Using the COMET diagnostic model to enhance occupational competence of Electrical Engineering students in TVET colleges.

James Sibanda

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD)

Faculty of Education
University of Western Cape

Supervisor: Prof. J. Papier
Co-Supervisor: Dr. P. Jacobs

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Dedication

This thesis is dedicated to my family and friends. A special word of gratitude to my parents Simon Fernando Sibanda and Marita Tapuwa Sithole and my partner Lebogang Mankwana Moepye who supported me and encouraged me to complete this study. I also dedicate this thesis to my children (Lefa, Gregory, Bokang Tendanyi, Bokamoso Tinotendamambo, and Bokang James Jr) from whom I spent a lot of time away during this study. All of you have been my best supporters. Not forgetting my late friend Tshepo Nicholus Mokwena who was brutally murdered at a critical stage of this study. May his soul rest in peace.

I am truly thankful to have you in my life.

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Many thanks go to my fellow COMETeers, Adhir Hanjunlal and Mogamat Adiel Arnold. You have been there for me throughout this journey. Without you this journey was going to be extremely difficult. I cannot really thank you enough.

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May God bless all of you.

Abstract

It is common cause that rapid digitisation and automation of industries has resulted in new challenges for current and future labour markets in which automated systems are constantly raising the complexity of tasks and demanding higher skills for entry-level positions. TVET colleges are seen as key institutions for training that is responsive to industry and skills needs, but there has been ongoing concern about the quality of TVET graduates, and whether the training offered at TVET colleges produces graduates with cutting-edge knowledge and skills. It has been argued that one of the ways to improve the quality and occupational competence of TVET graduates is a focus on teaching and learning, hence this research that shines a light on current teaching models and investigates what might improve poor throughput rates. The COMET (*Competence Measurement in Electrical Technology*), three-dimensional Diagnostic Model showed potential in earlier studies to both measure and develop occupational competence in TVET, but to date there has been no study to specifically explore the didactic application of the model, which is the knowledge gap addressed in this thesis. A longitudinal study was undertaken in the TVET Electrical Engineering domain to investigate how the COMET diagnostic model might be applied didactically in the quest to enhance the occupational competence of students at TVET colleges in South Africa**.** A mixed-methods sequential explanatory research design was adopted in which quantitative and qualitative data were collected from a purposive sample representative of five TVET colleges across four South African provinces. Open-ended test tasks inspired by authentic industry activities were designed to develop and test students' holistic problem-solving capabilities and their occupational competence. A large Cohen effect size value (d = 0.8) is reported between the professional occupational competence profiles of participating TVET students in the Baseline and Main Tests, which offer compelling evidence of the COMET diagnostic model's didactic enhancement of TVET Electrical Engineering student's occupational competence development in the current investigation. These findings highlight the COMET model's didactic potential to assess and develop occupational competence in TVET Electrical Engineering and underscore the COMET model as a valuable didactic tool that South African TVET colleges can implement, in order to bridge the existing divide between competence development at TVET institutions and industry-related occupational competence required for entry level positions. The findings of this research provide strategic guidance for assisting TVET students to achieve the holistic problem-solving competence that would be valuable to modern societies and work. Moreover, this study has the potential to inform other TVET programmes and to become a necessary didactic tool for college educators.

KEYWORDS:

Occupational Competence; COMET Diagnostic Model; Technical Vocational Education and Training (TVET); Electrical Engineering; Didactics; NC(V) Programme

Declaration of Authenticity

I, James Sibanda declare that the thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD) in the Faculty of Education at the University of the Western Cape, is my own, original work, and that it has not been submitted for any degree or examination at any other university. All sources used or referenced have been indicated and acknowledged according to the specifications of Version 6 of the American Psychology Association's referencing system.

18-06-2023

James Sibanda   Date

Certificate of Proof Reading and Language Editing

Faculty of Education

Cape Peninsula University of Technology

Jan van Riebeek Road

Wellington

7654

24/4/2023

To whom it may concern,

This letter serves to inform you of the fact that I undertook standard editing procedures for the doctoral thesis entitled:

Using the COMET diagnostic model to enhance occupational competence of electrical engineering students in TVET colleges

The editing process included the following:

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- Correction of active and passive voice errors
- Transitional phrasing
- Continuity of thoughts
- Supporting statements and argumentation

Thank you for your consideration in this matter.

Yours sincerely

Prof Candice Livingston

Associate Professor (English) and Research coordinator

Faculty of Education

Cape Peninsula University of Technology

livingstonc@cput.ac.za

Ethical Clearance Certificate

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I hereby certify that the Humanities and Social Science Research Ethics Committee of the mentioned research project.

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Please remember to submit a progress report by 30 November each year for the duration of the project.

The permission to conduct the study must be submitted to HSSREC for record keeping purposes.

