry's key goals (Park, Konge and Artino 2020). The basis of knowledge is human experience. It is necessary to quantify observations to conduct statistical analyses. This study prefers the positivism paradigm due to its empirical nature.

3.4 Research Methodology

3.4.1 Research Instruments

The author characterises research instruments as using quantitative or qualitative approaches, a combination of both (Melnikovas 2018). Quantitative research is most frequently used in science, and for investigative studies in social science and management Khumalo (2018). Quantitative approaches are often based on the positivist worldview. Furthermore, Khumalo (2018) claims that quantitative approaches are frequently used to experimentally verify theory-based hypotheses using several statistical analyses. Fundamentally, quantitative research methods gather and evaluate organised data that may be represented numerically to provide precise measures for statistical analysis.

Because quantitative research focuses on measurable data, it successfully addresses the "what" or "how" of a given scenario. Direct, quantitative questions use language such as "what percentage?" "what proportion?" "how far, how many, and how much?" These are questions that can be answered (Goertzen 2017). Quantitative techniques have several advantages, including generalisability and measurement precision. Quantitative research, which uses numbers, percentages, and statistics to measure public perception and thinking styles, and emotional and behavioural states, is extremely useful (Shields and Twycross 2003).

According to Khumalo (2018), the following are the features of quantitative research:

- Investigating variables using assumptions obtained from a theoretical model;
- Establishing causal (cause and effect) connections between constructs;
- Frequently extrapolating results beyond the scope of the study;
- Placing the individual at the centre of the empirical investigation; and
- Replicating research to assess the extent to which findings are relevant to different situations.

Initially, this study employed only quantitative methods, which was found to lack depth in certain instances.

In social research, qualitative research is not connected with an interpretative stance, but rather seeks to understand human behaviour (Jackson 2015). The information is generally semi-structured and textual, and is gathered from a limited number of instances, using a variety of techniques. According to (Corbin and Strauss 1990), the social sciences are most closely connected with qualitative research methodologies, encompassing several techniques that do not utilise statistical processes or quantification, where the information is typically descriptive. Case studies, ethnography, action research, phenomenography, discourse analysis, and narrative analysis are just a few of the qualitative research methodologies gaining ground in engineering education research. When it comes to determining meaning, Shields and Twycross (2003) state that qualitative approaches are most efficacious.

Whether to measure a phenomenon or determine its meaning, the research methodology, approach and methods must be tailored. Usually, qualitative research is utilised first, to extract concepts, which can then be converted into questions, and statistically evaluated (Shields and Twycross 2003). The following characteristics distinguish qualitative research from quantitative research (Khumalo 2018):

- There is an interest in analysing and interpreting study findings.

- Contextualism is emphasised, with a detailed description and analysis of the research subjects' surroundings or social context. It is process-oriented, examining inter-connected nature of events along a developmental continuum.
- Research is less dependent on theory and is more open, and disorganised.

Due to greater inferences needed, the study further adopted qualitative methods along with the quantitative (mixed-methods).

Such mixed-methods research employs pragmatic knowledge claims, where strategies for sequential, concurrent, and transformational inquiry are employed. Data may be captured concurrently, or sequentially. Either data type can be given priority, or both can be treated equally; enabling knowledge transfer from one technique to another, and to converge on, or confirm findings. It draws on the breadth of generalisation provided by quantitative research, and the depth of precise comprehension provided by qualitative research. A theoretical perspective may underpin the design (Terrell 2012). This research employs mixed-methods to obtain greater inferences. The quantitative data was given priority over the qualitative data.

The quantitative data was sourced from DUT's MIS system, and subjected to mathematical probing using Microsoft Excel to arrive at the quantitative results, while focus group interviews were held with certain lecturers of the BET (Mechanical Engineering) modules to source the qualitative data. The qualitative data was subjected to four stages to arrive at the themes to support the quantitative observations. More information is elaborated below.

3.4.2 Data (Population and Sampling)

The 'research population' refers to a group of participants comprising a study, and samples are participants from whom data is gathered (Maladzhi 2020). For the qualitative part of the study, the population comprised DUT academics lecturing the Mechanical Engineering students registered for the BET degree. The sample included 18 DUT academics lecturing the BET Mechanical Engineering students. Focus group sessions were held with the respective lecturers after obtaining ethical clearance from the DUT-Institutional Research Ethics Committee (Refer to Appendix B: Ethical clearance and Consent form).

Convenience sampling is a non-random sampling technique, where individuals who meet the study's criteria are identified through any means available (Emerson 2015). Convenience sampling was used in this study. The primary benefits of convenience sampling include its cost-effectiveness, simplicity, and quick execution. However, a significant drawback is that the sample may not be representative enough for broad generalization (Jager, Putnick and Bornstein 2017).

3.4.3 Data Analysis

Due to multiple sub-studies being performed, comprehensive methodologies for each sub-study are provided to outline how the data was obtained, organised, analysed and interpreted.

3.4.3.1 Success Rate Analysis

For this study, success rates were used as opposed to pass rates. Success rates are the total number of students who passed the module, divided by the number of students registered for the module; whereas pass rates refer to the number of students who passed the module, divided by the number of students who participated in the examinations. Pass rates factor out those students who did not receive a sufficient course mark to be eligible to partake in the examinations.

This sub-study sought to determine the success rates of all BET Mechanical Engineering modules. Starting in the first semester of 2018, and concluding in the second semester of 2021, this investigation spanned an eight-semester period (four years). The raw data was retrieved via DUT's MIS system. Students who dropped out were not included in this study. Class lists for certain Year One and Year Two modules were used to retrieve the student success rates for more accurate results. These modules are demarcated with an asterisk in Tables 4-1 to 4-2.

The retrieved student success rates were split into separate years, specifically 'Year One', 'Year Two', and 'Year Three'. Years One and Two contained all the modules offered in those years, the average success rates for the 2018, 2019, 2020, and 2021 cohorts, and the average of the cohorts. Year Three contained all the modules offered in the third year and the average success rate for the 2020 and 2021 cohorts, including the average for the cohorts. With this information, it is possible to evaluate the modules' respective success rates for each of the years offered. Modules with poor student success rates can be identified, and interventions recommended.

Concerning Strengths I and Mechanics I, for 2020 and 2021, when the modules were offered for both semesters, the weighted average for the two semesters for each module were calculated. The data was weighted as the number of students enrolled in the first semesters was significantly lower than in the second semesters. As such, a weighted average calculation was utilised. A weighted average utilises weights to estimate the relative relevance of each data element. The most common use of a weighted average is to equalise the frequency of values in a data collection set. The calculation was done as per Equation (1) below:

$$\left(\frac{P_1 \, x \, N_1}{(N_1 + N_2)}\right) + \left(\frac{P_2 \, x \, N_2}{(N_1 + N_2)}\right) \; (Equation\ 1)$$

Where, P_1 = Percentage passed in the first semester

P_2 = Percentage passed in the second semester

N_1 = Intake for the first semester

N_2 = Intake for the second semester

The arithmetic average would have resulted in the data being skewed, as the number of students registered for the 'back-to-back' modules in the first semester are significantly lower than those registered for the second semester.

Whilst analysing and interpreting the data, there were some concerns on the student success rates of certain modules that quantitative data could not answer in isolation. The modules were:

- **Year 1:** Computing and IT (CMIT101), Design I (DESG101), Electrical Principles I (ELEP101), Mechanics of Machines I (MCHM102), Thermofluids I (THFL101), and Strength of Materials I (SMTL101).
- **Year 2:** Computer Aided Draughting (CADR101), Analogue Electronics 1A (ANLE101), Strength of Materials II (SMTL201) and Design II (DESG201)
- **Year 3:** Design III (DESG301) and Strength of Materials III (SMTL301)

These modules were selected due to their student success rates, indicating a significant increase or decrease from one year to another when analysed over the four-year period: 2018 to 2021. Focus group sessions were held with the lecturers of the above-mentioned modules in the BET Mechanical Engineering programme. The responses were recorded. The questions can be perused in Appendix C (Focus group session questions).

The qualitative data analysis followed the four stages reported by Ravindran (2019) as recommended by Mayan (2016) and Polit and Beck (2020): (1) Data preparation, (2) Reading and reflecting, (3) Coding, categorizing and memoing and (4) Developing themes/conceptual models or theory. Each of the four steps have successively refined the data, enabling greater insights into the quantitative data obtained from the study. Each step is further explained below.

Step 1: Data Preparation (Compiling of Participant Responses)

After obtaining the necessary ethical clearance to obtain the qualitative data from the three sub-studies, the identified participants were invited to the respective focus group session. After the discussions were held and the responses were recorded, the responses for each question were collated in Microsoft Word format, and the text was clarified.

Step 2: Reading and Reflecting

The clarified responses were read to obtain a preliminary understanding of the trends, themes and patterns manifesting from the questionnaires. Reflections were made based on these understandings.

Step 3: Coding, Categorizing and Memoing

a) Coding

Step 3 encompassed sorting and categorizing the questionnaire data to systematically understand the phenomena relating to the participants' perspectives in each of the sub-studies (Ravindran 2019). In this step, the 'obvious' (manifest) and latent content were analysed (Mayan 2016) to derive the themes. The responses were searched for specific words and phrases used by the participants, each of which was allocated a certain code (Ravindran 2019). According to Mayan (2016), coding is the preliminary step in sorting and organizing data. Codes are labels allocated to statements, behaviours and reactions found in the participants' responses (Morse and Richards 2002).

b) Categorizing

Categorizing entailed grouping similar codes to formulate an understandable set of related data (Ravindran 2019). A category is a "group of content that shares commonality" (Morse 2008). By developing categories, conceptual coding structures were formulated, which were used to sort data as outlined by Ravindran (2019).

c) Memos/Reflections

According to Strauss and Corbin (1998), "memoing" refers to "the researcher's record of analysis, thoughts, interpretations, questions and directions for further data collection." A memo is a record of reflections prompted by the data as the analysis is in progress (Ravindran 2019). Memo-writing prompts theorizing for idea generation (Glaser 1978) to help the researcher understand what is occurring through the imposed intervention. Additionally, memos aid in analysing the data from different vantage points (Charmaz 2006).

The Gibbs reflective cycle was used for structured data reflections (Gibbs (1988). According to Jasper and Rosser (2013), reflection enables learning from experiences, to incorporate the new knowledge to inform future practice (Husebø, O'Regan and Nestel 2015). The Gibbs reflective cycle is comprised of key questions, which must be answered to yield knowledge from previous experiences by invoking feelings, thoughts, and future recommendations (Husebø, O'Regan and Nestel 2015). The Gibbs cycle is comprised of six steps: (1) Description, (2) Feelings, (3) Evaluation, (4) Analysis, (5) Conclusion, and (6) Action plan (Gibbs 1988) (Figure 3-1-1).

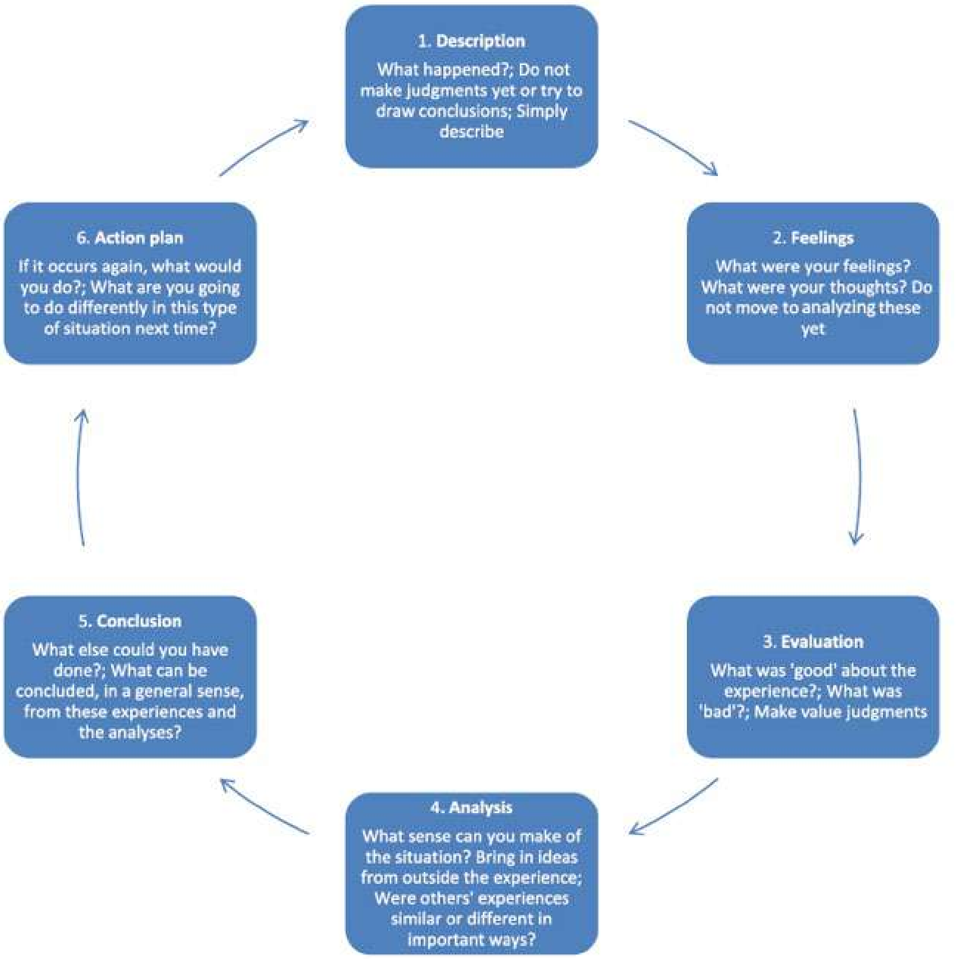

Figure 3-1-1 Gibbs reflective cycle

Step 4: Developing Themes/Conceptual Models or Theory

Theming involves combining the categories and clarifying the correlation within them (Mayan 2016). During theming, the researcher connects the deconstructed parts of the qualitative data by recognizing the inherent meaning that connects the behaviour, actions and reactions related to the observed phenomena (Ravindran 2019). Generally, the researcher will formulate one to three themes (Mayan 2016), as too many themes could indicate a premature analysis, implying the need for further interpretation and conceptualization.

The qualitative data helped determine the reasons for the fluctuation in student success rates by gaining insights into the internal factors (within and beyond the lecturers' control) and external factors (relating to student protests [local-external] and the Covid-19 pandemic lockdown [global-external]) that may have caused variations in the student success rates of the module from one year to another. The questions follow a logical progression from factors in which the lecturer has the most control to factors in which the lecturer has the least control.

3.4.3.2 Relationship between NSC Results and Success in Mechanical Engineering

Students' NSC results are compared to their first-year module results to understand the correlation between NSC Maths, NSC Physics, and NSC English in the relevant first-year modules. Thereafter, it is possible to compare the student success rates of the modules to ascertain if the entrance requirements are adequate.

To determine whether higher NSC marks correlate with success rates in first-year engineering modules, the relationship between NSC results and first-year engineering results were examined. For example, if students who achieved 70% in NSC Physics achieved a greater success rate for Mechanics I in first year than students who achieved 50% in NSC Physics, a greater NSC Physics score may correlate with a greater Mechanics I score. Based on this, it can be determined whether the entrance requirements are adequate to ensure the students' success.

Similar to the investigation performed by Maurice (2015), as outlined in Chapter 2, Pearson's correlation coefficient (PCC) was considered. PCC, providing a measure of the strength and linear association between two random variables, was used for several statistical indices, including data analysis, classification, grouping, and decision-making (Zhou et al. 2016). The strength and direction of the linear correlations between two variables are evaluated using correlation coefficients. PCC is relevant in this study, where both variables are normally distributed (Mukaka 2012).

Table 3-1 Guidelines for the Pearson's coefficient correlation interpretation (Zhou et al. 2016)

Coefficient, r		
Strength of Association	**Positive**	**Negative**
Small	0.1 to 0.3	-0.1 to -0.3
Medium	0.3 to 0.5	-0.3 to -0.5
Large	0.5 to 1.0	-0.5 to 1.0

Table 3-1 shows the guidelines for the Pearsons coefficient correlation containing the strengths of association.

The 2018 NSC results of Physics, Maths, a combination of Physics and Maths, English Home Language (HL) or First Additional Language (FAL), were considered. This data was obtained via the DUT MIS system.

The first-year engineering modules Mechanics I, Strengths I, Maths 1A, Maths 1B, and Thermofluids I were considered. The information was also obtained by retrieving the student success rates from the relevant class lists. For this investigation to be more accurate, only the second semester student success rates for Mechanics I and Strengths I were used and not their student success rate for the first semester offering. This is due to most students being enrolled for the second semester offering.

The data was arranged for the first-year modules (2018-2021) and their NSC marks. The data was then placed into Python 3 software. Python allows the analysis and modification of complex data sets by creating and managing data structures. Python also offers libraries and tools for effective data processing. Python is an excellent choice for data analysis because of all of these characteristics (Navlani, Fandango and Idris 2021) .

The Shapiro-Wilk and Kolmogorov Smirnov tests are prominently used to test for a normal distribution (Hanusz and Tarasińska 2015) . The two tests indicated that the data was not normally distributed. This finding motivated the author to undertake the Spearman rank-order correlation coefficient (Spearman’s correlation) approach as opposed to PCC. Spearman's correlation is a nonparametric measure of the strength and direction of relationship between two variables assessed on a scale of at least one ordinal. The test is used for ordinal variables or continuous data that failed the assumptions required for the PCC. Spearman's correlation is based on three assumptions:

- The two variables should be measured on a scale that is ordinal, interval, or ratio.
- The two variables represent paired observations.
- The two variables have a monotonic relationship. This is not a requirement. (Statistics 2018).

Considering the data works on a ranking system, where a higher mark implies a greater value, the data can be assumed ordinal. Considering it is the same students whose NSC results and first year engineering modules results are being analysed, the data can be assumed to represent paired observations. Concerning the assumed monotonic relationship, scatter plots were produced, and the relationship discussed in Chapter 4.3.

The interpretation is similar to PCC, in the sense that the closer the r value is to +1, the greater the monotonic relationship. Due to correlation being an effect size, it makes it possible to vocally characterise its strength using the following approach for the absolute value of r.

Table 3-2 Guidelines for Spearman's correlation

Coefficient, r	
Strength of Association	**Positive**
Very Weak	0.00-0.19
Weak	0.20-0.39
Moderate	0.40-0.59
Strong	0.60-0.79
Very Strong	0.80-1.00

Table 3-2 shows the guidelines for Spearman's correlation containing the strength of association.

Once there was a considerable correlation, Tables were created to determine the effect of Maths NSC results and Physics NSC results on success in first-year modules. The Tables include ranges for the NSC percentages received with their corresponding first-year modules marks. A benchmark was used to ascertain which groups achieve a student success rate (and how many) of greater than 50% for the first-year modules.

Table 4-10 was created to determine the effect of the combined Maths and Physics NSC results on success in first-year modules. This was done as one of the acceptance requirements into the BET programme is to have a combined Maths and Physics score of 120. This investigation was done to ascertain whether the requirements proved appropriate. The ranges for combined Maths and Physics results were <110, 110-119, 120-129, 130-139, 140-149, 150-159, and 160-200. Table 4-10 shows the percentage of cohorts that fall into these ranges, alongside their success rates.

The above process was repeated for the 2019, 2020, and 2021 first-time entering cohorts (as mentioned above). To enter the Engineering programme, learners are required to have a combined Maths and Physics score of 120 or greater. The benchmark to assess how many student success rates were over 50% for the various groups was also added.

Table 4-10 was compared to a similar one formulated by (Graham 2015) and (Walker and Graham 2013), where the authors compared the combined NSC Maths and NSC Physics scores with ND first year modules. From their work, the 120 combined score entrance requirement was introduced. Both Tables were compared to determine whether the 120 combined entrance requirement are suitable for the BET.

Notably, four students had a score of less than 120. This is most likely because learners attended a Technical and Vocational Education and Training college (TVET college) after school to allow them entrance into university. The only way the students enrolled into the Programme (with the combined Physics and Maths NSC results below 120) was by upgrading their results at the TVETs. Even though the students' marks are upgraded, the MIS only captures their NSC and not their upgraded marks, which, consequentially, shows their results to be lower than 120. These four students are statistically insignificant and, as such, were excluded from the study.

3.4.3.3 Graduate Attributes and their Effect

As seen in Table 3-3 below, these are the GAs used by the Department. Focus is placed on the assessed attributes only (indicated as "A").

Table 3-3 Graduate attributes per department (Department of Mechanical Engineering 2020)

Module Code	**Module Name**	**Graduate Attributes**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
SMTL301	Strength of Materials III	A									
MCHM301	Mechanics of Machines III		A								
THRM302	Thermodynamics III				A						
FLDM301	Fluid Mechanics III									A	
PMNT101	Principles of Management										A
EVLE101	Environmental Engineering							A			
CDSP101	Capstone Design Project			A		A	A		A		

Student results (assessment marks, full marks, and final marks) are captured in the University's MIS system. Additionally, students' GA marks are captured in a separate column and represented by a '0' or a '1' (0 indicating a failure and 1 indicating a pass of the GA). If the GA is failed, the student cannot qualify for the exam/ pass the module, even if all other assessments are passed. Considering that the BET was implemented in 2018, students who started in 2019 could only be in their third year in 2020 and 2021. The 2018 and 2019 cohorts were used for this investigation only for modules where GAs were assessed, as shown in Table 3-3. For each assessed module of the two cohorts, data was organised and tabulated (with the two years being separated). This data showed the student number, assessments and marks, GA status, and the full and final mark, with the final result. The full mark was the duly performed (DP) mark and was required to be or exceed 50 % to enable the student to write the final examination. The final mark incorporated the DP and the examination marks. Using this information, a result table for each of the assessed modules was produced, stating the number (and percentage) of students enrolled for the module, failed the module, failed the GA, and lastly, failed the module primarily due to failing the GA. Failures were investigated to ascertain the cause. If the student failed due to not achieving the required DP %, it can be concluded that the student failed, regardless of the GA. If the student failed but had a DP above 50 %, this would indicate on the GA that the student had failed ('0'). In certain modules, namely the Capstone Design Project (2020) and Strengths of Materials III (2020 and 2021), 'N/A' is listed under the GA result column instead of a '0' or a '1'. This is because a GA assessment was not conducted in the module for that year. The possible reasons for not conducting a GA assessment include these assessments being recently introduced to DUT, indicating that lecturers may have been confused as to how to offer a GA and/or how to record its success/failure.

3.4.3.4 'Back-to-back' Modules

This sub-study investigates the effect of the 'back-to-back' modules (Strengths I and Mechanics I) on student success rates in the DUT Mechanical Engineering department and is important in determining whether the intervention should be retained. The cohorts of 2018-2021 were used for this investigation.

Data showing the number of students registered, deregistered, their marks, and their outcome (pass or fail) was obtained via the DUT's MIS system. The number of passes was tallied, and the success rate calculated. Additionally, the number of students repeating Strengths I and Mechanics I was determined, to understand which semester and year they first attempted the 'back-to-back' modules, and which attempt they are currently undertaking the module.

For 2019, all student numbers from 2018 were placed in the same spreadsheet as the student numbers from 2019. If duplicate student numbers were found, this would indicate that the student is repeating the module. This enabled determining the number of times a student failed the module, and the year from which they are repeating it. For semester 1 of 2020, all student numbers from 2018 and 2019 were placed in the same spreadsheet as those from semester 1 of 2020. Duplicate student numbers were found, and the number of times a student failed the module and from which year they were repeating the module were respectively identified. For semester 2 of 2020, all student numbers from semester 1 of 2018, 2019 and 2020 were placed in the same spreadsheet as the student numbers from semester 2 of 2020.

With this information, the author could determine the number of students repeating the 'back-to-back' modules (and how many times these modules were repeated), and determine their success. Tables 4-13 and 4-14 were formulated for Mechanics I and or Strengths I (respectively) which indicated the number of students registered for the module, for all the semesters and their success rate. The tables also included the number of repeat students and stipulated their success rate.

During the data analysis, there were concerns on data retrieved for Mechanics I and Strengths I, that quantitative data could not answer in isolation. The purpose of this focus group study was to understand the impacts of the 'back-to-back' module intervention with respect to student success rates, student engagement, and perceived advantages and disadvantages, to determine whether an automatic re-registration system might benefit students who fail these modules and gain insights into how the 'back-to-back' intervention aids the overall throughput rate of BET Mechanical Engineering students (from first-year to graduation).

Focus group sessions were held with the lecturers for Strengths I and Mechanics I in the Mechanical Engineering BET programme. Discussions were held, questions were asked, and the responses were recorded. The questions can be seen in Appendix C (Focus group session questions).

3.4.3.5 National Diploma vs. BET 'Similar Modules'

The BET degree contains modules similar in content to those offered in the ND. The student success rate of BET modules deemed similar to modules taught in the ND programme were compared to determine if the BET is producing greater student success rates than the ND. In consultation with the staff from the Department of Mechanical Engineering at DUT, the 'similar modules' were identified. The respective study guides and module descriptors were consulted to identify overlaps in indicative content. Where there was significant overlap, the modules were deemed similar (Table 3-4).

Table 3-4 Similar modules between the BET and ND programmes

BET	Year module was offered	ND	Semester module was offered
Physics 1A	1st	Mechanics of Machines I	S1
Physics 1B	1st	Mechanics of Machines I	S1
Engineering Maths 1A	1st	Maths I	S1
Strengths of Materials I	1st	Strengths of Materials II	S2
Thermofluids I	1st	Fluid Mechanics II	S2
Thermofluids I	1st	Thermodynamics II	S2
Mechanics of Machines I	1st	Mechanics of Machines II	S2
Engineering Maths 1B	1st	Maths II	S2
Strengths of Materials II	2nd	Strengths of Materials III	S3
Fluid Mechanics II	2nd	Fluid Mechanics III	S3
Mechanics of Machines II	2nd	Mechanic of Machines III	S3
Thermodynamics II	2nd	Thermodynamics III	S3
Strengths of Materials III	3rd	Applied Strengths of Materials III	S4
Mechanics of Machines III	3rd	Theory of Machines III	S4
Thermodynamics III	3rd	Steam Plant III	S4
Fluid Mechanics III	3rd	Hydraulic Machines III	S4
Engineering Maths 2A	2nd	Maths III	S4

Table 3-4 shows the modules that are deemed similar between the BET and programmes. The success rates for S1, S2, S3 and S4 similar modules were retrieved from a previous study (Graham 2015), which analysed ND success rates. The success rates for both semesters for 2007, 2008, 2009 and 2010 were obtained from that study, as well as the arithmetic average for each module for these years.

Considering that DUT introduced the BET in 2018, first year module success rates were recorded from 2018 to 2021, second year module success rates from 2019 to 2021, and the third year module success rates from 2020 to 2021. All success rates and arithmetic averages for the BET modules were calculated. For Physics 1A, 1B and Engineering Mathematics 2A, faculty success rates were used as it was the only information obtainable. Due to Strengths I and Mechanics I being 'back-to-back' modules offered in 2020 and 2021, the weighted average of the two semesters for the two years were used.

The student success rates for the various years for the BET and ND were tabulated, and the average for each was calculated and compared.

As these modules are deemed similar, their success rates are assumed to be similar. This would be the case except for the first-year modules since the entrance requirements have increased and the student success rates for the first-year BET modules are assumed to have also increased. However, this was not the case. Consequently, qualitative data was needed to explain this deviation. Focus group sessions included lecturers teaching similar deemed modules in which a > 20 percentage points (pp) difference in the average student success rate was observed (Between the similar deemed ND and BET module) for the modules in the BET Mechanical Engineering programme.

The aim of this sub-study was also to gain qualitative insights from the lecturers concerned regarding the impact of the increased BET entrance requirements on the student success rates of similar modules. If there was a significant increase in the first-year modules, it was performed to understand if this increase was purely due to the increased entrance requirements or other factors. Other than the increased entrance requirements for the BET program, there are several potential factors that may influence the success rates in the similar modules: teaching quality and student support services, variations in class size, class composition, students' time management and workload, differences in teaching technologies and resources, and students' socio-economic circumstances. Each of these potential impacting factors on the modules' success rates were integrated into the discussions and questions to prompt the lecturer to provide insights incorporating these factors (Appendix C: Focus group session questions).

3.5 Limitations

The reported research was conducted at DUT, which geographically restricted its scope. Additionally, the research was limited to the cohorts from 2018, 2019, 2020, and 2021. Including additional cohorts could have yielded more information. The nature of data collection made the study particularly suitable for most quantitative research methods. However, more extensive qualitative research could have been conducted to draw deeper insights from the quantitative data. For sub-study 1, the qualitative study was only performed for 12 modules. The corresponding qualitative study was also only conducted with the lecturers concerned. A more thorough analysis could have been performed if the students were also interviewed. For sub-study 4, the focus group only consisted of the lecturers of the 'back-to-back' modules. Including the students in the qualitative study would have yielded greater insights. The same scenario exists for sub-study 5. Focus group sessions were only held with the lecturers teaching similar deemed modules in which a > 20 pp difference in the average student success rate was observed (between the similar deemed ND and BET modules). The focus group sessions could have included all the lecturers of the similar deemed modules to generate greater inferences from the data.

3.6 Ethical Considerations

Ethical clearance was obtained the Faculty of Engineering and the Built Environment's Institutional Research Ethics Committee (IREC) at DUT before commencing the qualitative data collection. By following the four ethical principles of autonomy, beneficence, non-maleficence, and justice in all interactions with the participants (lecturers) during the qualitative studies, the participants were not harmed or disadvantaged in any way, as outlined below:

- Autonomy was enforced by obtaining informed consent from the participants before data collection to ensure that they willingly participated and were aware of their rights and the procedures involved. The purpose of the study, potential risks and benefits, confidentiality measures, and voluntary participation were communicated to the participants (Varkey 2021). Specifically, through the informed consent form, the participants were made aware of their rights, which included: (1) that their participation was entirely voluntary, and their responses could be rescinded at any time without consequences, (2) the time and date of the focus group sessions; thus allowing them to budget the time to participate and (3) that the participants can request the final study documents (the final dissertation and publications emanating from the study).
- The principle of beneficence emphasizes the researcher's obligation to prioritize the participants' best interests (Varkey 2021). Beneficence involves actions taken to minimize harm to the participants. Measures were implemented throughout the data collection process to maintain confidentiality and anonymity of the participants. The collected data was kept confidential to protect participants' identities. Data was securely stored and accessed only by authorized personnel involved in the research, ensuring the participants' privacy.
- Objective data analysis was conducted, and the findings were reported accurately. Potential conflicts of interest, affiliations, and funding that could influence the research outcomes were acknowledged and disclosed. By adhering to these principles, the data collection process prioritized the participants' well-being and maintained the study's integrity.
- Non-maleficence is the researcher's responsibility to avoid asking unfair or harmful questions during focus group sessions (Varkey 2021). This ethical principle encompasses moral guidelines, including the prohibition against causing harm, offense, or deprivation of benefits to others. To implement non-maleficence, the researcher assessed each interview question, considered its advantages and disadvantages, and selected the most appropriate approach for the participants (Varkey 2021). Adhering to the principle of non-maleficence, the research entailed ethical data handling and protection guidelines. Similarly,

the study ensured the participants' well-being and ethical treatment throughout the data collection process.

- The justice principle emphasizes ensuring fairness and equality among all participants. In line with this principle, participants were given an equal opportunity to schedule their focus group sessions based on their schedules. Furthermore, upon request, participants will be provided with the study's findings. To uphold ethical standards, all written responses were securely stored once the research was concluded. To conduct the research ethically, justice was addressed by seeking ethical clearance approval from IREC. The approval confirmed that the study conformed to the ethical standards and established guidelines for research.

Through these measures, the risk to the participants was minimized.

3.7 Conclusion

This Chapter detailed the methodology utilized for this research, such that effective replication of the study can be performed. Specifically, the quantitative and qualitative (mixed- method) methodology was outlined. Quantitative data was gathered through the MIS and class lists. For the qualitative data, focus group sessions were formed and held with certain lecturers who had taught the relevant modules in the BET Mechanical Engineering programme. Ethical considerations were observed to ensure the research adhered to accepted ethical standards.

Chapter 4 - Results and Data Analysis

4.1 Introduction

Chapter 4 showcases the results obtained through the methodology explained in Chapter 3. These results of all five sub-studies are analysed and discussed in relation to the literature review (Chapter 2) for a greater analysis in this Chapter.

The term percentage point (pp) increase is used in this Chapter to refer to the arithmetic difference between two percentages, and not their ratio. For example, if the success rate were to increase from 40% to 55% the percentage point increase would be 15%, while the percentage increase would be 37.5%.

4.2 Success Rate Analysis

The student success rates that were retrieved were split into separate years, ‘Year One’, ‘Year Two’, and ‘Year Three’. This section analyses and discusses the student success rates for 2018, 2019, 2020 and 2021. It is noted from the qualitative study performed that all modules taught in 2020 and 2021 were taught online due to the COVID-19 pandemic.

Table 4-1 Success rates for Year One

Year One	2018		2019		2020		2021		Average
	No. enrolled	**Success rate**	**No. enrolled**	**Success rate**	**No. enrolled**	**Success rate**	**No. enrolled**	**Success rate**	
Engineering Maths 1A*	112	**86%**	130	**88%**	131	**89%**	104	**94%**	**89%**
Engineering Physics 1A	112	**87%**	129	**92%**	123	**89%**	103	**88%**	**89%**
Technical Literacy*	111	**79%**	139	**92%**	124	**92%**	101	**90%**	**88%**
Computing and IT*	112	**89%**	128	**80%**	132	**77%**	116	**53%**	**75%**
Cornerstone 101	110	**95%**	124	**90%**	127	**85%**	100	**91%**	**90%**
Design 1*	112	**74%**	137	**52%**	158	**82%**	118	**86%**	**74%**
Electrical Principles 1	103	**55%**	138	**59%**	168	**80%**	126	**87%**	**70%**
Mechanics of Machines 1*	98	**26%**	159	**69%**	152	**62%**	149	**68%**	**56%**
Engineering Mathematics 1B*	102	**76%**	128	**77%**	146	**90%**	105	**79%**	**81%**
Thermofluids 1*	99	**32%**	168	**42%**	184	**93%**	104	**89%**	**64%**
Strengths of Materials 1*	99	**54%**	134	**22%**	210	**67%**	152	**48%**	**48%**
Engineering Physics 1B	103	**77%**	125	**93%**	132	**89%**	103	**85%**	**86%**

Modules with an asterisk (*) are student success rates retrieved via class lists and not the MIS (for greater accuracy)

Values in red indicate the weighted average

Table 4-1 above shows the student success rates and the number of enrolled students for the first-year modules between 2018 and 2021. The average number of students enrolled for a first-year module between these years is 127 students. Based on the literature, it was assumed that if a class size is smaller (less than 127 in this case) it would positively impact the student success rate (Bourke 1986; Finn and Achilles 1990; Abizada and Seyidova 2024). Cornerstone 101 has the highest average student success rate of 90%, where the success rate is roughly constant throughout the years. Only in 2020 did Cornerstone 101 have the average number of enrolled students. For the other years, a slightly less than average number of students were enrolled for Cornerstone 101. In the year Cornerstone 101 performed the poorest (85%), it had its highest number of enrolled students (127 students). One of many reasons for the higher student success rate for Cornerstone 101 in the other years could be the smaller class sizes (Bourke 1986; Finn and Achilles 1990; Abizada and Seyidova 2024).

Strengths of Materials I exhibited the lowest average student success rate of 48%. Each year produced a different success rate, with 2019 being the lowest (22%). The class sizes of Strengths I (aside from 2018) were greater than the average class size of the first-year modules. The poor student success rate of Strengths I could not be attributed to larger class sizes because in 2020, the module had a class size of 210 students, corresponding to its greatest student success rate (67%). This may be an instance where there seems to be no discernible correlation between the class size and the student performance (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024). According to the lecturer, there were no curriculum or instructional design changes between 2018 and 2021. There was a strike in 2019 that caused disruptions. To remedy the situation, students were given work to learn independently to make up for the time lost. This accounts for the poorest student success rate for Strengths I in 2019. It is recommended that student support services should be configured appropriately, enabling more tutoring services for students. Additionally, the curriculum should be slightly changed to bridge a possible gap between high school and the first-year university module.

Mechanics of Machines I exhibited an extremely poor student success rate for 2018 (26%) which increased significantly over the following years. However, the module still has a low average student success rate of 56% over the four years. It is clear why Mechanics I and Strengths I are identified as bottleneck modules. According to the lecturer, there were no curriculum changes or changes in the support services and resources between 2018 and 2021. However, the lecturer observed increased and prolonged student protest actions, which could have adversely affected the 2018 student success rate. As with Strengths I, the student support services should be configured appropriately, enabling more tutoring services for students and the curriculum should be modified to bridge a possible gap between high school and the first-year university module.

Computing and IT exhibited good student success rates for 2018, 2019 and 2020 but the student success rate dropped significantly in 2021. The module exhibited its greatest student success rate (89%) when it had a less than average class size (112 students). However, the module also exhibited its worst student success rate (53%) when it had a smaller than average class size (116 students); another indictment of the notion of an unclear correlation between class size and student performance (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024). The lecturer indicated that he conducted the lectures and computing practical work during 2020 and 2021, and indicated significant difficulty in conducting the latter, which may have caused the substantial decrease in student success rate in 2021.

The student success rate of Design I was high for all years except 2019 (52%). According to the lecturer, there were no curriculum or instructional design changes in 2019. During this time, the lecturer indicated that academic support was adequate, the laboratory technicians were available to assist students, and the library staff ensured that students had access to the relevant textbooks. The lecturer also mentioned that the protests had no effect on the module, and after transitioning to online classes in 2020, the student success rate increased significantly. The years 2022 onwards should be investigated to ascertain the effects of resuming contact classes on student success rate.

Electrical Principals 1 showed poor student success rates in 2018 and 2019 and very strong student success rates in 2020 and 2021. The lecturer that taught this module retired from the university and the successor was interviewed to ascertain what may have caused the increased student success rate. According to the lecturer, digital tools including the increased use of Moodle, Microsoft Teams, and YouTube were incorporated into teaching practices. Additionally, simulation tools were used to demonstrate electrical circuit theorems, the tutoring capacity was increased and the technician allocation for practical demonstrations was increased. These combined factors may have led to increased student performance in 2020 and 2021.

Thermofluids I exhibited a poor student success rate in 2018 and 2019. However, the student success rate increased by 51 pp in 2020. In 2021, the student success rate was also very high (89%). These student success rate increases for 2020 and 2021 is many steps forward in achieving the desired student success rate. These significant student success rate increases, makes the author question the poor results in 2018 and 2019. In 2018 and 2019, the class sizes were less than average and greater than average, respectively. A similar situation existed in 2020 and 2021 – in 2020 the class size was greater than average and less than average in 2021 – with strong student success rates in both years. Hence, class size had no impact on the increased student success rates for 2020 and 2021 (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024). According to the lecturer, there were no curriculum and instructional design changes during 2018-2021. The availability of student support services and resources remained constant for this module. However, the lecturer indicated that protest action affected the module in 2018 and 2019, which could have affected the student success rate. When the module was taught online in 2020 and 2021, it was received well. This explains the increase in student success rate for those years.

With the first-year modules there appears to be no significant relationship between student success rate and the class size (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024).

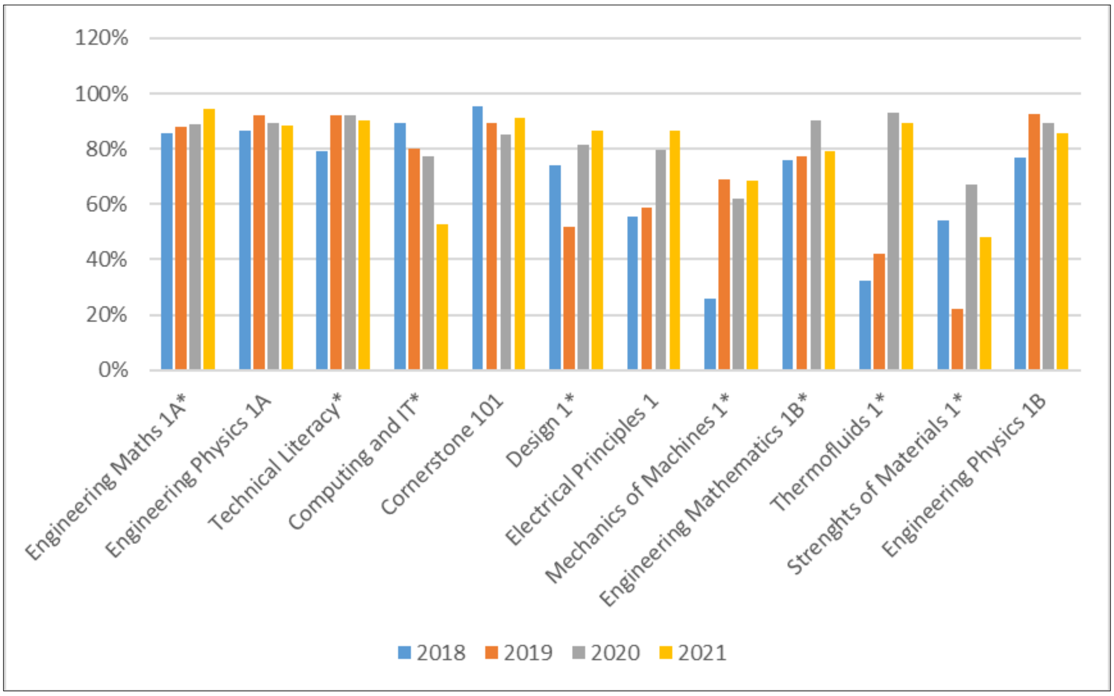

Figure 4-1 Year One Module success rates

Figure 4-1 above provides the average student success rates for first-year modules for between 2018 and 2021. The DHET success rate norm is 80%. However, a review of available literature shows that conventional engineering programmes have lower success rates, where a 70% benchmark was more appropriate (Pocock 2012). Nine out of 12 modules yielded average student success rate of 70% or higher, which is a positive indication. However, the three modules that achieved lower than 70% require critical attention. Modules yielding student success rates between 70% and 80% should be closely monitored to prevent further decreases in future cohorts. The Strengths I student success rate falls substantially below the benchmark of 70%, indicating that serious and immediate interventions need to be implemented.