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Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Director: Research Development
University of the Western Cape
Private Bag X 17
Bellville 7535
Republic of South Africa
Tel: +27 21 959 4111
Email: research-ethics@uwc.ac.za

NHREC Registration Number: HSSREC-130416-049

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

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List of Acronyms

CIP-Continuous Improvement Process

DeSeCo- Definition and Selection of key Competence (DeSeCo)

DFG-German Research Foundation

DHET-Department of Higher Education and Training

DIPF-German Institute for International Educational Research

FET- Further Education and Training

G20- Group of Twenty

GMI-The German-Malaysian Institute

ITB- Institute Technology and Education, University of Bremen

JCA-Job Competence Assessment

KMK- Kultusministerkonferenz

NC(V)-National Certificate Vocational

NIC- Newly Industrialised Country

NQF-National Qualifications Framework

NSDS III-National Skills Development Strategy

NVQ-National Occupational Qualifications

OECD-Organisation for Economic Co-operation and Development

PBL- Problem-Based Learning

PISA- Programme for International Student Assessment

PSET-Post-School Education and Training

QCTO-Quality Council for Trades and Occupations

SVQs -Scottish Vocational Qualifications

TIMSS- Trends in International Mathematics and Science Study

TLP- Teaching and Learning Plan

TQM-Total Quality Management

TVET-Technical and Vocational Education and Training

UK-United Kingdom

UNESCO- United Nations Educational, Scientific and Cultural Organisation

USA-United States of America

VET- Vocational Education and training

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Chapter 1

Introduction and Background

1.1 Introduction

The National Digital and Future Skills Strategy (Department of Communications and Digital Technologies, 2020, p. 16) reports that South Africa is currently experiencing a serious skills shortage that could inhibit the economy from thriving. The South African economy and labour market are characterised by a demand for high skilled workers, but there is a surplus of low-skilled workers (Bhorat & Jacobs, 2010), resulting in a discrepancy between the trajectory and skills demand of the economy and the skills set and expectations of the labour force (Reddy, Bhorat, Powell, Visser, & Arends, 2016, p. 74). The rapid digitisation and automation of industries has resulted in new challenges for current and future labour markets. Automated systems are constantly raising the complexity of tasks, which in turn demands higher skills levels for entry-level positions (Makgato, 2019). Shusterman (2015) holds that many education and training institutions are educating and preparing students for obsolete occupations and work for which human activities are no longer required, due to the digital automation of industries, a concern echoed by Makgato (2019, p. 390):

> Youth and people who lack high level technological and interpersonal skills are becoming vulnerable due to digital automated jobs. There is a need for targeted and strategic skills, education and training that are responding to the changing technological world…supporting the application of transferable skills will be a key priority as we foster a sustainable and more productive economy.

This issue, however, is not unique to South Africa as according to Oh and Cukierman (2018), there is also a shortage of qualified engineers in Asia. The South African National Skills Development Strategy 3 stressed that the public Technical and Vocational Education and Training (TVET) College System "is central to government's programme of skilling and re-skilling of youth and adults. Its transformation is key to the integration of education and training and responding to the skills needs in our country" (Department of Higher Education and Training, 2013a, p. 15). However, there is a growing concern about the quality of TVET graduates, and whether the training offered at TVET colleges adequately produces graduates with cutting-edge industry-based knowledge and skills (Teis & Els, 2021; Zungu, 2015). One way to improve the quality of TVET graduates is a focus on teaching and learning that will improve both the performance of TVET colleges, as well as the occupational competence of their students (Department of Higher Education and Training, 2013a, 2013b, 2013c). It is therefore essential to evaluate current teaching models at TVET colleges and investigate what might improve the throughput rates of TVET colleges.

The Teaching and Learning Plan (TLP) for TVET that was released by the Department of Higher Education and Training (2019) has two focal points, namely quality assurance of curriculum delivery, and student success. It has been shown that student success is dependent on the quality of teaching and learning, and ultimately, on the quality of the lecturers (Badenhorst & Radile, 2018; Oketch, 2007). Human capital TVET provisioning is demand-driven, and is curriculum competence-based (Rasool & Mahembe, 2014). Competence-based training primarily focusses more attention on students and their ability to master practical tasks and the ability to acquire competence, than on the level or type of qualification, or the length of training, and is "developed in accordance with identified skills needs derived from the workplace" (UNESCO, 2012, p. 16). Therefore, using the application of a competence diagnostic model (COMET), as will be described in more detail in chapters two to six of this thesis, my study sought to investigate how teaching and learning might enhance the occupational competence and development of National Certificate Vocational Engineering students at TVET colleges.