Table 4-2 Success rates for Year Two

Year Two	**2019**		**2020**		**2021**		**Average**
	No. enrolled	**Success rate**	**No. enrolled**	**Success rate**	**No. enrolled**	**Success rate**	
Computer Aided Draughting*	83	**86%**	113	**71%**	128	**23%**	**60%**
Analogue Electronics 1A	82	**68%**	119	**49%**	170	**68%**	**62%**
Fluid Mechanics 2*	29	**83%**	93	**85%**	164	**97%**	**88%**
Engineering Mathematics 2A	64	**75%**	101	**77%**	146	**74%**	**75%**
Materials Science*	82	**66%**	115	**73%**	141	**89%**	**76%**
Mechanics of Machines 2*	41	**61%**	127	**88%**	103	**68%**	**72%**
Strengths of Materials 2*	58	**69%**	94	**61%**	146	**49%**	**59%**
Design 2*	69	**80%**	109	**83%**	131	**34%**	**66%**
Thermodynamics 2*	28	**82%**	94	**84%**	176	**72%**	**79%**
Digital Electronics 1A	67	**82%**	117	**85%**	129	**84%**	**83%**
Project Management*	59	**85%**	118	**93%**	129	**75%**	**84%**
Electrical Principles 2	56	**71%**	90	**88%**	140	**78%**	**79%**

Modules with an asterisk (*) are student success rates retrieved via class lists and not MIS (for greater accuracy)

Table 4-2 above shows the student success rates for the second-year modules between 2019 and 2021. The average number of students enrolled for second-year modules between 2019 and 2021 is 103. Again, aligning with literature findings, it was assumed that smaller class sizes would have a positive effect the student success rate (Bourke 1986; Finn and Achilles 1990; Abizada and Seyidova 2024).

Fluid Mechanics II (Fluids II) yielded the highest average student success rate of 88%, with each year yielding a high percentage. 2021 yielded a 97% student success rate, which is a great indictment of the module's performance. The Fluids II class size increased each year, with the greatest student success rate occurring with the largest class size (164 students). Contradicting the assumption made earlier, the increased class size positively affected the Fluids II student success rate, indicating an unclear relationship between the class size and student performance (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024).

Once again, the lowest average student success rate was observed in Strengths, with the Strengths of Materials II student success rate being 59% (an 11 pp increase, versus Strengths I). It is likely that Strengths I did not cover the foundations needed to ensure that most students can achieve strong marks for Strengths II. As the class size increased in Strengths II, the student success rate decreased, aligning with the findings of Kusi and Manful (2019), Taha (2021) and Uhrain (2016). Another explanation could be that the greater administrative load on teachers of large classes leaves them with less time for instruction, thus impeding student performance (Abubakar, Diri and Shuaibu 2023). A smaller Strengths II class size may have created a more conducive learning environment, ensuring a greater student success rate (Blatchford *et al.* 2002; Pedder 2006; Harfitt 2013). According to the lecturer, there were protests during 2019-2021, which may have adversely affected the student success rates. The lecturer also noted that the students did not get support services in 2020 and 2021 during the pandemic lockdown and reported being challenged to adjust to online teaching in 2020 and 2021. These combined factors may have contributed to the module's poor performance. Further investigation ought to be conducted for Strengths II in the following years to ascertain if contact lectures positively impacted the student success rate. Additionally, it is recommended that student support services be re-implemented to aid the students' performance.

The Analogue Electronics IA student success rate experienced a significant drop in 2020. According to the lecturer, student support services such tutoring was negatively impacted during online teaching and learning, which may have affected the student success rate. Additionally, the lecturer indicated that strikes delayed the lesson plans, resulting in students being bombarded with work, leaving them feeling suffocated to the extent that many students complained that they couldn't survive working under the pressure with limited preparation time.

Computer Aided Draughting (CAD) exhibited an average student success rate of 60%, which is a false student success rate representation. In 2019 and 2020, the CAD student success rates were 86% and 71% respectively, while it significantly dropped to 23% in 2021. A part-time lecturer taught the course from 2019 to 2021. According to the part-time lecturer, there were no changes regarding tutoring, academic support and consultations between 2018 and 2021. The accessibility of the student support services remained constant and were up to standard. The part-time lecturer further indicated that the students struggled with the online classes, which may have impacted the 2021 student success rate. In 2022 a full-time lecturer was once again appointed for CAD. Considering interventions were made, thorough observation of the student success rate for 2022 is recommended. Similar to Strengths II, the CAD class size was inversely proportional to its student success rate (Uhrain 2016; Kusi and Manful 2019; Taha 2021). A smaller CAD class size may have created a more conducive learning environment, ensuring a greater student success rate (Pedder 2006).

The average Mechanics II student success rate greatly increased to 72%, despite Mechanics I being a first-year bottleneck module. Similar to Fluids II, the Mechanics II student success rate was greatest when it had the greatest class size (127 students). Apparently, the increased class sizes positively impact certain modules' success rates, while the opposite is observed in other modules, thus supporting the literature notion that the correlation between class size and student performance remains unclear (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024). There are clearly more influencing factors impacting the student success rates than just the class size.

Similar to CAD, Design II attained great student success rates for 2019 and 2020, while it was substantially poor for 2021 (34%). This is concerning and immediate corrective interventions need to be implemented for this module. The student success rate of Design II was the poorest when it had its greatest class size (131 students), aligning with the findings of Kusi and Manful (2019). According to the lecturer, the curriculum was not modified in the years being investigated. However, the project was updated to include more mechanical design, CAD, and final product manufacturing through assistance from the laboratory technicians. Considering that the CAD student success rate was extremely poor in 2021 and due to the increased CAD requirements in Design II, it may have resulted in the significant decrease in the module's student success rate. As with the first-year modules, there appears to be no significant relationship between student success rate and the class size for the second-year modules (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999; Abizada and Seyidova 2024).

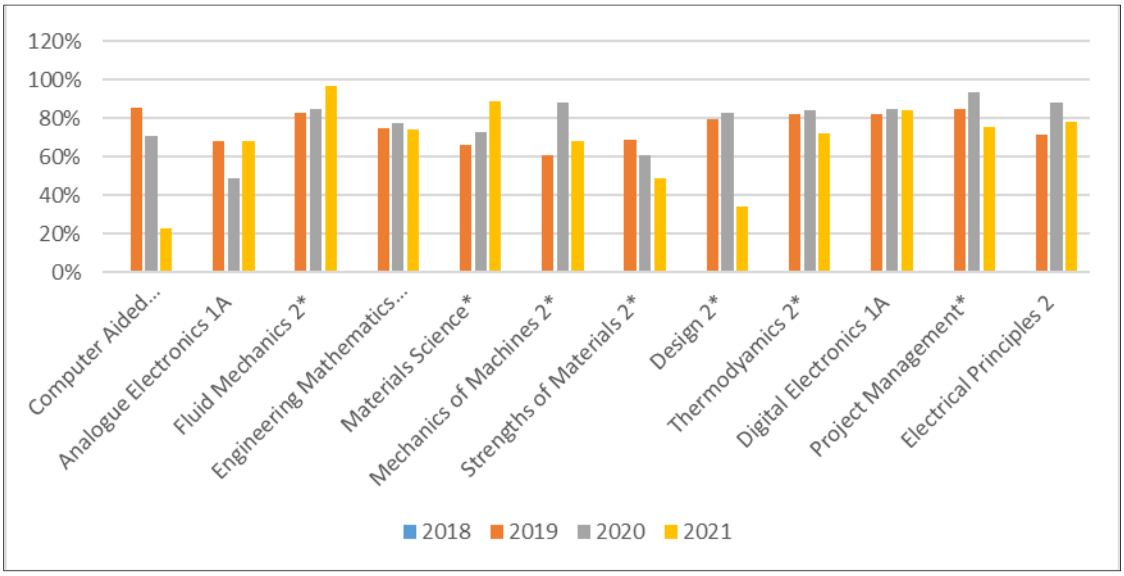

Figure 4-2 Year Two success rate

In Figure 4-2 above, the average student success rates for second-year modules in 2019–2021 are displayed. As with the first year, most of the student success rates exceeded 70% (eight out of 12) which is a positive indication.

Table 4-3 Success rates for Year Three

Year Three	2020		2021		Average
	No. enrolled	**Success rate**	**No. enrolled**	**Success rate**	
Design III	51	**92%**	87	**49%**	**71%**
Strengths of materials III	39	**28%**	81	**73%**	**51%**
Mechanics of Machines III	31	**97%**	105	**75%**	**86%**
Thermodynamics III	23	**87%**	78	**99%**	**93%**
Fluid Mechanics III	24	**92%**	80	**98%**	**95%**
Instrumentation and Control I	49	**98%**	62	**89%**	**93%**
Advanced Mechanical Manufacturing	40	**98%**	105	**92%**	**95%**
Electrical Technology Applications	39	**82%**	97	**66%**	**74%**
Principles of Management	46	**96%**	103	**92%**	**94%**
Environmental Engineering	50	**92%**	96	**98%**	**95%**
Capstone Design Project	37	**84%**	56	**96%**	**90%**
Numerical Methods	46	**98%**	99	**99%**	**98%**

Table 4-3 above shows the student success rates for the third-year modules between 2020 and 2021. The average number of enrolled students for third-year modules from 2020 to 2021 is 64. As with other years, it was assumed that smaller class sizes positively impacted the student success rate, based on the studies of Pedder (2006), Blatchford *et al.* (2002) and Harfitt (2013).

Numerical Methods had the highest student success rate of 98%, with only 1 pp difference between 2020 and 2021. In 2021, the class size was below the average and in 2021 it was greater than average. The class size had no effect on the student success rate of Numerical Methods; aligning with the findings of (Nye, Hedges and Konstantopoulos 1999), Hanushek (1986), Hanushek (1989) and Slavin (1989). The third-year student success rates were greater than those of Year One, and Year Two, with most exceeding 85%. Notably the average third-year class size is significantly smaller than the average first and second-year class sizes (almost half the class size of the average first-year module class size).

Each year, the average Mechanics student success rates increased, indicating that students could better grasp the content over time. Concerning Mechanics III, in 2020 the class size was below the average and the student success rate was 97%. In 2021 the class size was significantly over the average and the student success rate was

75%. The larger class size seemed to negatively impact the student success rate, supporting the findings of Kusi and Manful (2019), Uhrain (2016) and Taha (2021).

Once again, Strengths proved to be the problematic module, with the Strengths III average student success rate being 51%. Strengths II could not be providing the students substantial prerequisite knowledge to Strengths III for them to perform well. There is a substantial difference between 2020 and 2021 for Strengths III, 28% and 73%, respectively, constituting a 45 pp increase. This could be due to students returning to contact lectures, whereas in 2020, they were restricted to online lectures. The class size in 2020 was smaller than in 2021, yet the 2021 student success rate was greater, validated by the literature findings suggesting an unclear correlation between the class size and student performance (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999). Considering that the former lecturer for Strengths resigned from the university, his successor was interviewed to gain insights regarding the student success rate. The lecturer indicated that the protests in 2020 and 2021 in addition to the lack of student support services (during the pandemic lockdown) may have adversely impacted the 2020 student success rate. The lecturer also experienced difficulties to adjust to the online classes, which was a challenge shared with other academics globally (Schuck and Lambert 2020; García-Alberti *et al.* 2021; Roopchund 2022). In subsequent years, further research should be done on Strengths III to determine whether returning to contact classes improves student success rates. Furthermore, re-introducing student support programmes is necessary to improve students' performance.

Additionally, another notable pp difference is for Design III, with the 2020 student success rate being 92% and 2021 being 49% (43 pp decrease). The significant increase in class size between the years could have led to the decrease in the student success rate; a notion supported by the study of Abubakar, Diri and Shuaibu (2023). During the focus group study, the module’s lecturer attributed the decreased student success rate to the protest action experienced during that timeframe. The lecturer also indicated that students did not receive support services in 2020 and 2021 due to the pandemic lockdown. Additionally, the lecturer experienced challenges in adjusting to online teaching during 2020 and 2021; validated by the studies of Schuck and Lambert (2020) and Roopchund (2022). Further investigation ought to be conducted for Design

III in the following years to ascertain if contact lectures have a positive impact on student success rate, and student support services should be once again implemented to aid the students' performance.

There was a noticeable pp drop for Electrical Technology Applications from 2020 to 2021 (16 pp). Once again, this could be attributed to the increase in class size.

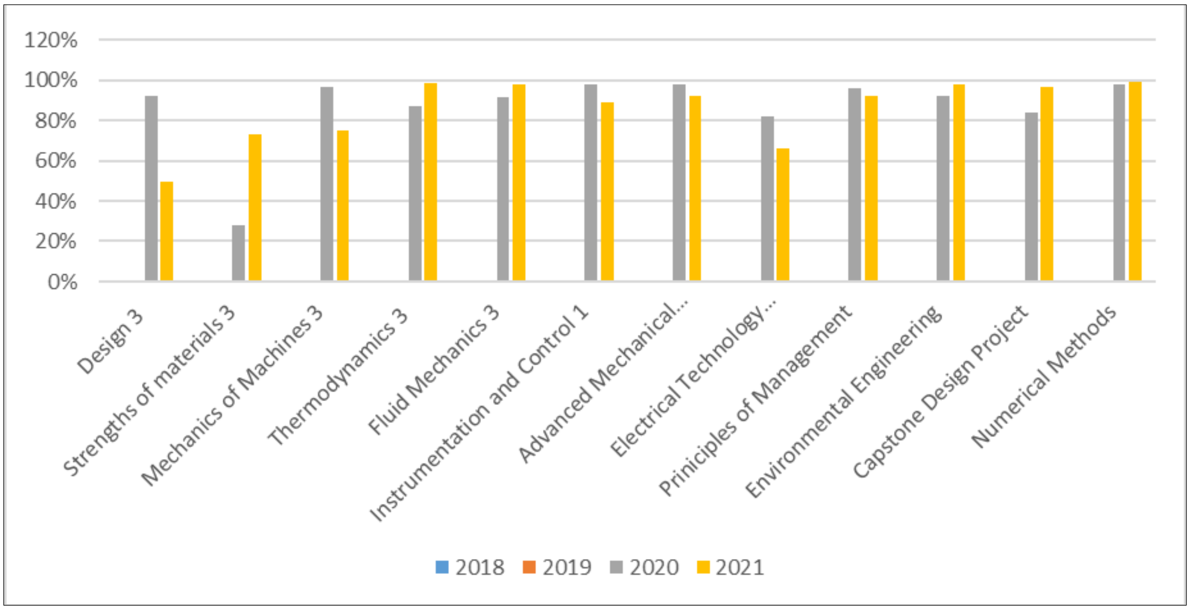

Figure 4-3 Year Three success rates

Figure 4-3 shows the average student success rates for third-year modules between 2020 and 2021.

Table 4-4 Average success rates for academic years

Year	2018	2019	2020	2021	Average
One	69%	71%	83%	80%	**76%**
Two	NA	76%	78%	68%	**74%**
Three	NA	NA	87%	86%	**86%**

Table 4-4 above shows the average BET student success rates for all the academic years. Year One is at 76%, Year Two at 74% and Year Three at 86%. Considering the

DHET norm of 80% being unrealistic, a benchmark of 70% is pragmatic, the average of each is above 74%, which is a positive indictment on the student success rate of cohorts. Year Three proves to be the most successful. This is possibly due to students building solid knowledge foundations, and successfully applying the relevant principles upon reaching third year.

Additionally, the lower-performing students could have failed or dropped out and not have progressed to the third year. As such, the third-year cohorts could be filled with stronger-performing students. 2020 was the first possible year of BET students being in their third year of study, implying their progression to third year without failing any modules. As such, these students are deemed strong-performing. Additionally, the average third-year class size was smaller than in other years, which may have positively impacted the third-year student success rates (Pedder 2006; Harfitt 2013). More data for the following years ought to be gathered to further evaluate the third-year student success rate.

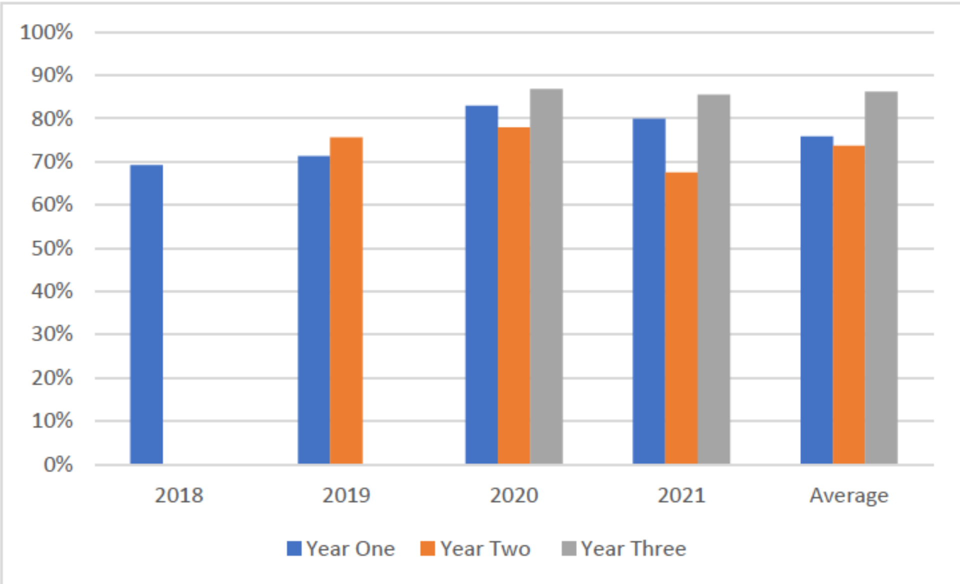

Figure 4-4 Average success rates for all years

Figure 4-4 above visually represents the average success rates for the respective academic years. As per the average column it may be noted that the most successful year was Year Three, followed by Year One, and Year Two.

4.3 Relationship between NSC Results and Success in Mechanical Engineering

This sub-study investigated whether there is a correlation between NSC Maths, NSC Physics, and NSC English Home Language (HL) and NSC English First Additional Language (FAL), and first-year Engineering modules. 91 students were considered for 2018, 98 students for 2019, 139 students for 2020 and 133 students for 2021. A correlation would make it possible to determine acceptable entrance requirements into the BET Mechanical Engineering programme.

The first step before using PCC was to test for a normal distribution. Table 4-5 below showcases the modules' data that was tested for a normal distribution by using the Shapiro-Wilk test and Kolmogorov-Smirnov test. If the p-value for both tests is less than 0.05, the test rejects that the data is a normal distribution. The p-value for all subjects is less than 0.05, implying that the data is not of normal distribution. Logically, this makes sense as the students who got into Mechanical Engineering at university ought to have higher grades. Essentially the data is skewed to the right.

Table 4-5 Normality Test

Subject	Test Performed	Statistic	p-value	Significant
Mechanics I	Shapiro-Wilk	0,9611629	0,00	Yes
Strengths I	Shapiro-Wilk	0,9682755	0,00	Yes
Mathematics 1A	Shapiro-Wilk	0,9387756	0,00	Yes
Mathematics 1B	Shapiro-Wilk	0,9178639	0,00	Yes
Thermofluids 1	Shapiro-Wilk	0,9358106	0,00	Yes
PHYSICAL SCIENCES	Shapiro-Wilk	0,9923321	0,02	Yes
MATHEMATICS	Shapiro-Wilk	0,9829726	0,00	Yes
ENGLISH HOME LANGUAGE	Shapiro-Wilk	0,8708134	0,00	Yes
ENGLISH FIRST ADD LANG	Shapiro-Wilk	0,9226615	0,00	Yes
Mechanics I	Kolmogorov-Smirnov	0,9694836	0,00	Yes
Strengths I	Kolmogorov-Smirnov	0,9575576	0,00	Yes
Mathematics 1A	Kolmogorov-Smirnov	0,9986501	0,00	Yes
Mathematics 1B	Kolmogorov-Smirnov	0,9719785	0,00	Yes
Thermofluids 1	Kolmogorov-Smirnov	0,9662334	0,00	Yes
PHYSICAL SCIENCES	Kolmogorov-Smirnov	1	0,00	Yes
MATHEMATICS	Kolmogorov-Smirnov	1	0,00	Yes
ENGLISH HOME LANGUAGE	Kolmogorov-Smirnov	0,9937888	0,00	Yes
ENGLISH FIRST ADD LANG	Kolmogorov-Smirnov	0,9966997	0,00	Yes

Spearman’s correlation could be used, considering that is not viable to use PCC. The first two assumptions were made and proved in Section 3.4.3.2. The final assumption is that the two variables have a monotonic relationship. As mentioned in Section 3.4.3.2, the two variables are not required to have a monotonic relationship to use Spearman’s correlation. The scatterplots in Figures 4-5 to 4-9 were produced to test for the monotonic relationship between the variables.

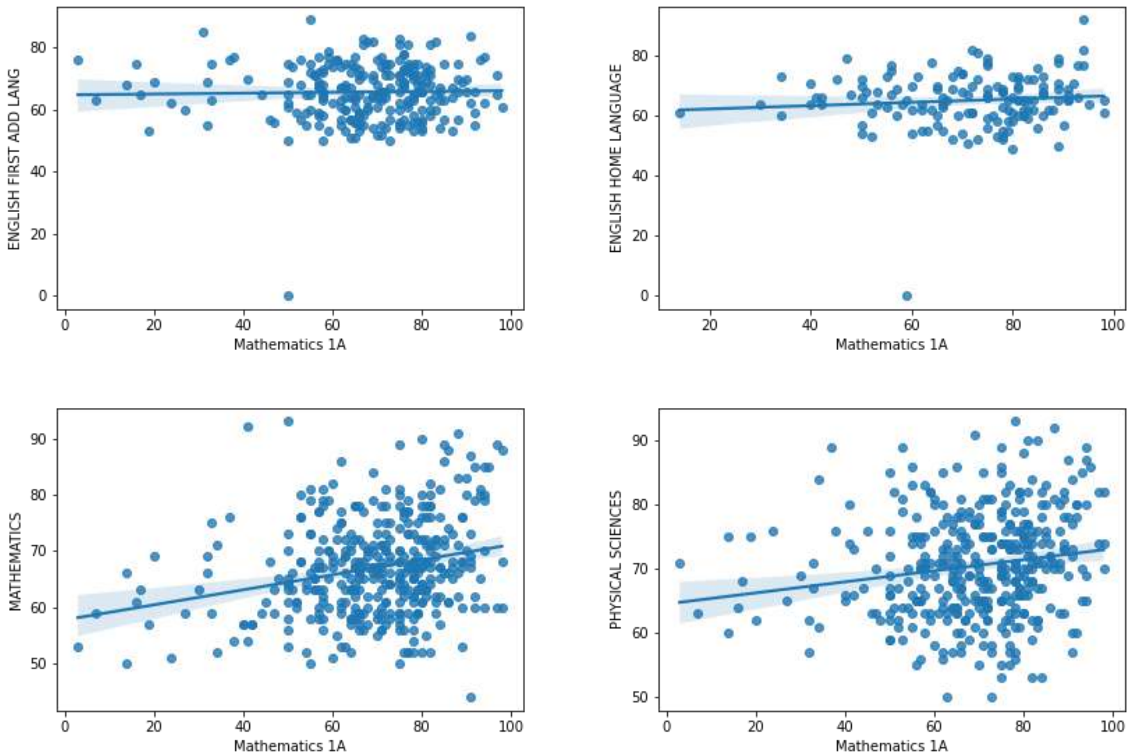

Figure 4-5 Mathematics 1A vs NSC Subjects

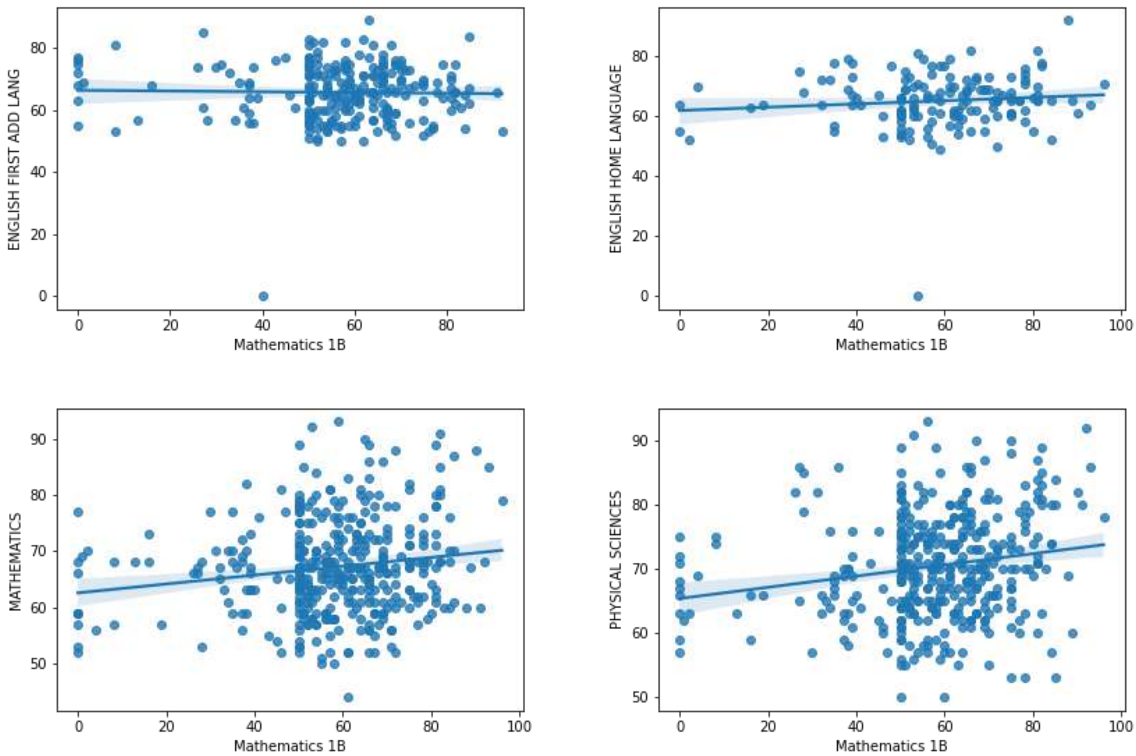

Figure 4-6 Mathematics 1B vs NSC Subjects

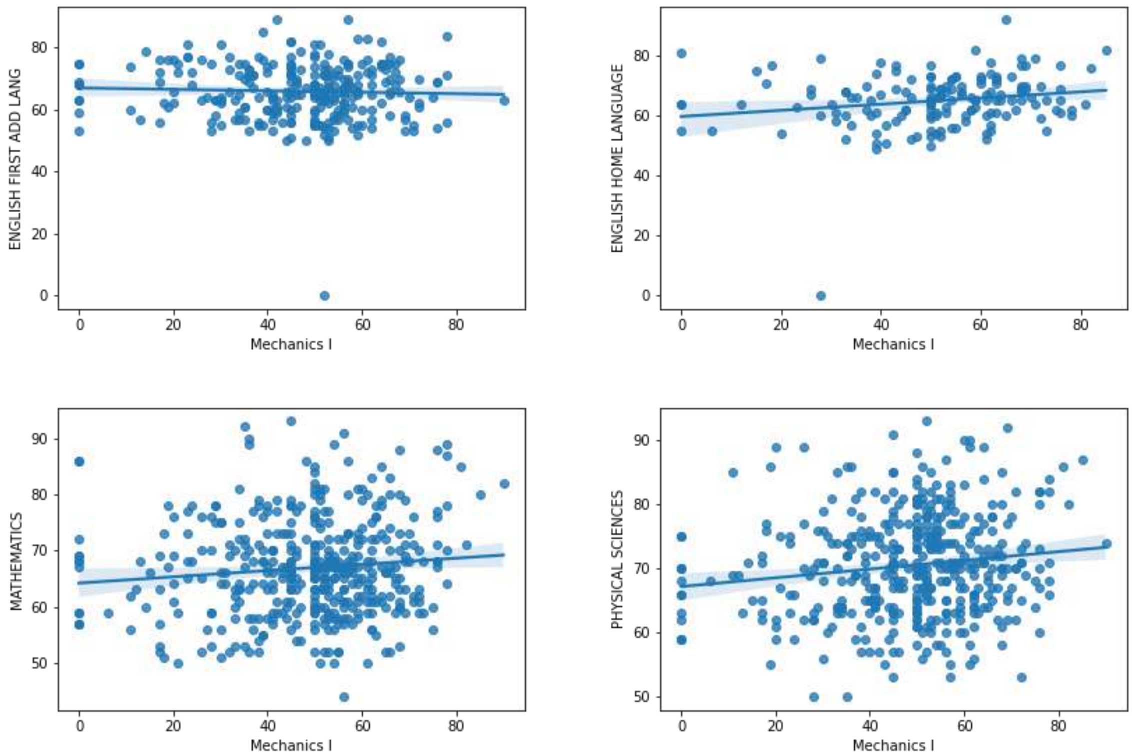

Figure 4-7 Mechanics I vs NSC Subjects

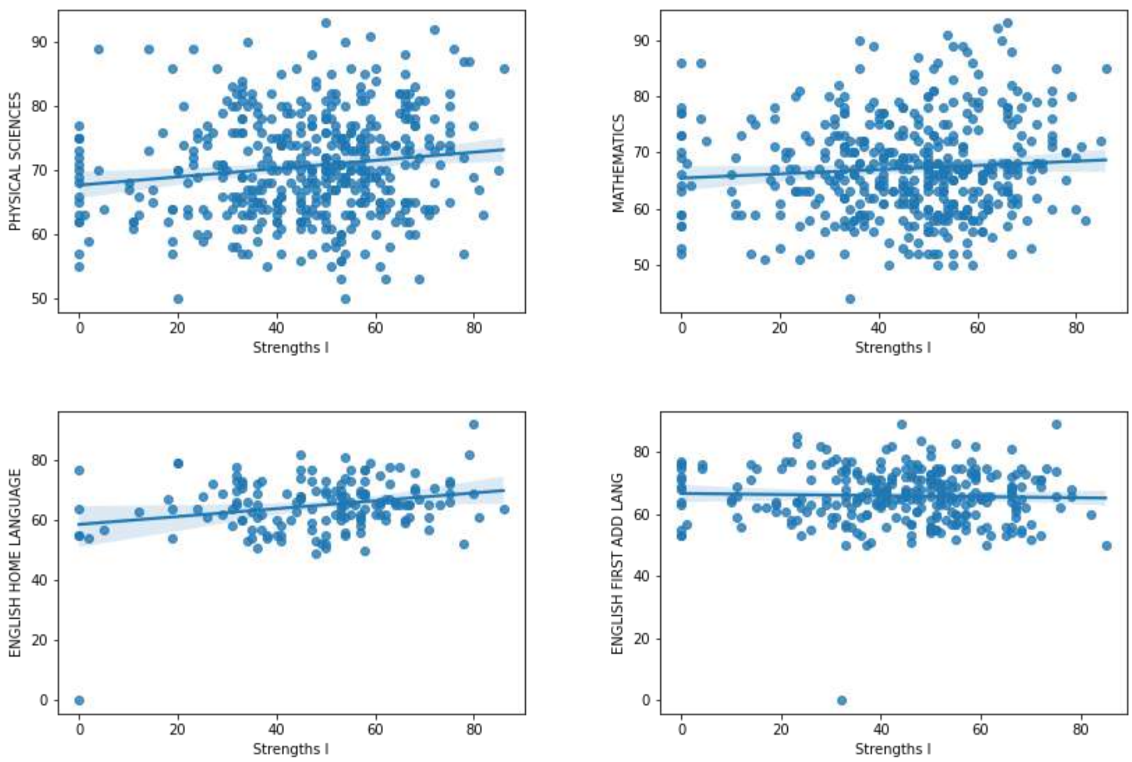

Figure 4-8 Strengths I vs NSC Subjects

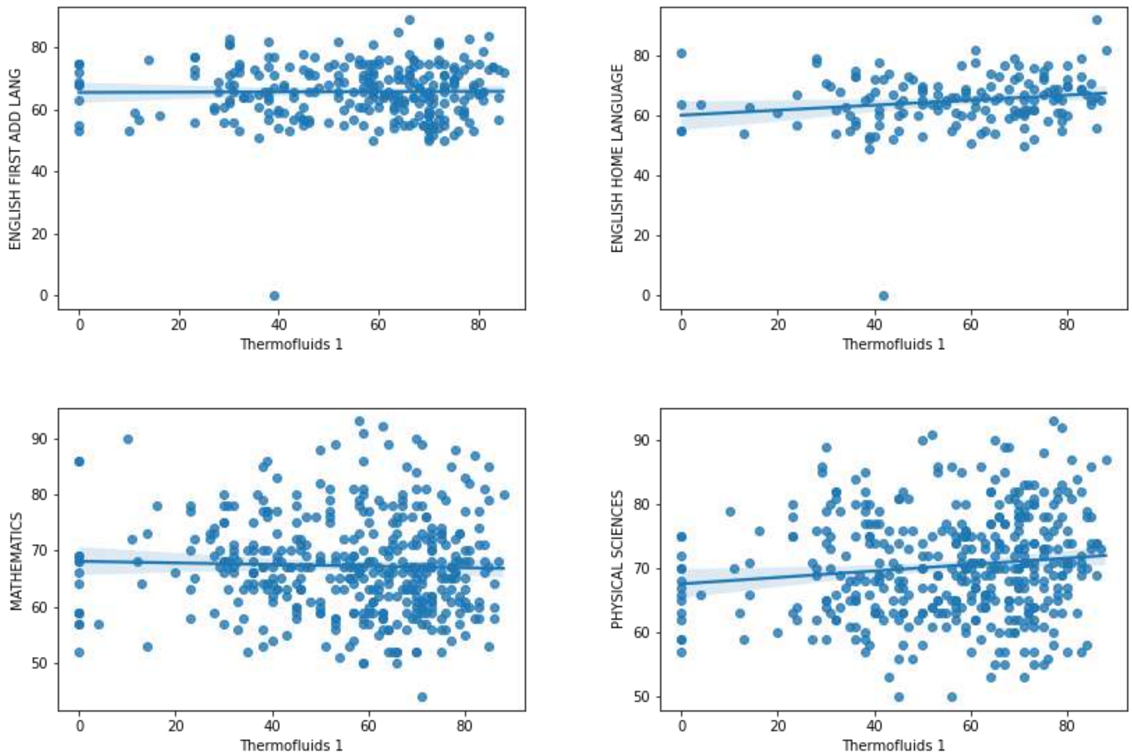

Figure 4-9 Thermofluids I vs NSC Subjects

The scatterplots indicate no deviation from a monotonic relationship. By observing the line of best fit for most of the graphs, as one variable increases, the other increases (more apparent with Maths 1A and Maths 1B) or decreases. Spearman`s correlation could then be used.

Table 4-6 below stipulates the subjects correlated, the sample size, Spearman's correlation, the p-value and if the correlation is significant (at the 0.05 level of significance) for all the years (2018-2021).

Table 4-6 Spearman's correlation

NSC Subjects	First Year Module	Sample Size	Spearman's correlation	p-value	Significant
PHYSICAL SCIENCES	Mechanics I	425	0,13	0,0083	Yes
PHYSICAL SCIENCES	Strengths I	447	0,14	0,0031	Yes
PHYSICAL SCIENCES	Mathematics 1A	394	0,20	0,0001	Yes
PHYSICAL SCIENCES	Mathematics 1B	392	0,18	0,0003	Yes
PHYSICAL SCIENCES	Thermofluids I	414	0,13	0,0091	Yes
MATHEMATICS	Mechanics I	425	0,08	0,0846	No
MATHEMATICS	Strengths I	447	0,06	0,2025	No
MATHEMATICS	Mathematics 1A	394	0,23	0,0000	Yes
MATHEMATICS	Mathematics 1B	392	0,11	0,0240	Yes
MATHEMATICS	Thermofluids I	414	-0,06	0,2416	No
ENGLISH HOME LANGUAGE	Mechanics I	155	0,21	0,0091	Yes
ENGLISH HOME LANGUAGE	Strengths I	159	0,16	0,0394	Yes
ENGLISH HOME LANGUAGE	Mathematics 1A	147	0,07	0,4138	No
ENGLISH HOME LANGUAGE	Mathematics 1B	148	0,10	0,2385	No
ENGLISH HOME LANGUAGE	Thermofluids I	152	0,19	0,0187	Yes
ENGLISH FIRST ADD LANG	Mechanics I	273	-0,03	0,6502	No
ENGLISH FIRST ADD LANG	Strengths I	291	-0,05	0,3732	No
ENGLISH FIRST ADD LANG	Mathematics 1A	250	0,03	0,6814	No
ENGLISH FIRST ADD LANG	Mathematics 1B	247	-0,01	0,9010	No
ENGLISH FIRST ADD LANG	Thermofluids I	265	-0,02	0,7734	No

With reference to Table 4-6, Physical Sciences contains a very weak positive correlation for all the first-year modules, except Maths 1A, and contains a weak positive correlation with Maths 1A. The correlation between Physical Sciences and all first-year modules are deemed significant. Consequently, NSC Physics will be further used in this Chapter to ascertain the necessary entry requirements.

NSC Mathematics contains a very weak positive correlation with Mechanics I, Strengths I and Maths 1B. It contains a weak positive correlation with Maths 1A and contains a very weak negative correlation with Thermofluids I. The correlation between Maths 1A and Maths 1B are significant. NSC Maths must be considered as part of the entry requirements, considering the significant correlations with the two Maths first-year modules. NSC Maths has the strongest correlation, with Maths 1A (0.23) (significant).

English FAL has very weak negative correlations with all first-year modules and with Maths 1A being the only positive correlation. No correlations are significant for English FAL. As a result, it would not be used any further in this investigation.

English HL has a very weak positive correlation with all modules besides Mechanics I, which has a weak positive correlation. The correlation between Mechanics I, Strengths I and Thermofluids I is significant. There is a noticeable small sample size of students who did English HL (slightly exceeding half the student population doing English FAL). Considering the NSC English subjects, it is noted that the population will be split into each choice of HL and FAL. Therefore, in forming entry requirements, both subjects must either be considered or not considered to ensure that no unintended advantage is provided. Notably, no significant correlations were identified for English FAL, and as such both subjects were not considered further.

Considering the correlations between the NSC subjects and first-year Engineering modules, it was possible to determine the requisite entrance requirements.

Table 4-7 Average NSC Maths scores and first year success

NSC Maths	% of students enrolled	#	Mechanics I Success	Strengths I Success	Maths 1A Success	Maths 1B Success	Thermofluids I Success	Benchmark
50-54	6%	27	43%	42%	59%	46%	48%	1
55-59	15%	68	41%	43%	62%	49%	52%	2
60-64	20%	93	50%	46%	69%	61%	57%	4
65-69	25%	116	48%	47%	70%	56%	55%	3
70-74	14%	64	50%	45%	72%	60%	57%	4
75-79	12%	54	46%	45%	70%	57%	53%	3
80-84	4%	20	58%	51%	78%	63%	61%	5
85-89	3%	14	53%	50%	89%	77%	55%	5
90-94	1%	5	N/A	44%	N/A	N/A	42%	0
95-100	0%	0	0%	0%	0%	0%	0%	0

n = 461

Table 4-7 above shows the average NSC Maths scores for students enrolling in the BET programme for 2018, 2019, 2020, and 2021, and their success rate in the first-year modules. 461 students enrolled within the four years. The sample sizes in the correlation slightly differs to the total sample size given in Table 4-7 due to certain students not doing a particular first-year module, but doing the others. For example, a student may have marks for all first-year modules except for Mechanics I, as they may have credits for the module due to coming from a different institute or having completed the module before 2018 (the beginning of the investigation year).

Most students achieved between 55% to 69% (comprising 60% of all the students enrolled). 25% of the enrolled students achieved between 65%-69% for NSC Maths. Notably, as the NSC Maths marks increased, so did the performance on the first-year modules, with the NSC Maths 80%-84% and 85%-89% (comprising only 7% of all the students enrolled) achieving the highest success rates for the first-year modules. 1% of the enrolled students achieved 90%-94% for NSC Maths. However, this cannot be taken into consideration, due to the fact that these students did not have results for Mechanics I, Maths 1A, and Maths 1B. Further to that investigation, the poor success rate for Strengths I and Thermofluids I indicate that this cohort can be regarded as an outlier.

A benchmark (last column of Table 4-7) was placed to determine the number of groups achieving percentages over 50% to ascertain if the Maths and Physics entrance marks are acceptable. The entrance requirement of an NSC Maths mark of 50% can be considered low, as the 50-54% group achieved average student success rates less than 50% (excluding Maths 1A). In other words, the 50-54% group only had 1/5 greater than 50%, which is not acceptable. The 55-59% group only had 2/5 success rates exceeding 50%. The 60-64% group had a greater average student success rate for the modules with 4/5 percentages exceeding 50%. An acceptable benchmark should be 3/5 percentages greater than 50%. Based on these findings, it is recommended that a minimum of 60% in NSC Maths be the new entry requirement for the BET degree.

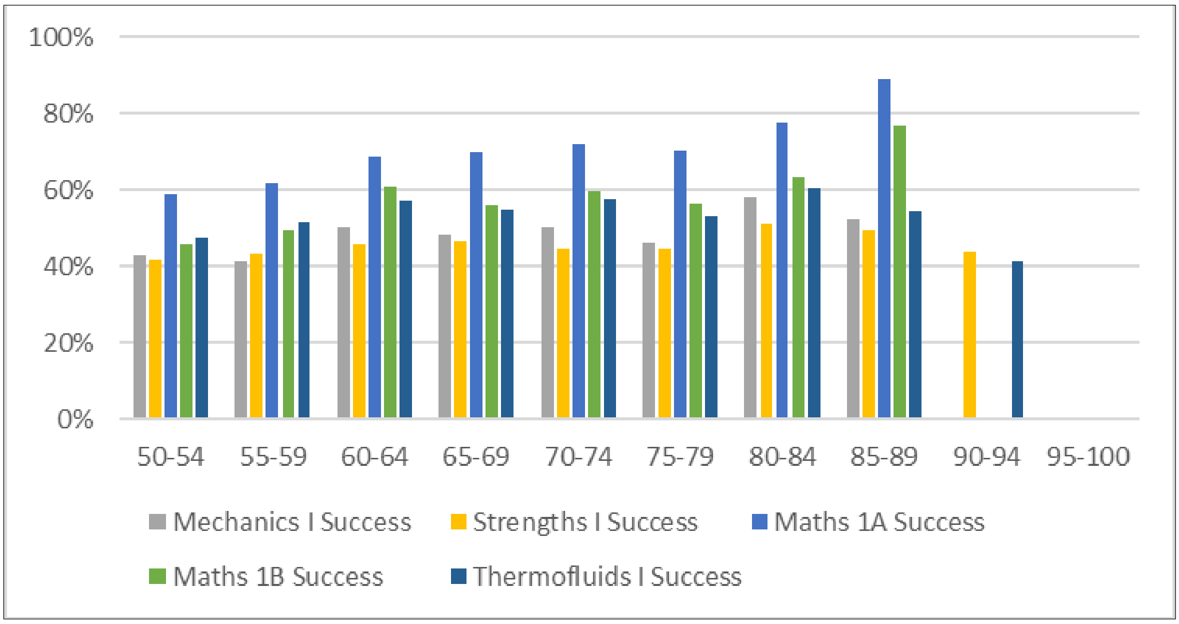

Figure 4-10 NSC Maths vs First Year Module success

Figure 4-10 above visually represents the average NSC Maths scores for students enrolled in the BET programme during 2018, 2019, 2020, and 2021, and their success rate in the first-year modules (Table 4-7). The standout module is Maths 1A. Figure 4-10 shows a relationship of direct proportionality between the NSC Maths mark and the Maths 1A mark. A similar, but not as apparent, relationship is observed with Maths 1B.