1.2 TVET context in South Africa

Education has often been accused of delivering graduates who are not really prepared for their jobs (Makgato, 2019; Shusterman, 2015). The question posed is whether TVET college students are sufficiently prepared for a professional work environment directly after completing their college qualifications (Els, Teis, & Seleke, 2022; Teis & Els, 2021). But how ought we to measure or test the industry-relevant competence and readiness of TVET students for what will be expected of them when they enter the labour market? The ability of graduates to apply their knowledge in certain working conditions may be constrained, and they may not be able to match the demands of shifting industries, even though they may be knowledgeable and have had extensive and in-depth training in a given sector.

The White Paper on Post-School Education and Training (PSET) (Department of Higher Education and Training, 2013c, p. 16), holds that "the main purpose of the TVET colleges is to prepare students for the workplace and/or self-employment". However, research has shown that there are weaknesses in the current TVET system when it comes to preparing students for the world of work. It is for this reason that the current system needs to be strengthened, in order to achieve the vision of PSET.

McGrath (2012) points out that the South African TVET system is located within the more focussed economic and productivist approach, with many stakeholders who have competing interests, causing the system to be less productive (Rasool & Mahembe, 2014). Rasool and Mahembe (2014) argue that there is a lack of clarity about the manner in which the TVET sector should contribute to the development of South Africa, which since 2011 has been categorised as a newly industrialised country (NIC) by the International Monetary Fund (2011). NICs are characterized by: (i) an economy that has not yet reached First World status but has, in a macroeconomic sense, outpaced it's developing country counterparts; (ii) rapid economic growth that is export-oriented; (iii) an increasingly open-market economy that allows for free trade; (iv) ongoing industrialization; (v) migration of populations to cities to work in industries, factories, and mines; and (vi), increased social freedom and civil rights (International Monetary Fund, 2011). The nature of TVET college education has been a topic of debate for the past 20 years. On the one hand, some believe that TVET colleges should provide broad and foundational learning to students in preparation for their future occupations, while on the other hand, others maintain that TVET should be focused on work preparation and build close linkages with workplaces (UNESCO, 2012, p. 16).

In order to bridge the gap between TVET education and industry, the National Certificate Vocational qualification was introduced into public TVET colleges in South Africa in 2007, with a modernised curricula and updated knowledge and skills. Although the National Certificate Vocational programmes were intended to be occupationally oriented, some employers found the occupationally oriented National Certificate Vocational programmes offered at TVET colleges to be rigid and insufficiently work-focused. This led to some employers being critical of these programme offerings (Magnus, Bird, Prinsloo, & Singh, 2013).

The South African TVET college system currently delivers two mainstream programmes, namely, National Certificate Vocational and NATED/Report 191 Programmes, which in the Engineering field provide a theoretical foundation for trade apprenticeships. The National Certificate Vocational programme was intended to replace the NATED programmes, but the phasing-out of the engineering NATED programmes was halted in 2010 due to employers being nervous about losing a familiar trade programme and having to deal with a new, unfamiliar programme (Magnus et al., 2013). With few options for employed workers since these programmes are offered to students full-time, the National Certificate Vocational programme attracted primarily school-leavers or those who had not yet entered the workforce. The NATED programme had allowed working students the chance to continue their education, occupational training, and ongoing skills development (Magnus, Bird, Prinsloo & Singh, 2013, cited by Rasool & Mahembe, 2014, p. 36).

The purpose of the TVET college sector is located within a vision of “a single, coherent and integrated system of post-school education and training” which can “contribute to overcoming the structural challenges facing our society by expanding access to education and training opportunities and increasing equity, as well as achieving high levels of excellence and innovation” (Department of Higher Education and Training, 2013c, p. 3). The White Paper envisions that:

> The design of training systems, including curricula, requires close cooperation between education and training providers and employers – especially in those programmes providing occupational training. In areas of work such as the artisan trades, apprenticeships have traditionally been the pathway to qualifications; however, the apprenticeship system has been allowed to deteriorate since the mid-1980s, resulting in a shortage of mid-level skills in the engineering and construction fields. Re-establishing a good artisan training system is an urgent priority; the current target is for the country to produce 30 000 artisans a year by 2030. It is also important to expand other forms of on-the-job training, including studentships and internships in non-artisan fields (Department of Higher Education and Training, 2013c, p. xvi).

The Department of Higher Education and Training defines vocational education as “mid-level education which provides knowledge and skills to enter the economy. Vocational education refers to educational programmes that are focused on preparation for specific occupations, as well as ongoing professional development and training in the workplace” (Department of Higher Education and Training, 2012, p. 1). TVET colleges in South Africa were merged between 2002 and 2006 to create 50 overarching college administrations for over 254 college campuses, that led to considerable structural turmoil (Department of Higher Education and Training, 2013c, p. 12). The new multi-campus colleges were called Further Education and Training (FET) colleges, which in 2012 were renamed as Technical and Vocational Education and Training (TVET) colleges. In 2006, 11 new National Certificate Vocational programmes at levels 2, 3, and 4 of the South African National Qualifications Framework were launched, signalling the beginning of curriculum restructuring. The National Certificate Vocational was created by the Government to address the problems of poor-quality programmes, lack of economic relevance, and low technical and cognitive capabilities of TVET graduates (Department of Higher Education and Training, 2013c). The National Certificate Vocational qualification, it was said, would enable students to acquire the necessary knowledge, practical skills, applied competence, and understanding, that is fundamental to finding employment at the basic level of a particular trade or occupation.