Table 4-8 Average NSC Physics scores and first year success

NSC Physics	% students enrolled	#	Success rate (%)					Benchmark
			Mechanics I	Strengths I	Maths 1A	Maths 1B	Thermofluids I	
50-54	1	5	47	50	75	69	58	4
55-59	6	29	41	40	67	49	50	2
60-64	17	78	44	42	64	55	52	3
65-69	22	100	48	45	67	54	54	3
70-74	23	104	51	47	72	59	58	4
75-79	16	73	47	46	69	57	53	3
80-84	10	47	55	51	76	66	60	5
85-89	4	20	43	50	69	60	55	4
90-94	1	5	44	38	60	51	41	2
95-100	0	0	0	0	0	0	0	0

n = 461

Table 4-8 above shows the average NSC Physics scores for students enrolled in the BET programme for the years 2018, 2019, 2020 and 2021, and their success rate in the first-year modules. 461 students enrolled within the four years, where most (78%) achieved between 60% to 79%. Within that range, most of the students achieved between 70%-74% for NSC Maths (comprising 23% of all the students enrolled). The sample sizes in the correlation slightly differs from the total sample size in Table 4-8 due to certain students not doing a particular first-year module but doing the others.

For example, a student may have marks for all the first-year modules except for Maths 1A, due to having credits for the module.

The best performing student group achieved 80-84% for NSC Physics (consisting of only 10% of all the students enrolled). The second-best performing group achieved 50-54% for NSC Physics. However, these students make up only 1% of the population, and can be considered an outlier. The students who achieved 90%-94% for NSC Physics (comprising 1% of all the students enrolled) did not perform as well as the average population. The NSC physics entrance requirement of 50% can be considered low, although the 50-54% student group achieved average success rates exceeding 50% (aside from Mechanics I), as they comprise only 1% of enrolments. The group attaining an average of 55-59%, achieved 50% and greater for only two modules of the five. On the other hand, the 60-64% group achieved a greater than average success rate for the modules, achieving 3/5 percentages over 50%, according to the applied benchmark. Hence, a minimum of 60% in NSC Physics ought to become the new entry requirement for the BET degree.

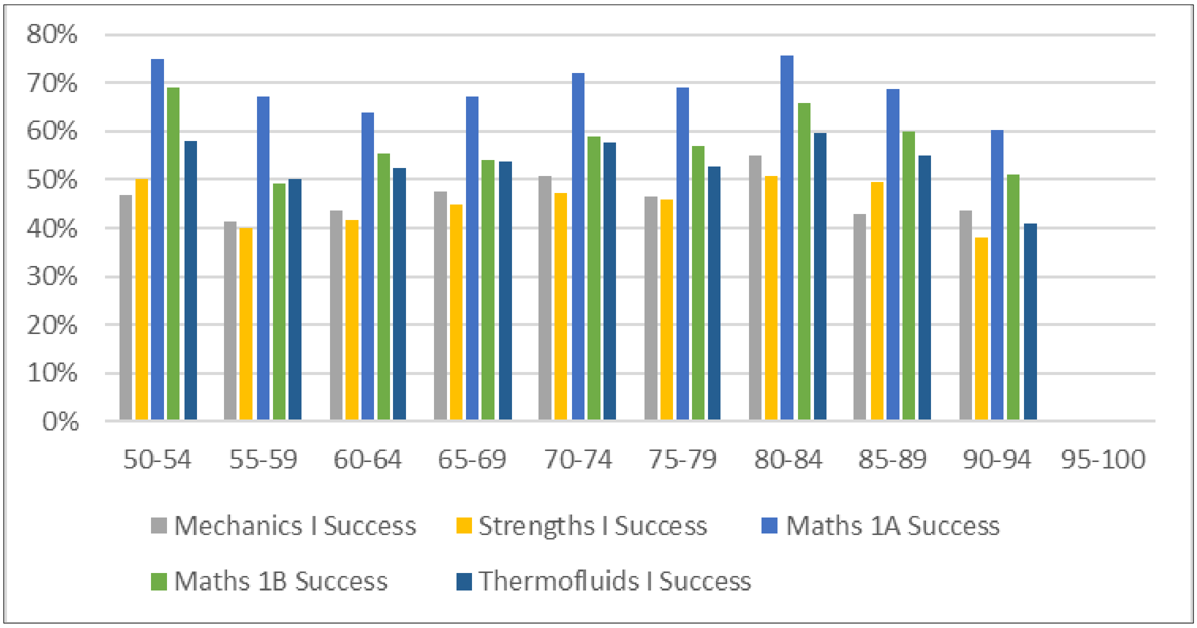

Figure 4-11 NSC Physics vs First Year Module success

Figure 4-11 above visually depicts the average NSC Physics scores for students enrolled in the BET programme between 2018 and 2021 (Table 4-8), and their success rate in the first-year modules. Not taking into consideration the 50-54% group (due to it being 1% of the cohort) as the NSC Physics marks increases, so does the Strengths I mark. However, there was a small decrease in the 75-79% group and the ’85-89% group. Most of the columns fluctuate with the various score groups.

Table 4-9 Average NSC Maths and Physics scores and ND First Year Success (Walker and Graham, 2013; Graham, 2015)

NSC P + M	Cohort %	Maths 1 Success	Mech 1 Success
<110	11	31%	25%
110-119	19	36%	27%
120-129	23	66%	52%
130-139	19	57%	51%
140-149	14	77%	62%
150-159	11	89%	89%
160-200	4	100%	90%

n = 249

Table 4-9 was obtained from previous research by Graham and Walker and Graham to determine a suitable combined NSC Maths and NSC Physics entrance requirement. The results indicated that students achieving lower than 120 have an extremely low success rate and comprise 30% of the students enrolled. It is due to this research that the entrance requirement of 120 was introduced at DUT for the BET programme (Walker and Graham 2013).

Table 4-10 Average NSC Maths and Physics scores and first year success

NSC P+M	% students enrolled	#	Success rate (%)					Benchmark
			Mechanics I	Strengths I	Maths 1A	Maths 1B	Thermo-fluids I	
<110	0,4	2	50	0	100	100	100	4
110-119	0,4	2	50	50	50	50	50	5
120-129	29	137	50	48	79	69	52	4
130-139	31	140	51	40	81	73	59	4
140-149	20	94	56	49	84	74	53	4
150-159	11	51	56	46	70	66	55	4
160-200	8	35	56	64	80	82	66	5

n = 461

Table 4-10 above shows the average NSC Maths and Physics combined scores for the 461 students enrolled in the BET programme between 2018 and 2021, and their success rate in the first-year modules. The sample sizes in the correlation slightly differs from the total sample size in Table 4-10 due to certain students not doing a particular first-year module but doing the others. The University entry requirement was a combined NSC Maths and Physics score equal to or greater than 120. 0.8% of the enrolled cohort did not achieve that benchmark, because these students may have come from TVET colleges or completed a higher certificate to allow them entrance into the programme. Most of the students achieved between 120-149 (80% of all the students enrolled). Within that range, most achieved between 130-139 for NSC Maths and Physics (31% of all the students enrolled). Excluding students below the 120 mark, the best performing group was those students who achieved 160-200 for NSC Maths and Physics (comprising only 8% of all the students enrolled).

The entrance requirements of having a combined score of 120 for NSC Maths and Physics is appropriate, as the average success rate for all the modules exceeds 50%, besides Strengths I (48%). This average success rate for Strengths I is roughly constant for all the other 'NSC P+M' groups, besides the '160-200' group. When considering the benchmark, groups including and between '120-129' – '150-159' had achieved 4/5 student success rates over 50%. When compared with Table 4-9 (devised by Walker and Graham), a 120 combined score was deemed suitable. Similarly, it can be concluded that the 120 score is also a suitable requirement for the BET.

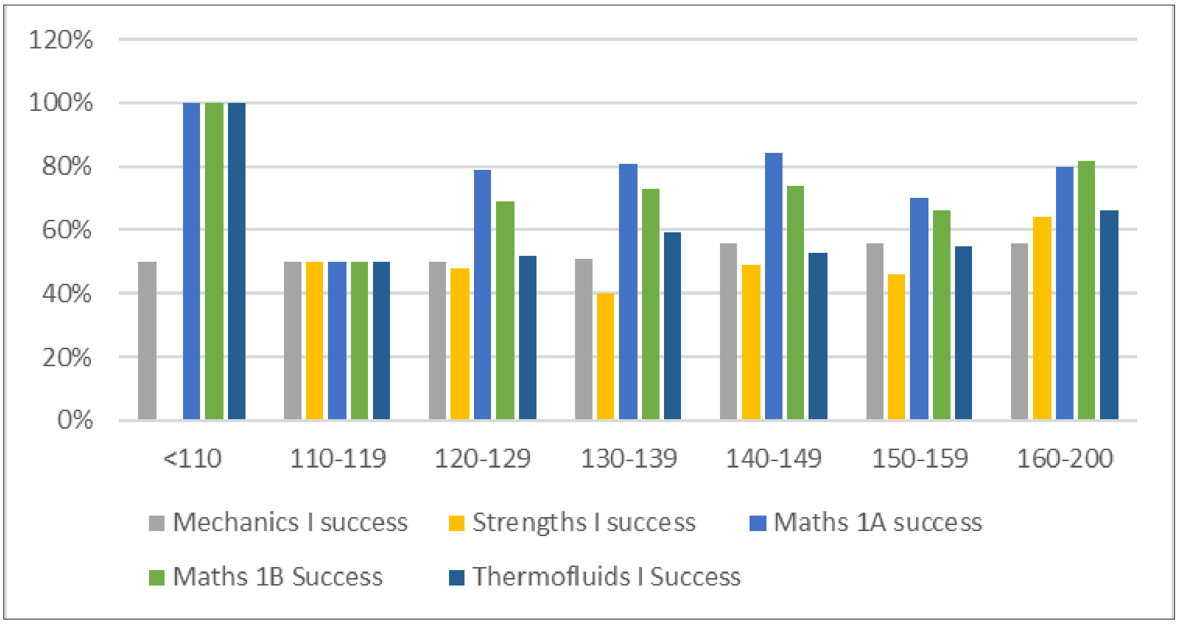

Figure 4-12 NSC P+M vs First Year module success

Figure 4-12 above graphically represents Table 4-10 above and shows average NSC Maths and Physics combined scores for students enrolled in the BET programme during 2018, 2019, 2020, and 2021, and their success rate in the first-year modules. It can be observed that as the NSC P+M increases, so does the student success rate for Mechanics I. Ignoring '<110' group, the '160-200' group achieved the highest student success rates (expect for Maths 1A). Conspicuously, the student success rates for the '120-129' – '150-159' groups are similar. These findings imply that an increase in combined P+M marks did not have a substantial effect on student success rates.

4.4 Graduate Attributes and their Effect

Section 4.4 discusses the resulting GA data to ascertain if it is impeding student throughput rates.

Table 4-11 GA assessed modules for 2020 and failure rate

2020	**Number of students**	**No. failed GA**	**% failed GA**	**No. failed because of GA**	**% failed because of GA**	**No. failed**	**% failed**
Capstone Design Project	37	N/A	N/A	N/A	N/A	6	16,2
Environmental Engineering	50	3	6,0	0	0	4	8,0
Fluid Mechanics III	24	1	4,2	0	0	2	8,3
Mechanics of Machines III	31	1	3,2	0	0	1	3,2
Principals of Management	46	2	4,3	0	0	2	4,3
Strengths of Materials III	39	N/A	N/A	N/A	N/A	28	71,8
Thermodynamics IIII	23	0	0,0	0	0	3	13,0
Total	**250**	**7**	**17,7**	**0**	**0**	46	18,4

*N/A - GA was not yet implemented on those modules

Given that the BET went into effect in 2018, 2020 was the earliest that students may be in their third year. As a result, 2020 and 2021 were the only options available for this preliminary investigation.

Table 4-11 above shows the GA-related results for 2020. This sub-study was performed purely to determine if students are failing the module only because of failing the GA. Of the 250 enrolled students, seven had failed the GA. However, none of those students failed the module purely by failing the GA. Even if these students passed the GA, they would have still failed the module.

Table 4-12 GA Assessed Modules for 2021 and Failure Rate

2021	**Number of students**	**No. failed GA**	**% failed GA**	**No. failed because of GA**	**% failed because of GA**	**No. failed**	**% failed**
Capstone Design Project	56	2	3,6	0	0	2	3,6
Environmental Engineering	96	2	2,1	0	0	2	2,1
Fluid Mechanics III	80	2	2,5	0	0	2	2,5
Mechanics of Machines III	105	7	6,7	0	0	26	24,8
Principals of Management	103	2	1,9	0	0	8	7,8
Strengths of Materials III	81	N/A	N/A	N/A	N/A	22	27,2
Thermodynamics IIII	78	1	1,3	1	1,3	1	1,3
Total	**599**	**16**	**18,0**	**1**	**6,25**	63	10,5

*N/A - GA was not yet implemented on those modules

The GA-related results for 2021 and each of the assessed modules are displayed in Table 4-12 above. 16 of the 599 registered students did not pass the GA. Only one of these 16 students failed the module due to a failure on the GA. Even if they had passed the GA, 15 of the 16 students would still have failed the module. This sub-study aimed to ascertain whether students are failing the module primarily due to failing the GA, which was not the case for 2021.

During the course of the two-year investigation, 23 pupils failed the GA assessments. Even if they had passed the GA assessment, 22 of them would still have failed the module. It is evident from these 22 cases that the addition of a GA assessment did not cause students to fail the module. The only module in which a student passed all of the assessments but failed the GA assessment was Thermodynamics III. Thermodynamics III includes GA 4 (investigations, experiments, and data analysis). A practical/laboratory investigation and report are used to assess GA 4. Taking into account that 101 students were registered for the module in the two-year period, one failure can be deemed an outlier, and cannot be considered statistically significant.

Thus, it is reasonable to draw the conclusion that, throughout the years under investigation, the GA assessments did not have a significant negative effect on success and throughput. It is recommended that this investigation be expanded to include future cohorts.

4.5 ‘Back-to-back’ Modules

Strengths of Materials I and Mechanics of Machines I are second-semester modules. However, due to their poor success rates, these modules are now offered in both semesters, and are thus known as 'back-to-back' modules (as of 2020). In this section, the author analyses and discusses whether the ‘back-to-back’ offering of the modules had a major impact on student success and throughput. Both modules were taught online in 2020 and 2021.

Table 4-13 'Back-to-back' module success rates – Mechanics I

Year and semester	Number of students	Total passed	Total percentage	Number of repeating students	Number of repeating students passed	% Repeating students passed
2018 S2	97	25	26%	-	-	-
2019 S2	159	109	69%	41	30	73%
2020 S1	22	18	82%	20	16	80%
2020 S2	129	76	59%	7	0	0%
2021 S1	17	14	82%	17	14	82%
2021 S2	131	88	67%	39	19	49%

Table 4-14 'Back-to-back' module success rates – Strengths I

Year and semester	Number of students	Total passed	Total percentage	Number of repeating students	Number of repeating students passed	% Repeating students passed
2018 S2	98	53	54%	-	-	-
2019 S2	134	30	22%	17	7	41%
2020 S1	57	43	75%	56	42	75%
2020 S2	153	98	64%	29	17	59%
2021 S1	18	13	72%	18	13	72%
2021 S2	134	60	45%	41	21	51%

Tables 4-13 and 4-14 above show the semesters' Mechanics I and Strengths I offered (including the 'back-to-back' offering in the first semesters), together with the modules' student success rate for that semester. It indicated the number of the students who passed the module as well as the number of repeating students who have done so.

With reference to Table 4-13 (Mechanics I), there is a substantial difference between the number of students registered in the first semester (S1) and second semester (S2). The enrolment in 2019 S2 was 159. Of those 159, 50 had failed. In the 2020 S1, only 22 students were enrolled for Mechanics I, which is less than half the population repeating the module. In 2020 S2 129 students were enrolled and 53 had failed. In 2021 S1, only 17 students were registered. Once again, less than half the population is repeating the module in the following semester. This difference in the number of students registered could be attributed to students not knowing the offering of the module in the first semester. It is recommended that a thorough induction be introduced at DUT where students are explained how Mechanics I is offered in both semesters.

Although less students were registered for the first semesters, the module's student success rate is greater than when offered in S2. 81.82% was the student success rate for 2020 S1 and 82.35% was the student success rate for 2021 S1, averaging 82.09%. 39 students attempted Mechanics I in the first semester (37 being repeat students). Of those 37 students, 30 passed the module, resulting in an 81.08% student success rate. The average student success rate for the S2 offering was 55.10%. The number of repeating students in the second semesters was 87, of which, 49 passed, resulting in a student success rate of 56.32%. This suggests that, due to the module being offered in S1, the author observed an increase in the success rate by 24.76 pp.

Qualitative data collected from a focus group study was used to shed light on why the Mechanics I S1 student success rate exceeded that of S2. By analysing the data, it was found that the greater success rate in S1 was due to a smaller class size, and a larger percentage of repeating students. According to the Mechanics I lecturer, the smaller class sizes allowed the students to be more engaged and focused; aligning with the findings of Bourke (1986) and Finn and Achilles (1990). The lecturer supported the 'back-to-back' Mechanics I offer (despite indicating challenges, such as resources, greater workload, and running parallel class for other program modules) because in S1, it produced a greater than 80% pass rate. The lecturer believes offering this module again provides another chance to the student to catch up or complete their remaining higher-level modules within the required time. The lecturer further attributed the poor student success rate when the module was taught on campus (2018 and 2019) to student high absenteeism (due to student protests). Considering that this module is a sensitive/progressive subject, any absences (even two consecutive classes missed) will seriously impede student learning and performance.

With reference to Table 4-14 (Strengths I), there is a substantial difference between the number of students registered in S1 and S2. The enrolment in 2019 S2 was 134. Of those 134, 104 had failed. In the 2020 S1, only 57 students were enrolled for Strengths I, which is just more than half the repeating population. In 2020 S2 153 students were enrolled and 55 had failed. In 2021 S1, only 18 students were registered. Roughly, only one third of the population is repeating the module in the following semester. This reason for the difference in the number of students registered is the same as Mechanics I, that is, it could be due to students not knowing the offering of the module in S1, which can be resolved through a detailed induction.

Although fewer students were registered for the first semesters, the Strengths I student success rate is greater than when offered in S2. The total success rate for the first semesters was 75.44% and 72.22% respectively, averaging 73.83%. A total of 75 students attempted Strengths I in S1 (74 of which were repeat students). Of those 74, 55 passed the module, yielding a 74.32% student success rate. The average student success rate for the S2 offering is 46.32%. The number of repeating students in the second semesters is 87 of which, 45 passed, yielding a student success rate of 51.72%. This finding suggested that due to the module being offered in S1, there was an observable increase in success rate of 22.6 pp.

Once again, qualitative data was used to gain insights on why the S1 Strengths I student success rate exceeded that of S2. By analysing the data, the greater success rate in S1 was due to a smaller class size and a larger percentage of repeating students. According to the Strengths I lecturer, the overall S1 performance (second attempt) was better than in S2 (first attempt). The lecturer reported that the students were more engaged and focused due to the smaller class sizes in S1 (Bourke 1986; Finn and Achilles 1990). However, contrary to the Mechanics I lecturer, the Strengths I lecturer does not support the ‘back-to-back’ offering of Strengths I as they believe that if the students know that a module will be re-offered in the following semester, they tend not to take it seriously knowing that they will get a second chance. The lecturer further provided insight into the poor performance in 2019. There was a strike in 2019 that caused disruptions, and to remedy the situation, students were asked to self-study to make up for the time lost, accounting for the poorest student success rate for Strengths I in 2019. Protest actions can be viewed as ‘transient disruptions’ adversely affecting teaching and learning as lecturers are not equipped for ERT&L (Schuck and Lambert 2020; Roopchund 2022).

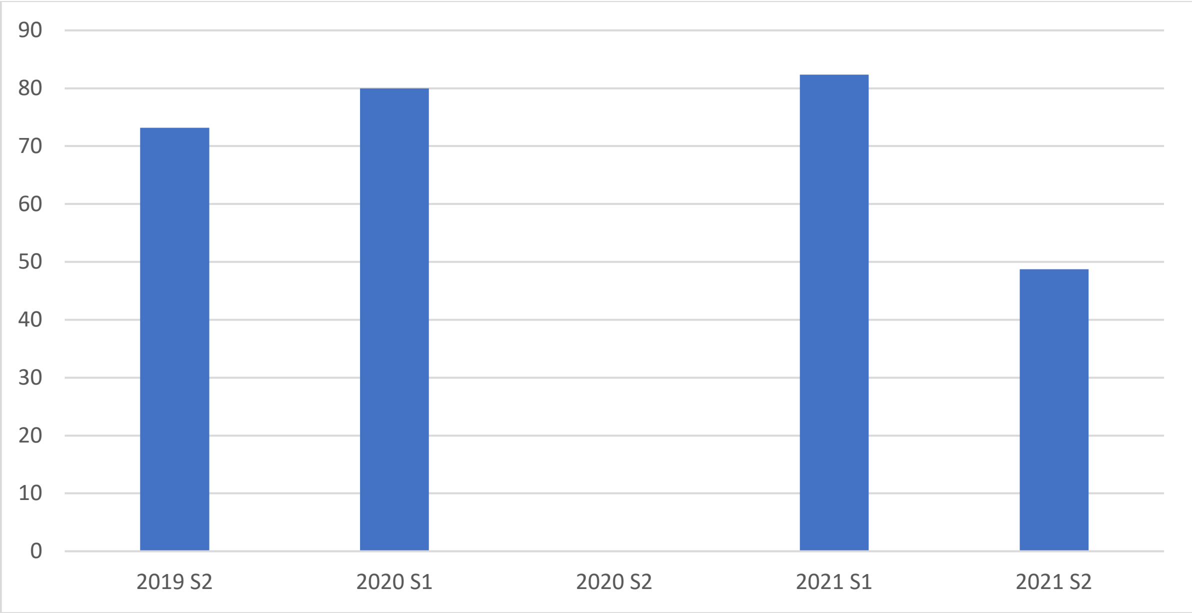

Figure 4-13 Mechanics I repeating student success rate

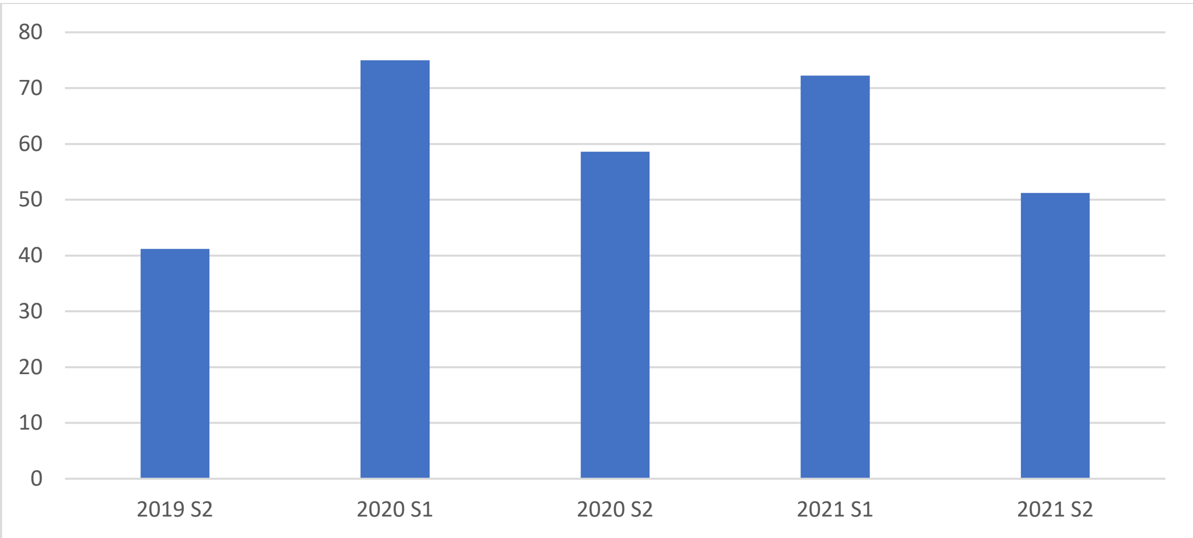

Figure 4-14 Strengths I repeating success rate

From Figure 4-13 and 4-14 above, the success rates of repeating students in S1 were significantly greater than that of repeating students in S2. Despite the greater success rate, the number of students registered in the first semesters is significantly lower than that of the second semesters. This dearth of enrolments in S1 overpowers the benefit of its success rates. Therefore, it could be concluded that the overall effect of 'back-to-back' modules is positive when it comes to student progression. However, due to a lack of students enrolled for S1, it is not a suitable solution. A thorough induction might help to create a suitable awareness about Strengths I and Mechanics I being offered in both semesters. A better recommendation is to install a system, whereby if a student fails Strengths I or Mechanics I in S2 (first offering), they are automatically registered for the 'back-to-back' offering in S1 (for repeat students) of the next year. The Mechanics I lecturer supported the proposal of an automatic re-registration system for first attempt failures, as he believes it will lead to greater class sizes in the S1 offering. Similarly, the Strengths I lecturer also supported the proposal.

Table 4-15 Number of repeating students for Mechanics I

Current Semester	From 2018 S2	From 2019 S2	From 2020 S1	From 2020 S2	From 2021 S1	From 2021 S2
2018 S2	**97**	N/A	N/A	N/A	N/A	N/A
2019 S2	41	**159**	N/A	N/A	N/A	N/A
2020 S1	4	19	**22**	N/A	N/A	N/A
2020 S2	3	7	0	**129**	N/A	N/A
2021 S1	2	7	4	12	**17**	N/A
2021 S2	4	3	0	37	0	**131**

Table 4-15 above shows the number of repeating students for Mechanics I. The bold figures show the total number of students registered for that semester. Regarding the '2018 S2' cohort, all students were assumed to be registered for the first time. Although in Table 4-13, the S1 success rates were higher, Table 4-15 indicates that the number of students registered for the module in S1 was significantly less.

It is possible for students to appear in more than one column. For example, a student registered for Mechanics I in 2021 S1, could have repeated Mechanics I in 2020 S1 and again in 2020 S2 and now attempting Mechanics I for the third time. This motivated the next investigation shown below which shows student attempts at Mechanics I.

With reference to Table 4-13 there was not a 100% student success rate for repeating students in S1. It is also noted that (with reference to Table 4-15), students who did not pass Mechanics I in S1 did not repeat the module in S2. Similarly, an automatic registration system may be beneficial in this case.

Table 4-16 Attempts at Mechanics I

Current semester	**1st Attempt**	**2nd Attempt**	**3rd Attempt**	**4th Attempt**	**5th Attempt**	**6th Attempt**
2018 S2	**97**	N/A	N/A	N/A	N/A	N/A
2019 S2	**118**	41	N/A	N/A	N/A	N/A
2020 S1	**2**	17	3	N/A	N/A	N/A
2020 S2	**122**	4	3	0	N/A	N/A
2021 S1	**0**	10	6	1	0	N/A
2021 S2	**92**	36	1	2	0	0

Table 4-16 above shows the number of attempts made by students to complete Mechanics I. In S2, the number of first attempts at Mechanics I is large, averaging 108 per semester, while the average number of students registered in S1 is one. Clearly, many students attempt the module at least twice. Even in the second attempts, more students are registered in S2 than in S1 for Mechanics I. Per university rules, students are only allowed to register five times for a three-year degree. This means that a student can only fail two academic years at most. It is noteworthy that certain students are still attempting a first-year module for a fourth time, making it impossible for the student to complete the degree, as they will have to re-register various times to complete subsequent modules. It is the recommendation of this sub-study that the university develops an automatic deregistration system to deregister such students, instead of adding unnecessary financial strain on them.

Table 4-17 Number of repeating students for Strengths I

Current semester	From 2018 S2	From 2019 S2	From 2020 S1	From 2020 S2	From 2021 S1	From 2021 S2
2018 S2	**98**	N/A	N/A	N/A	N/A	N/A
2019 S2	17	**134**	N/A	N/A	N/A	N/A
2020 S1	4	56	**57**	N/A	N/A	N/A
2020 S2	3	26	2	**153**	N/A	N/A
2021 S1	4	12	8	8	**18**	N/A
2021 S2	2	5	2	38	2	**134**

Table 4-17 above shows the number of repeating students for Strengths I. The bold figures indicate the total number of students registered for that semester. In 2018 S2, all students were assumed to be registered for the first time. As with Table 4-15, it is possible for students to appear in more than one column.

As such, the next investigation indicates student attempts at Strengths I. Although the S1 student success rates are higher, Table 4-17 indicates that the number of S1 registrations for the module is significantly less. With reference to Table 4-14, there was not a 100% student success rate for repeating students in S1. Unlike the results with Mechanics I, it is noted that (with reference to Table 4-17) certain students who failed Strengths I in S1 are repeating the module in the following S2 offering. Two students repeated Strengths I in 2020 S2 from 2020 S1. From Table 4-14, 14 students failed Strengths I, implying that 2/14 students repeated. Similarly, two students repeated Strengths I in 2021 S2 from 2021 S1. From Table 4-14, five students failed Strengths I. As with Mechanics I, an automatic deregistration system is recommended, irrespective of the semester.

Table 4-18 – Attempts at Strengths I

Current semester	1st Attempt	2nd Attempt	3rd Attempt	4th Attempt	5th Attempt	6th Attempt
2018 S2	**98**	N/A	N/A	N/A	N/A	N/A
2019 S2	**117**	17	N/A	N/A	N/A	N/A
2020 S1	**1**	52	4	N/A	N/A	N/A
2020 S2	**124**	27	2	0	N/A	N/A
2021 S1	**0**	12	5	1	0	N/A
2021 S2	**93**	34	6	1	0	0

Table 4-18 above shows the number of attempts made by students to complete Strengths I. In S2, the number of first attempts at Strengths I is large, averaging 108 per semester. The average amount of students attempting Strengths I for the first time (S1) is less than one. Clearly, several students attempt the module at least twice. Converse to the Mechanics I analysis, with regards to second attempts at Strengths I, a few more students were registered for Strengths in S1 than S2 (excluding the 2019 S2). Per university policy, students are only allowed to register five times for the three-year degree. However, certain students are still attempting Strengths I, which is a first-year module, in their fourth attempt. The university ought to deregister a student, instead of imposing upon them unnecessary financial strain.

4.6 ND vs. BET

The entrance requirements have increased from the ND programme for the new BET programme. The student success rate of BET modules deemed similar to modules taught in the ND programme were compared to determine if the BET is producing greater student success rates than the ND. The sub-study was also done to determine the effect the increased entrance requirements had on the similar deemed modules (only for the first-year BET modules) and will only be relevant for modules which are deemed similar for S1 and S2. During the ND programme, modules were also offered per semester. Tables 4-19 to 4-22 below show the ND modules offered in their relevant semester, and the module reflected below is a similar BET module. As such, the average student success rate of similar modules is obtained.

For the ND, data was taken from eight semesters, because much of the information and data is available. Only four years of data is available for the BET programme. Hence, the years 2018-2021 were used. It is noted that modules were taught online in 2020 and 2021.

Focus group sessions were only held with lecturers teaching similar deemed modules in which a greater 20 pp difference in the average student success rate was observed (between the similar deemed ND and BET module). The modules were Engineering Physics 1A (EPHA101), Engineering Physics 1B (EPHB101), Engineering Mathematics 1A (EMTA101), Engineering Mathematics 1B (EMTB101), and Mechanics of Machines III (MCHM301), and Fluid Mechanics III (FLDM301).

Table 4-19 Similar modules for semester one (BET vs. ND)

ND/BET Module	**Success rate (%)**												
	’07		**’08**		**’09**		**’10**		**’18**	**’19**	**’20**	**’21**	**Avg.**
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**					
ND Mechanics I	74	55	59	51	57	57	62	57					**58**
BET Physics 1A*									87	92	89	88	**89**
BET Physics 1B *									77	93	89	85	**86**
ND Maths I	61	42	61	50	66	74	67	47					**64**
Engineering Math 1A									86	88	89	94	**89**

Faculty success rate - *

As observed in Table 4-19 above, Mechanics I in the ND programme was deemed similar to Physics 1A and 1B in the BET programme, and Maths I in the ND programme was deemed similar to Engineering Mathematics 1A in the BET programme. The faculty student success rate was inserted for the BET modules for S1, as it was the only data available.

The average student success rate (over eight semesters) of Mechanics I is 58% and that of Physics 1A and 1B (over four semesters) are 89% and 86%, respectively. These results constitute a 31 pp and 28 pp increase, respectively. Four co-lecturers were interviewed for Engineering Physics 1A and 1B. Three of the four co-lecturers had no knowledge on the similarity of Engineering Physics to Mechanics I as they did not teach Mechanics I. The one co-lecturer that did teach in the ND and BET programmes indicated that approximately 80% of the contents are similar between the modules and that the difficulty level is also similar.

According to the team of lecturers, students' mathematical background affects their level of participation and academic preparation in the Physics modules. A student's comprehension of Physics modules, and their general engagement and performance, may be hampered by inadequate mathematical skills. Although the high student success rates of Engineering Physics 1A and 1B, the lecturers still believed that the students could perform better.

According to the lecturer who taught in the ND and BET programmes, the class sizes were similar but the greater workload for the Physics modules in the BET programme required greater time management. The lecturer also believes that the student success rate in the Engineering Physics modules is greater due to the higher entrance requirements in the BET programme as the foundation of the Engineering Physics modules stems from Maths and Physics. Considering that 80% of the contents are similar between the modules and that the difficulty level is also similar, the increased student success rates can be attributed to the increased entrance requirements. Considering that more lecturers are lecturing the students, it may also positively affect the increased student success rates of Engineering Physics 1A and 1B.

The average student success rate of Maths I is 64% and that of Engineering Maths 1A is 89%, constituting a 25 pp increase. These are significant increases in student success rate. According to the lecturer, the Engineering Maths 1A content is very similar to that of Maths 1 in the ND. Some topics in Engineering Maths 1A were not taught in the ND and vice versa. However, an increased difficulty level in respect of delivery of Mathematical content and assessments were implemented. The lecturer who taught Maths I in the ND programme is not the same lecturer who taught Engineering Maths 1A in the BET programme. Despite endeavours for teaching and learning, student engagement in Mathematics is not satisfactory due to procedural factors and little attention to conceptual understanding in schools. The lecturer highlighted that the same problem existed in the ND programme, and expressed his difficulty in acknowledging trends in Engineering Maths IA, as the programme moved online in 2020 and 2021. Furthermore, the lecturer does not believe that the increased entrance requirements was the sole reason for increased student success rates in Engineering Maths 1A and stated a 60% NSC Mathematics requirement should be introduced. Considering the similar content between the modules and even though the difficulty level increased, the increased student success rates can be attributed to the increased entrance requirements (contrary to the response from the Maths 1A lecturer) and the change in lecturer.

When looking at the overall pp difference in S1, there is a 53 pp increase for the BET modules, which is a positive indication on the increased entrance requirements and the student success rates for the BET programme. For the similar deemed modules in S1, it can be stated that the student success rate in the BET is greater than in the ND.

Table 4-20 Similar modules for semester two (BET vs ND)

ND/BET Module	Success rate (%)												
	'07		'08		'09		'10		'18	'19	'20	'21	Avg.
	S1	S2	S1	S2	S2	S2	S1	S2					
ND Strengths of Materials II	58	66	59	65	59	47	48	64					**55**
BET Strengths I ++									54	22	67	48	**48**
ND Fluids II	74	74	67	47	63	51	43	54					**53**
BET Thermofluids I									32	42	93	89	**64**
ND Mechanics II	63	74	70	59	55	47	48	58					**52**
BET Mechanics I ++									26	69	62	68	**56**
ND Thermodynamics II	63	74	67	56	76	58	58	56					**62**
BET Thermofluids I									32	42	93	89	**64**
ND Maths II	55	52	49	54	58	62	70	50					**60**
BET Engineering Math 1B									76	77	90	79	**81**

Weighted average of 2 semesters - ++ ('20 and '21 only)

Table 4-20 above shows S2 ND modules, and its similar modules in the BET programme. Strengths of Materials II in the ND is deemed similar to Strengths I in the BET, Fluids II is similar to that of Thermofluids I, Mechanics II is similar to Mechanics I, Thermodynamics II is similar to Thermofluids I, and Maths II is similar to Engineering Maths 1B. The weighted average is used for Strengths I and Mechanics I in the BET programme for 2020 and 2021, as the module was offered twice in each year ('back-to-back').

The average student success rate of Strengths of Materials II (ND) (over eight semesters) is 55%, and that of Strengths I (BET) (over four semesters) is 48%, constituting a 7 pp decrease. The average student success rate of Fluids II is 53% and that of Thermofluids I is 64%, constituting a 11 pp increase. The average student success rate of Mechanics II is 52% and that of Mechanics I is 56%, constituting a 4 pp increase. The average student success rate of Thermodynamics II is 62% and that of Thermofluids I is 64%, constituting a 2 pp increase.

The average student success rate of Maths II is 60% and that of Engineering Maths 1B is 81%, constituting a 21 pp increase. The lecturer claims that the content covered in Engineering Maths 1B and Maths II in the ND are very similar. Certain topics taught in the ND were not covered in Engineering Maths 1B, and vice versa. Nonetheless, a higher difficulty standard was applied to the teaching and assessments. The lecturer who taught Maths II in the ND programme is not the same lecturer who taught Engineering Maths 1B in the BET programme. Student involvement in Mathematics is reducing, despite efforts to educate and learn because schools place a greater emphasis on procedural aspects and pay less attention to conceptual understanding. The lecturer claimed that the ND course had the same issue, and indicated the challenges in identifying trends in Engineering Maths IB when the course went online in 2020 and 2021. The lecturer believed that a 60% NSC Mathematics requirement should be implemented and that the higher entry requirements is the only factor contributing to the higher student success rates in Engineering Maths 1B. Therefore, it is possible to conclude that the higher student success rates are a result of the higher admission requirements and the change in lecturer, given that the content of the modules were similar, and the level of difficulty also increased.

When considering the overall pp difference in S2, there is a 31 pp increase for the BET modules. From that 31 pp increase, Engineering Maths 1B constitutes 21 pp. That is the only significant pp increase in this comparison. When analysing both Maths IA (semester I) and Maths 1B student success in the BET, both are considerably higher than Maths I and Maths II. Ultimately, the overall 31 pp suggests that this is a positive indication on the increased entrance requirements and the student success rates for the BET programme.

Table 4-21 Similar modules for semester three (BET vs. ND)

ND/BET Module	Success rate (%)												
	'07		'08		'09		'10		'18	'19	'20	'21	Avg.
	S1	S2	S1	S2	S1	S2	S1	S2					
ND Strengths of Materials III	31	37	50	49	67	58	80	73					**70**
BET Strengths of Materials II										69	61	49	**59**
ND Fluids III	95	84	75	80	79	73	78	86					**79**
BET Fluids II										83	85	97	**88**
ND Mechanics III	76	87	82	84	85	85	86	84					**85**
BET Mechanics II										61	88	68	**72**
ND Thermo-dynamics III	77	44	58	97	80	67	65	63					**69**
BET Thermo-dynamics II										82	84	72	**79**

Table 4-21 above shows Semester Three (S3) ND modules and its similar modules in the BET programme. Strengths of Materials III (ND) is deemed similar to Strengths II

(BET), Fluids III is similar to Fluids II, whereas Mechanics III is similar to Mechanics II, and Thermodynamics III is similar to Thermodynamics II.

The average student success rate in Strengths of Materials III (ND) (over eight semesters) is 70%, and that of Strengths II (BET) (over three semesters) is 59%. That is 11 pp decrease. The average student success rate of Fluids III is 79% and that was Fluids II is 88%. That is a 9 pp increase. The average student success rate of Mechanics III is 85% and that of Mechanics II is 72%. That is a 13 pp decrease. The average student success rate of Thermodynamics III is 69% and that of Thermodynamics II is 79%. That is a 10 pp increase. Strengths and Mechanics were the reason of the pp decrease in this comparison. Although it is not substantial, it is evident. It is likely that Strengths I fails to cover the essential concepts to ensure most students can achieve strong marks for Strengths II. Interventions ought to be implemented, for example, examining and ensuring the literature for Strengths I is adequate to ensure students are better equipped to handle Strengths II.

When considering the overall pp difference in S3, there is a 5 pp decrease for the BET modules, suggesting that there is no improvement in the student success rates on the BET modules. The increased entrance requirements cannot be mentioned here as it is no longer dealing with first-year modules.

Table 4-22 Similar modules for semester four (BET vs ND)

ND/BET Module	**Success rate (%)**												
	’07		**’08**		**’09**		**’10**		**’18**	**’19**	**’20**	**’21**	**Avg.**
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**					
ND Applied Strengths III	77	64	17	63	72	54	29	45					**50**
BET Strengths III											28	73	**51**
ND Theory of Machines III	45	56	59	92	84	67	60	48					**65**
BET Mechanics III											97	75	**86**
ND Steam Plant III	91	44	56	63	72	70	91	68					**75**
BET Thermodynamics III											87	99	**93**
ND Hydraulics III	77	71	68	63	72	81	60	72					**71**
BET Fluids III											92	98	**95**
ND Maths III	75	46	61	79	70	85	80	57					**73**
BET Eng Math 2A *										75	77	74	**75**

Faculty success rate - *

Table 4-22 above shows Semester Four (S4) ND modules and other similar modules in the BET programme. Applied Strengths III (ND) is deemed similar to Strengths III (BET), Theory of Machines similar to Mechanics III, Steam Plant III similar to Thermodynamics III, Hydraulics III similar to Fluids III, and Maths III similar to

Engineering Maths 2A. The faculty success rate is used for Engineering Mathematics 2A, as this was the only information available.

The average student success rate of Applied Strengths III (ND) (over eight semesters) is 50%, while that of Strengths III (BET) (over two semesters) is 51%, resulting in a 1 pp increase.

The average student success rate of Theory of Machines III is 65% and that of Mechanics III is 86%. That is a 21 pp increase. According to the lecturer interviewed, who taught both modules, the modules' content are broadly similar with the same difficulty level. The lecturer noticed greater engagement and focus levels by students in the BET programme for Mechanics III but also indicated that online classes may have further affected the student performance. The lecturer highlighted that attendance and time management was a concern during 2020 and 2021 (during the pandemic lockdown). However, considering that the modules were similar in content and have a similar difficulty level, the increased student success rates In Mechanics III could be attributed to the greater level of engagement and focus of the students and having classes online.

The average student success rate of Steam Plant III is 75% and that of Thermodynamics III is 93%. That is an 18 pp increase.

The average student success rate of Hydraulic III is 71% and that of Fluids III is 95%, constituting a 24 pp increase. According to the lecturer interviewed (who taught both modules) approximately 80% of the content is overlapped. Despite the content being largely similar, there were variations in assessment, particularly additional assignments and projects necessary to meet GAs. The lecturer also mentioned the online classes in 2020 and 2021 may have been a positive factor, even though attendance was an issue. The lecturer indicated that the academic preparedness and engagement level of students were similar for both modules. It can be stated that the increased Fluids III student success rate is due to the variations in how the content is assessed as opposed to how Hydraulics III was assessed. The extra assignments and project work may be aiding the students' performance. Moving to online classes may have also impacted the student success rate further, as validated by the study of García-Alberti *et al.* (2021).

The average student success rate of Maths III is 73%, and that of Engineering Maths 2A (over 3 semesters) is 75%. That is a 2 pp increase.

When considering the overall pp difference in S4, there is a 66 pp increase for the BET modules. These are, once again, huge improvements in student success rates. With each successive year, the average Mechanics student success rates have increased. This is the same scenario with Thermodynamics and Fluids. The increased entrance requirements cannot be mentioned here, as they relate solely to first-year modules.

Three out of four semesters indicated a positive change on the student success rate in BET modules as compared to their similar ND modules. The pp increase for the BET in S1 and S2 is a positive indictment on the increased entrance requirements. For S2 and S3, Strengths was predominantly the problematic module which caused a decrease in pp. Overall, the BET modules are producing greater student success rates than the ND modules. However, attention needs to be placed on Strengths of Materials.

4.7 Conclusion

This Chapter aimed to offer a comprehensive presentation, analysis, and interpretation of the data collected from the DUT's MIS, class lists and lecturers who taught within the BET programme in the Department of Mechanical Engineering.

Through categorization of the qualitative data obtained from the focus group studies, the recurring themes observed across the sub-studies include the fact that protest actions impede lessons, forcing students to self-study, the imposed lockdown during 2020 and 2021 eliminated the possibility of contact learning, specifically on-campus support services, and that lecturers experienced challenges to rapidly transition to online emergency remote teaching and learning during the lockdown. Additionally, a minimum of 60% scores in NSC Maths and Physics, and a combined minimum score of 120, is needed to ensure optimal success and throughput rates.

Finally, while the assessment of GAs does not adversely impact the throughput rate of students, the offering of 'back-to-back' 'bottleneck' modules is beneficial, but the dearth of enrolments in S1 overpowers the benefit of the increased success rates. It also requires students to remain focused, and not take the initiative for granted. However, some students are not aware of the ‘back-to-back’ offering, prompting the need for an automatic re-registration system to improve the throughput rate.

The subsequent Chapters will present the study’s conclusions, and recommendations.

Chapter 5 – Conclusions and Recommendations

5.1 Introduction

The five sub-studies comprising this dissertation enabled a better understanding of the success of BET Mechanical Engineering students at DUT, thus indicating the success of the program since its inception in 2018. Specific conclusions for each sub-study are presented in this Chapter. The purpose of the conclusion is to summarise the analysis, reiterate the significance of the research, and propose recommendations for improvement. The Chapter further addresses the study's limitations, and proposes where future research can be conducted.

5.2 Summary of Findings

5.2.1 Success Rates Analysis

For the Year One modules, the average student success rate, excluding Strengths of Materials I (48%) and Mechanics of Machines I (56%), exceeded 64%. Seven out of 12 modules' average student success rates were distinctions (greater or equal to 75%), indicating strong academic performance in those modules. Considering that the DHET student success rate norm is 80%, whereas typical engineering programmes have lower success rates (Pocock 2012), a 70% benchmark was deemed more appropriate. Nine out of 12 modules were above the 70% benchmark, while three of the twelve modules were below the benchmark with Strengths I being significantly below the benchmark at 48%. Modules with success rates between 70% and 80% should be monitored to maintain the success rates in subsequent cohorts, while interventions are recommended for modules with lower success rates.

Considering that the student success rates for Strengths I and Mechanics I is significantly lower than the benchmark, necessary and immediate interventions are recommended. Such recommendations include appropriately configuring student support services, enabling more tutoring services for students. Additionally, the curriculum should be slightly modified to bridge a possible gap between high school and the first-year university modules. Several lecturers noted that due to student protests, time was lost, and students were required to catch up on their own. Consequently, the lost time could have adversely affected the first-year student success rates. Most of the first-year modules saw an increase in student success rates when the classes were moved online. With the first-year modules there appears to be no significant relationship between student success rate and the class size; aligned with the notion that there exists an unclear correlation between class size and student performance (Hanushek 1986, 1989; Slavin 1989; Nye, Hedges and Konstantopoulos 1999).

For the Year Two modules, the average student success rates, except Strengths II, exceeded 60%. The Strengths II student performance was better than Strengths I (59% from 48%), possibly indicating that students better grasped the content with time, or that the assessments are more aligned. However, it is still below the 70% benchmark. For eight out 12 modules, the average student success rate is 70% and greater. Masked by most of the positive average student success rates, CAD and Design II success rates for 2021 were poor, especially in comparison to its 2019 and 2020 success rates. CAD should be given additional time to determine whether the success rate improves in 2022.

It was noted from certain lecturers of the second-year modules that protest action affected the lecturing and may have adversely affected the student success rates. Additionally, the student support services for many second-year modules halted during 2020 and 2021 and may have negatively affected the students' performance. Lecturers of the second-year modules also stated that there were many struggles experienced in online classes which could have affected the students' performance, validated by the findings of García-Alberti *et al.* (2021). However, with the second-year modules there appears to be no significant relationship between student success rate and the class size (Nye, Hedges and Konstantopoulos 1999).

For all the Year Three modules, the average student success rates exceeded 70%, except (Strengths of Materials III). The Strengths III average student success rate is 51%, an 8 pp drop from that of Strengths II. It was noted from the Design III and Strengths III lecturers that protest action may have adversely affected the student success rate. As with the Year Two modules, the students' performance during 2020 and 2021 may have suffered due to the lack of student support services. Another recurring theme is that the lecturers faced challenges in transitioning to online classes, which may have adversely impacted the students' performance.

Nine out 12 third-year modules had pass rates above 75%, with seven of those nine exceeding 90%. This provides an indication that the third-year modules are appropriately aligned. The average student success rate of the third-year modules exceeded that of second-year modules, and first-year modules; indicating that students tend to better grasp modules as they progress further in the engineering years.

The average student success rate for all the academic years were 74% and greater, with Year Three being the highest (86%). Considering that the 80% DHET standard for Engineering modules is unrealistic, and a pragmatic target of 70% is realistic, the average of each year is over 74%, which is a good indication of cohort performance. Year Three is the most successful, possibly attributed to the fact that students have a solid basis in their Engineering courses and, by the third year, can successfully apply relevant concepts to new areas of study. Furthermore, poorer performing students may have failed or dropped out, resulting in the third-year cohorts being filled with the higher performing students. 2020 was the first potential year for students to be in their third year of study, implying that this cohort succeeded without failing modules, and was therefore a group of high-achieving students. More data for the following years is needed to better assess the third-year student success rate. The Strengths modules are problematic for all the years being offered, for which interventions are recommended. There is also the consideration the average class size in the third-year modules were smaller than the other years' average class sizes which may have positively impacted the student success rates in the third year, as explained in the studies of Blatchford *et al.* (2002) and (Harfitt 2013).

5.2.2 Relationship between NSC Results and Success in Mechanical Engineering

The first step in investigating whether the entrance requirements were suitable was to determine whether there was a correlation between NSC results and first-year engineering modules. If there was a correlation, then the acceptable entrance requirements can be determined. The normality test (used to ascertain if PCC could be used) proved that the data was not normally distributed. Consequently, Spearman's correlation was used.

Upon investigation using Spearman's correlation, positive correlations (although weak) between the NSC subjects and first-year engineering modules were found. Consequently, it was possible to test whether the entrance requirements were suitable. NSC Maths and NSC Physics were further used to ascertain the adequate entrance requirements.

When analysing the average NSC Maths mark against the first-year Engineering modules, it is notable that 50% was too low, as students who attained between 50%-59% for NSC Maths performed poorly on average for the first-year modules. It can be concluded that the minimum required NSC Maths mark should be 60% (as per the benchmark that a minimum of 3/5 percentages should exceed 50%), to ensure a greater success in Mechanical Engineering at DUT. The same situation exists for the average NSC Physics marks. Hence, the NSC Physics entrance requirement should be 60% or greater.

The current entrance requirements of 120 was found to be suitable, and this aligns with the investigation done by (Walker and Graham 2013). The average student success rate for each module exceeds 50%, except for Strengths I (48%). If the entrance requirements were to be increased, this would require greater marks from Matric students. Furthermore, there is no substantial difference in student success rates between the '120-129' group and the '130-139' group. Except for the '160-200' group, the average success rate for Strengths I is consistent for all the other 'NSC P+M' groups. Unsurprisingly, those who achieved between 160-200 for their 'NSC P+M' performed the best. The combined NSC Maths and Physics entrance requirements are appropriate, but not ideal and should be left as-is. If the entrance requirement of 60% NSC Maths and 60% NSC Physics is introduced, it is recommended that this investigation be repeated.

5.2.3 Graduate Attributes and their Effect

All third-year students must pass the GA assessments incorporated in the modules. There was concern that the introduction of GA assessments would adversely impact student achievement and throughput, in the sense that students might fail a module primarily because they failed a GA. This may be problematic if a substantial percentage of students were failing modules due to failing the GA assessments.

During the two-year study period, 23 students failed GA assessments. Even if they had passed the GA assessment, 22 of them would have still failed the module. In these 22 instances, the GA assessment had no effect on the students failing the module. Thermodynamics III is the only module in which a student passed all the assessments, but failed the GA. Thermodynamics III incorporates GA 4 (Investigations, experiments, and data analysis). This is a GA that is unrelated to the module topic, and is assessed by a laboratory/practical study and report. Given that 101 students enrolled for this subject over a two-year period, this single failure is an aberration, and cannot be deemed important. Hence, it can be concluded that the GA assessments had no substantial negative impact on success and throughput over the investigated years. As the years pass, this study may be extended to include the forthcoming cohorts.

5.2.4 'Back-to-back' Modules

Strengths of Materials I and Mechanics of Machines I are referred to as 'back-to-back' modules, since they are offered in semesters 1 and 2 as of 2020. In 2018 and 2019 they were only offered once per year, in the second semester. Essentially, the second semester is the first offering of the module, and the first semester is for repeating students. This study investigated the efficacy of offering these modules in the first semester for student progression and success. Upon analysis, for both modules, a greater student success rate was observed in the first semester when compared to the second semester due to the smaller class size and a larger percentage of repeating students.

The lecturers' responses also supported the analysis that the smaller class sizes enabled the students to be more engaged, which increased the first semester student success rate (Bourke 1986; Finn and Achilles 1990). Mechanics I lecturer supported the 'back-to-back' system, believing that it gives another chance to the student to catch up or complete their remaining higher-level modules within the required time. However, the Strengths I lecturer believes that if the students know that a module will be offered again in the following semester, they tend not to take it seriously knowing that they will get a second chance.

The greater student success rates in the first semester are masked by the significantly lower number of students registered in the first semester. Too many students who fail the modules in the second semester (when the module is first offered) do not repeat them the following semester (semester 1 of the following year). If all the students who failed the first attempt in the second semester could automatically be registered for the modules the following semester (semester 1 in the next year), this intervention has the potential to be studied further to evaluate its success. The lecturers both supported an automatic re-registration system to ensure a suitable class size in the second offering of the modules.

According to the University's requirements, students can only register for the three-year degree five times, implying that a student can only fail two academic years. However, some students were found to be taking a first-year module for the fourth time, making it difficult to complete the degree. Instead of placing unnecessary financial strain on the student, it is recommended that the university devises a system that automatically deregisters students after a given number of fails.

5.2.5 National Diploma vs. BET

The entrance requirements have increased from the ND programme for the new BET programme. The student success rate of BET modules deemed similar to modules taught in the ND programme were compared to determine if the BET is producing greater student success rates than the ND.

The student success rate of BET modules, in total, were higher in three out of four semesters when compared to similar ND modules. Strengths were the most troublesome module in semesters 2 and 3, resulting in a drop in pp. There are many instances where there are significant increases in student success rate. Various factors affected the significant increases, such as changes in student engagement, the difference in which the modules were assessed, changes in lecturers and transitioning to online classes. The pp increase for the BET first-year modules suggests a positive indication on the increased entrance requirements. Overall, the BET modules were found to yield greater student success rates than the ND modules. However, Strengths of Materials was identified as a bottleneck, and must be afforded the necessary interventions, accordingly.

5.3 Conclusions

The results of the study provided a “yes” to the first part of the overarching research question: “Is the new BET (Mechanical Engineering) at DUT successful?” and also provided practical recommendations concerning the second part of the research question: “…what interventions can be made to ensure its success?” In addition, each of the five sub-questions were adequately addressed through the five sub-studies comprising the dissertation using qualitative and quantitative (mixed-methods) data collection.

Aligning with the research questions, the overarching aims of the study sought to ascertain the success of the BET (Mechanical Engineering) program and identify interventions to ensure current and future success. Based on the extensive results yielded by the respective sub-studies, the success of the program was validated, despite the challenges encountered during disruptions (annual student protests and the COVID-19 pandemic lockdown during 2020 and 2021). The detailed recommendations provide practical pathways to address the broader challenges and specific module-linked challenges identified in the study. The objectives were linked to the sub-questions of the study, which were addressed through the five sub-studies. Therefore, the aims and objectives of the study were well met.

5.4 Summary of Contributions

This research contributes to addressing the issue of poor student success rates in the new BET (Mechanical Engineering) program at DUT relative to those proposed by the DHET (80%) and established South African engineering academics, such as Pocock (2012), by qualitatively and quantitatively determining the causes behind poor student success rates.

By following the proposed empirical framework (Figure 5-1), current and future lecturers within the Mechanical Engineering department at DUT can be guided to continue teaching and learning activities in emergency remote teaching and learning (ERT&L) mode to eliminate any losses in class time due to any possible disruptions (internally and externally) which can adversely affect student performance, success rates and throughput rates.

By thoroughly investigating the performance of the NSC candidates enrolled within the BET (Mechanical Engineering) program at DUT, the optimal entrance requirements (60% in NSC Maths, 60% in NSC Physics, and a combined score of 120) was determined. By implementing these entrance prerequisites, students better equipped to handle the cognitive demands of the program will be admitted, which will positively impact the success rates and overall throughput rates.

The effect of the 'back-to-back' module intervention for the 'bottleneck' modules was proven to have a positive effect on student success rate but the dearth of enrolments in the first semester is masking this benefit. The automatic re-registration system ought to be implemented to ensure a greater enrolment in the first semester offering.

The sub-studies collectively proved the efficacy of the BET (Mechanical Engineering) program at DUT, identified the critical challenges, categorized them into themes through the qualitative study, and yielded dynamic recommendations for improvement.

5.5 Suggestions for Further Research

Considering that the study focused on the 2018 to 2021 cohorts, data from subsequent cohorts can be interrogated to gain further insights and identify emerging challenges regarding the performance of the BET (Mechanical Engineering) program at DUT.

The recommendations proposed below can be systematically piloted as pedagogical interventions, and their effects monitored. If positive effects are observed, the interventions can be retained or modified for improvement in future cohorts.

Considering the enhanced student satisfaction and success rates achieved when teaching South African undergraduate engineering classes with the aid of 4IR technologies (such as game-based learning and virtual reality) (Roopchund and Seedat 2023) training sessions should be arranged for DUT Mechanical Engineering lecturers to promote technology-aided teaching and learning. Technology-aided pedagogical interventions can be captured as research studies, to be disseminated to the wider academic community. Future studies and further research could include focus interest group interviews with students to get their viewpoint.

5.6 Recommendations for Implementation

5.6.1 Overall Recommendations

This research focused on the 2018, 2019, 2020, and 2021 cohorts as the BET was only introduced in 2018. While analysing the data, it is noted that many other factors could influence success rates, and should be investigated in future studies. Firstly, third-year success rates were limited to two cohorts, as 2018 was the first year of the BET degree. Aligning with Section 5.5, it is recommended that more cohorts be used to investigate the success rates of the third-year modules to yield more thorough analysis and clearer results.

Noticeably, scores in 2020 were sometimes significantly different from those in 2019 and 2018. This could be a result of students studying remotely, and not being able to attend contact lectures. A study should be performed wherein the effects of online lectures on student success rates are investigated at DUT. Similarly, in 2021, hybrid classes were conducted. An investigation ought to be performed where the effects of hybrid lectures on student success rates are investigated at DUT.

It is also recommended that an investigation of the effects of COVID-19 on student success rates and student dropout rates be performed. These effects may have motivated many students to deregister. If the suggested entrance requirements are introduced (60% minimum entry mark for NSC Maths and NSC Physics), an investigation is recommended to determine the suitability of the new entrance requirements.

It was concluded that offering the ‘back-to-back’ modules is only partially effective, without an automatic re-registration system for repeating students in the first semester of the following year. If this system is introduced at DUT, its effects on student progression ought to be investigated. Alternatively, if the ‘back-to-back’ offering of Strengths and Mechanics is abandoned, then its effect on student success ought to be investigated.

5.6.2 Recommendations Linked to Challenge Themes

The three recurring challenge themes qualitatively categorized in Chapter 4 are depicted in Figure 5-1 below, which shows the links between the themes.

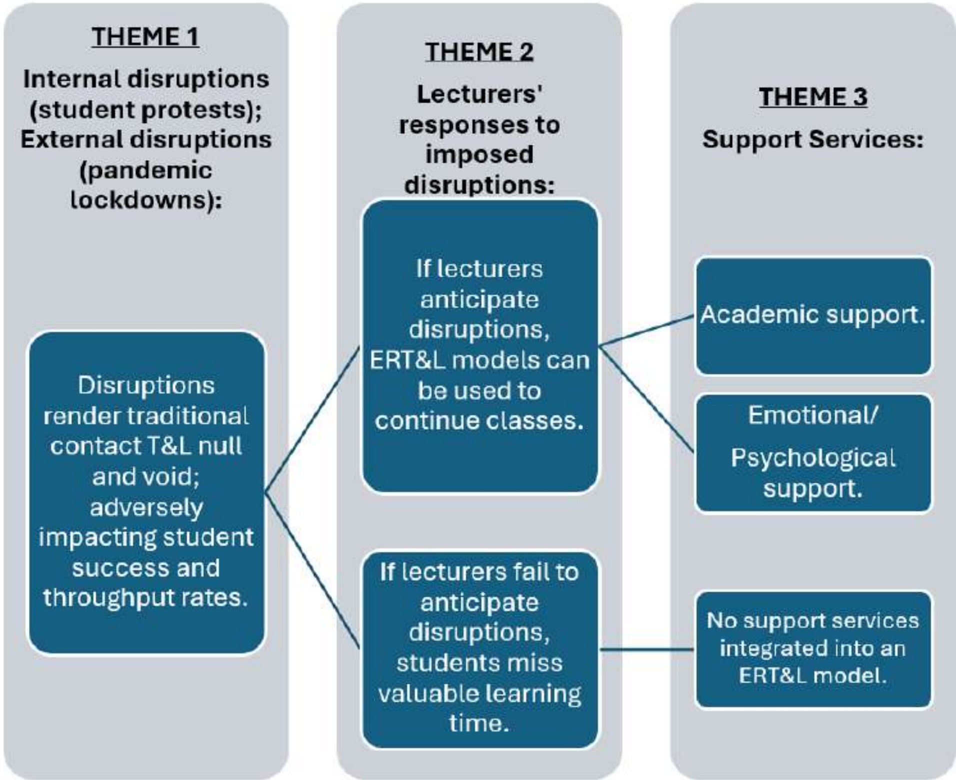

Figure 5-1 Links between the recurring challenge themes

As an internal disruption, protest actions are predictable, as they typically occur at the beginning of each academic year. Considering their recurrence at the same time each year, lecturers should be proactive in their response to transitioning to ERT&L models to prevent any loss in class time. Once the protests have been resolved, the lecturers can then continue with contact classes at the university. The ‘transient’ ERT&L model must be clearly explained to students in their learning guide to ensure that everyone understands the procedures and expectations for a seamless transition.

It must be noted that external disruptions, such as the pandemic lockdown, cannot be perceived as ‘once-off’ incidents. Other epidemics/pandemics may arise in future, which will once again force lecturers and students to use ERT&L strategies. To ensure that lecturers respond proactively to disruptions (internal or external) (Themes 1 and 2 in Figure 5-1), this study recommends an empirical framework (Figure 5-2) adapted from Roopchund (2022) that can be applied by the current and future academic staff within the Mechanical Engineering Department at DUT to seamlessly transition to ERT&L strategies, without any loss of class time, and with integrated support services (Theme 3 in 5-1) (tutors and campus mental health support professionals).

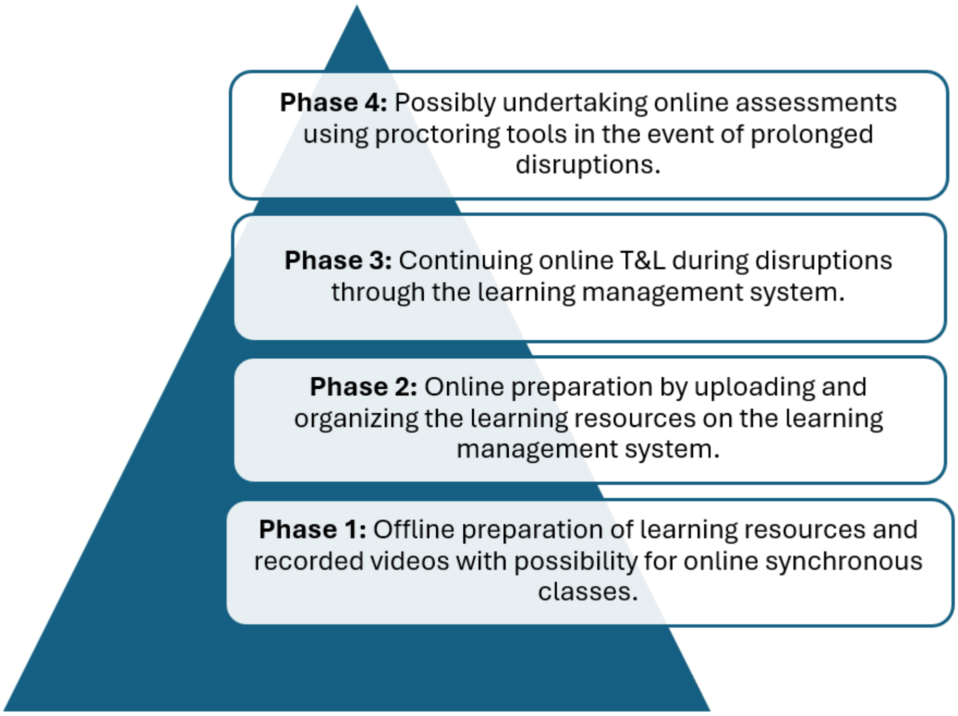

Figure 5-2 Empirical framework recommended for ERT&L during disruptions to contact classes.

This ‘transient’ ERT&L approach is beneficial to manage any possible disturbance to contact classes, which were qualitatively linked to poor student performance, success rates, and throughput rates in the BET (Mechanical Engineering) program at DUT.

The empirical framework coupled with the ‘back-to-back’ intervention should be maintained with an automatic re-registration system for repeating students and an awareness of the ‘back-to-back’ offering in the respective ‘bottleneck’ modules’ learning guides to ensure that students benefit from the intervention. To prevent students from taking the ‘back-to-back’ intervention for granted, a maximum failure limit must be imposed, which can exclude students from the program if their failure of the ‘back-to-back’ modules exceeds a predetermined limit. Equally, students must be informed of the failure limits in their learning guides.

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Appendix A – Further information on GAs

The GAs defined below are aligned to the ECSA document E-02-PT (Department of Mechanical Engineering 2016).

The graduate attributes are as follows:

Exit Level Outcome 1: Problem-solving

It is necessary to apply engineering concepts to methodically identify and solve mechanical engineering issues with wide definitions.

Exit Level Outcome 2: Application of scientific and engineering knowledge

It is necessary to address widely specified mechanical engineering issues, and to use knowledge of mathematics, natural science, and engineering sciences to define and apply engineering techniques, processes, systems, and methodologies.

Exit Level Outcome 3: Engineering design

It is necessary to perform procedural and non-procedural design of widely specified components, systems, works, products, or processes in accordance with relevant standards, codes of practice, and regulations to satisfy desired goals.

Exit Level Outcome 4: Investigation

It is necessary to conduct studies into broad-defined problems by discovering, searching, and choosing relevant data from codes, databases, and literature, whilst developing, and conducting experiments in addition to analysing and interpreting outcomes to arrive at valid conclusions.

Exit Level Outcome 5: Engineering methods, skills, tools, including information technology

For the solution of broadly specified engineering issues, it is necessary to be able to use suitable approaches, resources, and current engineering tools, such as information technology, prediction, and modelling, with an awareness of the relevant limitations, restrictions, premises, assumptions, and constraints.

Exit Level Outcome 6: Professional and technical communication

It is necessary to effectively communicate with engineering audiences and impacted parties, both verbally, and in writing.

Exit Level Outcome 7: Impact of engineering activity

It is necessary to demonstrate knowledge and comprehension of the influence of engineering work on society, the economy, the industrial environment, and the physical environment, as well as the ability to analyse and evaluate situations.

Exit Level Outcome 8: Individual and teamwork

It is necessary to demonstrate knowledge and comprehension of engineering management concepts and the way one would apply these to one's own work as a team member, leader, and project manager.

Exit Level Outcome 9: Independent learning

Through well-developed learning skills, it is necessary to engage in autonomous and life-long learning.

Exit Level Outcome 10: Engineering professionalism

It is necessary to understand and implement ethical concepts, as well as commit to engineering technology practice's professional ethics, obligations, and standards (Department of Mechanical Engineering 2016).

Development and assessment of graduate attributes for Mechanical Engineering

Where the graduate attributes are assessed, the Department follows the following principles (Department of Mechanical Engineering 2020):

- GAs are assessed according to ECSA documents E-02-PT or E-09-PT;
- GA development and assessment is embedded in modules as per the matrix;
- GAs may be developed implicitly or explicitly;

- Each GA must be developed explicitly once at Level 1, and explicitly once again at Level 2;
- where a GA is developed explicitly, the study guide must contain a reference to the GA and the range statement, and explain the way in which the GA is to be developed;
- where a GA is developed implicitly, it may contribute in a minor way towards the development of the GA; and
- each GA must be assessed once at the exit level.

The assessment is guided by a rubric, which is derived from the respective range statement and associated assessment criteria.

- The assessment rubrics, range statement, and associated assessment criteria are shown in the relevant module study guide.
- In the event of students not demonstrating competence, according to the assessment criteria of the rubric, they will be permitted to correct inadequacies in the work, and re-submit.
- The module in which the GA is assessed will be failed if competence in the GA is not demonstrated after resubmission.
- All assessments of GAs are externally moderated to meet both DUT and ECSA requirements.
- GAs are recorded on the MIS system, in a separate column, with 1 indicating ‘competence demonstrated’, and 0 indicating ‘competence not demonstrated’.
- Evidence of GA assessments are kept in their respective subject files.

Table 0-1 DUT GAs and ECSA GAs (Department of Mechanical Engineering 2020)

DUT Graduate Attributes		**ECSA Graduate Attributes**									
		Problem-solving	Scientific & Eng. Knowledge	Engineering Design	Investigation	Eng Methods, Skills, Tools & IT	Communication	Impact of Eng. Activity	Individual & Teamwork	Independent Learning	Engineering Professionalism
		1	2	3	4	5	6	7	8	9	10
Critical and creative thinkers who work independently and collaboratively	1			**X**	**X**				**X**		
Knowledgeable practitioners	2	**X**	**X**	**X**		**X**					**X**
Effective communicators	3						**X**				
Culturally, environmentally and socially aware within a local and global context	4							**X**			**X**
Active and reflective learners	5									**X**	

Level Descriptor: Broadly-defined engineering problems

a) necessitate a thorough understanding of the technical principles that support the technology; and one or more of the following characteristics (Engineering Council of South Africa 2020);

   i) are ill-posed, under-, or over-specified, or require identification and interpretation within the technological domain;
   ii) include systems inside complex engineering systems; and
   iii) pertain to families of issues that are treated in well-accepted yet novel methods.

b) and their solutions have one or more of the characteristics (Engineering Council of South Africa 2020):

   i) can be solved using structured analytical approaches;
   ii) may be partially outside of standards and codes; reason for operating outside is required;
   iii) necessitate incomplete information from the practice area and sources engaging with the practice area; and
   iv) entail several challenges that may result in competing demands and limits; technical, engineering, and interested or affected parties are all involved.

Appendix B – Ethical Clearance and Consent Form

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

6 June 2024

Mr S Sheoratan
5 Hadden Place

Hillary

Dear Mr Sheoratan

Application for Amendment of Approved Research Proposal

Investigating the efficacy of the Bachelor of Engineering Technology Degree in Mechanical Engineering at the Durban University of Technology
Ethics Clearance Number: IREC 005/22

I am pleased to inform you that your application for amendment to the title of your study and the addition of focus group discussions to your study has been approved.

Yours Sincerely

Dr K Padayachy
Deputy Chairperson: DUT-IREC

Figure 0-1 Ethical Clearance

CONSENT

Full Title of the Study: Investigating the efficacy of the Bachelor of Engineering Technology Degree in Mechanical Engineering at the Durban University of Technology

Names of Researcher/s: Shoreek Sheoratan

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, _____________ (Name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: IREC 005/22 ,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____________________ _________ ______ _______________

Full Name of Participant **Date** **Time** **Signature / Right Thumbprint**

I,(name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________ _________ ___________________

Full Name of Researcher **Date** **Signature**

_________________ _________ ___________________

Full Name of Witness (If applicable) **Date** **Signature**

_________________ _________ ___________________

Full Name of Legal Guardian (If applicable) **Date** **Signature**

Figure 0-2 Consent Form

Appendix C – Focus group session questions

Table 0-1 Questions for Success rate analysis

Question	Motivation
1. Which module(s) do you teach and will be answering questions for? If you teach multiple (two or more) modules, please answer each question for each module.	To understand which module is being dealt with.
2. Is/are this/these module(s) purely calculation based? Or theory based? Or a combination of both?	This question allows the researcher to ascertain if the engineering students are performing better on calculation-based modules or theory-based modules or a combination of both.
3. Were there any curriculum changes (e.g. new topics/assessment methods/course materials) or instructional design changes (using teaching innovations) that occurred during 2018 to 2021? If so, what were the changes, and in which year were they implemented?	To understand if any internal factors within the lecturers' control could have caused a fluctuation in the modules' success rates from one year to another.
4. Did the availability and accessibility of student support services and resources (such as tutoring, academic support systems and advising) change between 2018 to 2021? If so, what were the	To understand if any internal factors beyond the lecturers' control could have caused a fluctuation in the modules' success rates from one year to another.

changes, and in which year were they implemented?	
5. Were there any significant student protests in the years 2018-2021 that may have impacted your module success rate? For which year(s) was this? Were there any other challenges you experienced teaching the BET curriculum? If so, how did you overcome them?	To understand if any local external factors could have caused a fluctuation in the modules' success rates from one year to another. Identifying such challenges in curriculum delivery can shed light on potential barriers to success and provide opportunities for improvement.
6. Was/were this/these module(s) taught at campus or online (during the Covid-19 pandemic lockdown)? If so, which year(s) was it taught online?	To understand how the student success rates were impacted by the global external factor of transitioning to online teaching brought on by the Covid-19 pandemic lockdown. This deviation from traditional pedagogical practices counts as an external factor comprising economic, societal, and technological disruptions.

Table 0-2 Questions for 'back-to-back' modules

Question	Motivation
1. Which 'back-to-back' module do you teach? Strengths of Materials I or Mechanics of Machines I?	
2. How do you think offering the module 'back-to-back' has impacted students' success rates and dropout rates?	This question will help understand the lecturers' perspective on whether offering these modules consecutively has positively affected students' ability to complete them successfully within a shorter timeframe.
3. Are students more engaged in the smaller class sizes (in the first semester) due to the module being offered in both semesters?	Understanding how students are responding to the consecutive offering of these modules can provide valuable insights into their effectiveness in promoting engagement and motivation.
4. Do you believe that an automatic re-registration system should be implemented for students who fail your module the first time? i.e. the student is automatically enrolled into the second offering of the module in the next semester.	To gauge the lecturer's perspective on whether an automatic re-registration system should be implemented to address the high failure rate in the module.
5. Based on your experiences, do you believe continuing to offer your module	The lecturers' perspective is valuable in determining whether the current scheduling approach is conducive to

back-to-back is good for students' overall throughput through the BET program?	student success and should be maintained.
6. (a) Were there any disturbances during the teaching of this module? (b) Was there a part time lecturer? (c) Was this module taught online due to COVID? If yes to any of the above, please specify which situation exists and for which year and semester.	To understand if any factors may be affecting the modules' student success rates

Table 0-3 Questions for National Diploma vs. BET

Question	Motivation
1. Which module(s) do you teach and will be answering questions for? If you teach multiple (two or more) modules, please answer each question for each module.	To understand which module is being dealt with.
2. In what respect is your BET module similar to its 'similar deemed module' (please see above Table)? Is it the same lecturer teaching this module who taught the National Diploma (ND) module? Please specify the year if there were changes. Does it have a similar level of difficulty? Are the contents of the module similar?	This question would allow the author to gauge whether the 'similar deemed modules' are truly similar and with what respect are they similar.
3. How do you perceive the academic preparedness and engagement level of students in your similar module(s), considering teaching quality and student support services?	This question expands on the factors influencing student readiness and engagement by considering the impact of teaching quality and support services on student success rates.
4. Have you encountered any trends in student performance in your similar module(s), considering any differences in class size, class composition, students' time management and workload?	This question broadens the scope of student performance analysis to include considerations of class size and composition, which can influence peer learning opportunities and classroom dynamics.

5. How would you describe the overall quality of work exhibited by students in your similar module(s), considering any differences in teaching technologies and resources?	This question highlights the impact of technological resources and learning materials on student performance and engagement in similar modules.
6. Based on your experiences, do you believe that the higher entrance requirements of the BET program are contributing to improved student success in your similar module(s), considering external factors such as students' socio-economic circumstances?	This question acknowledges the potential impact of external factors on student success rates and prompts the lecturer to consider these factors in their assessment of the BET program's entrance requirements.

Appendix D – Publications

WEEF & GEDC
partnering with AEEA Conference
Cape Town – South Africa | 28 November–1 December 2022
Adapting to Global Disruption

Prof Sunil Maharaj (General Conference Chair)
University of Pretoria
Private Bag X20, Hatfield, 0028
South Africa

Shoreek Sheoratan
Durban University of Technology
Mechanical Engineering
5 Hadden Place Hillary
4094 Durban
South Africa

20/Dec/2022

To Whom It May Concern

Dear Madam or Sir,

We confirm that **Shoreek Sheoratan** participated at World Engineering Education Forum & The Global Engineering Deans Council (WEEF&GEDC 2022).

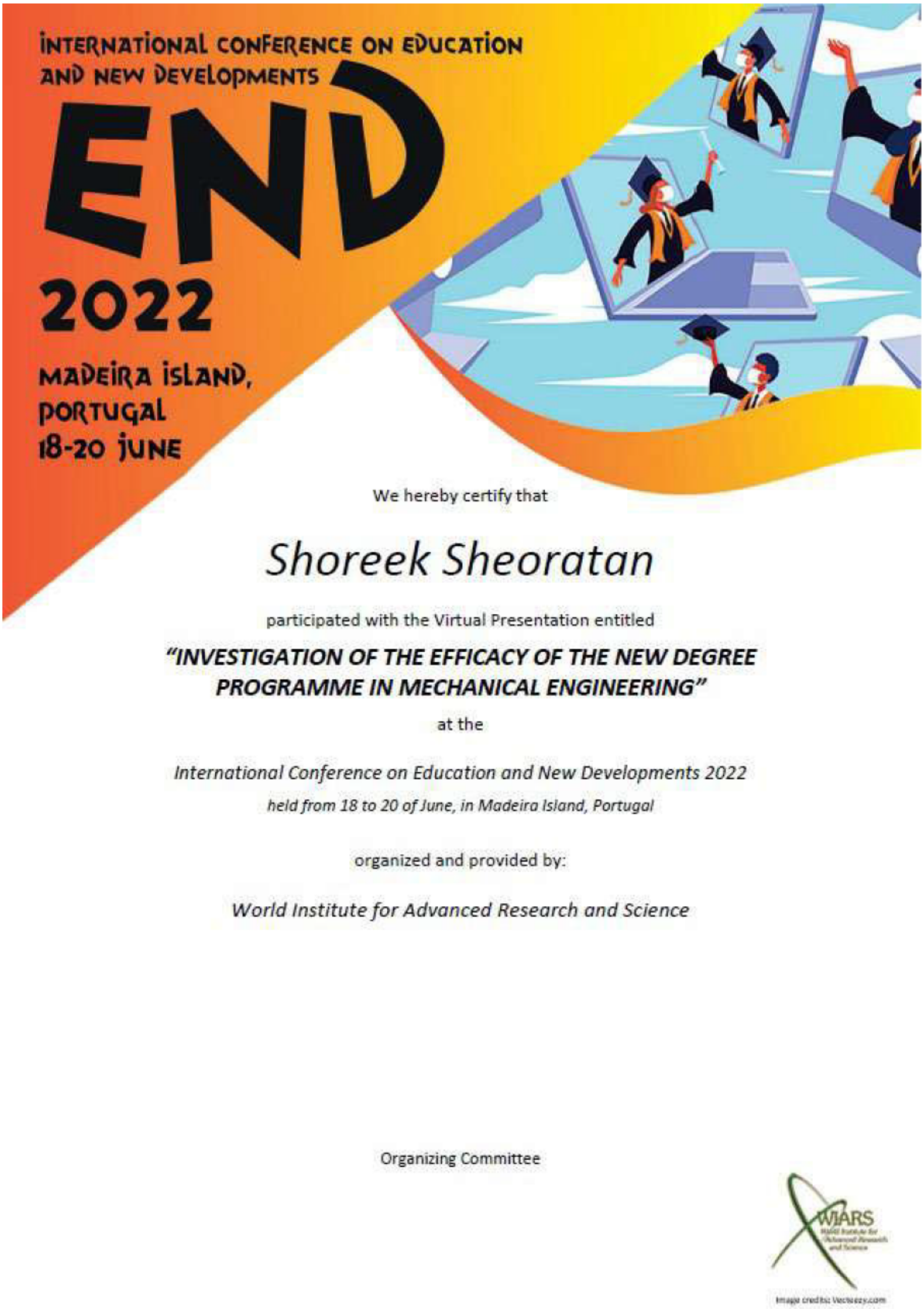
Shoreek Sheoratan is author/co-author of the following accepted contribution(s):

ID: 2112
THE EFFECT OF INTEGRATING GAs INTO THE CURRICULUM ON THE DESIGN OF A NEW 3-YEAR MECHANICAL ENGINEERING DEGREE AT DUT
Author(s): Walker, Mark; Graham, Bruce; Sheoratan, Shoreek
Presenting Author: Sheoratan, Shoreek
Submission Type / Conference Track: Poster Submission (Abstract + Poster)

With best regards,

Prof Sunil Maharaj
General Conference Chair
WEEF & GEDC / AEEA 2022

Figure 0-1 WEEF and GEDC



INTERNATIONAL CONFERENCE ON EDUCATION AND NEW DEVELOPMENTS

END 2022

MADEIRA ISLAND, PORTUGAL

18-20 JUNE

We hereby certify that

Shoreek Sheoratan

participated with the Virtual Presentation entitled

"INVESTIGATION OF THE EFFICACY OF THE NEW DEGREE PROGRAMME IN MECHANICAL ENGINEERING"

at the

International Conference on Education and New Developments 2022

held from 18 to 20 of June, in Madeira Island, Portugal

organized and provided by:

World Institute for Advanced Research and Science

Organizing Committee

WIARS

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Figure 0-2 END 2022

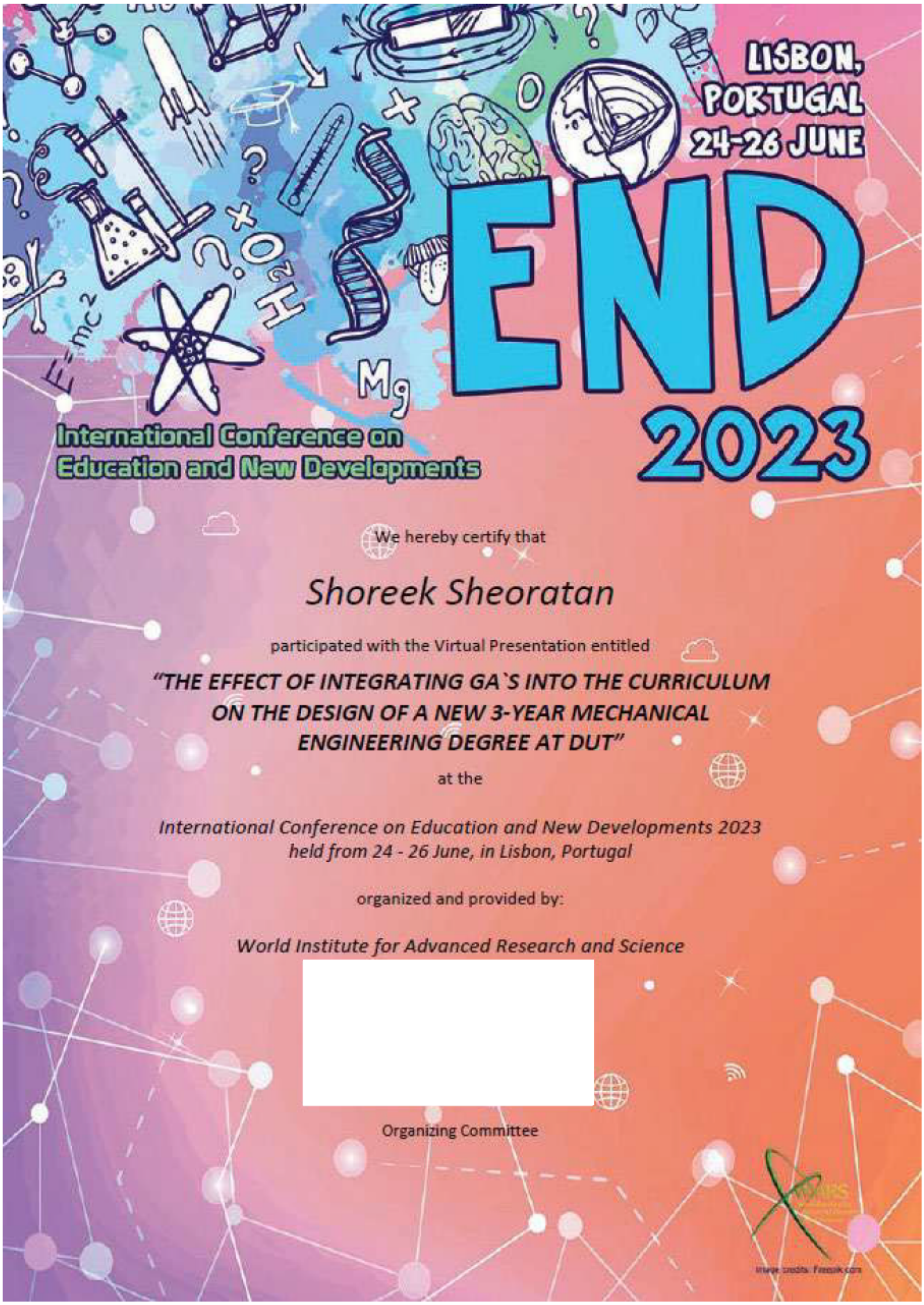

Figure 0-3 END 2023