In its National Review, the Department of Higher Education and Training reported shortly after the National Certificate Vocational was introduced, that the National Certificate Vocational was not meeting all its planned needs: it lacked universal industry support; its performance and completion rates were widely considered as poor; and it faced a deficiency of 'universal support' (Republic of South Africa, 2010, p. 41). In fact, the National Certificate Vocational was widely panned. Challenges related to the implementation of the new curriculum surfaced 'during the preparation and implementation of the new curricula, [when] systemic problems came to light and were conveyed to the relevant authorities,' according to a report on the implementation of new college programmes (Papier, 2009, p. 5).

The Department of Education was split into two entities after the original restructuring of TVET colleges, leading to the creation of the Department of Higher Education and Training (DHET), under whose purview FET, now known as TVET, was located (Van der Bijl & Lawrence, 2018). The DHET published blueprints for the further transformation of the post-school education sector in the form of a Green Paper (Department of Higher Education and Training, 2012), as well as a White Paper on Post-School Education and Training (Department of Higher Education and Training, 2013c). Terblanche (2017) explains that the new TVET system had a new governance framework, a new framework for programmes and qualifications, a new quality improvement and assurance institution, and a new funding system, which were envisaged as key levers for system change (South African Qualifications Authority, 2016, p. iv).

The Minister of Higher Education, Science and Innovation (Nzimande, 2014, p. 3), stated in his address to the Conference of the South African Heads of Mission, that the intention of the White Paper was "to begin the creation of a responsive education and training system that would address broader societal and developmental objectives by expanding access and improving the quality of teaching and learning". The intention was also to increase diversity and create opportunities for workplace-based learning. A successful TVET system, it was argued, should provide diversified programme offerings that promote the knowledge, skills, attitudes, and values required by South Africans as individuals and citizens, as lifelong students, and as economically productive members of society (Terblanche, 2017). A system like this might offer crucial intermediate to advanced skills and competencies that the nation needs to forge its own path in the 21st century's competitive, international environment (South African Qualifications Authority, 2016, p. iii). The Quality Council for Trades and Occupations (QCTO) is responsible for the establishment of a new occupational qualifications sub-framework as an integral part of the National Qualifications Framework (NQF). The continuation of the national N-certificates was linked to the new mandate given to the QCTO to revise the N1 to N3 engineering qualifications, in order to develop qualified artisans, as well as the N4 to N6 business and utility qualifications (Terblanche, 2017).

South Africa's public TVET colleges began offering the National Certificate Vocational programmes in 2007. This qualification was designed to give students the opportunity to gain the necessary knowledge, practical skills, applied competence, and understanding to enter a trade or related occupation. However, the National Certificate Vocational programmes' lack of industry acceptability and its largely under-prepared student profile resulted in credibility issues among a range of stakeholders (Van der Bijl and Lawrence, 2018).

The real challenge facing the TVET system in South Africa is to make high quality technical occupational education accessible to all, without losing sight of TVET's special relationship with the world of work (McGrath, 2012). To achieve this, South African TVET policy needs to shift from a human capital approach towards a broader approach that includes human capability and sustainable development approaches. On an operational level, South Africa needs to customise best practices from models in Singapore, Korea and Germany, to establish an effective TVET model for the unique South African TVET context (Rasool & Mahembe, 2014). A new model should take into account the South African economic development phases, socio-economic development challenges, and student and community expectations.

The White Paper on Post-school Education and Training (Department of Higher Education and Training, 2013c, p. 11) furthermore states that:

> Colleges cater mainly for those who have left school – whether they have completed secondary school or not – and who wish to do occupational training or complete their schooling. Colleges should be rooted in their communities, serving community as well as regional and national needs. They should primarily – although not exclusively – provide education and training to members of their own and nearby communities and develop skills for local industry, commerce and public-sector institutions. They should constantly strive to be seen by their communities as providers of skills that offer a route out of poverty and that promote personal or collective advancement.

The extract above suggests that the purpose of TVET colleges is two-fold: (i) to offer students an opportunity to complete schooling, and (ii) to promote the personal development of students through vocational education. Psacharopoulos (2018) asserts that occupational education and training has been offered as a viable option for primary or secondary school students who are deemed unable to pursue academic studies, a stereotype that has had a negative impact on South African TVET colleges. Despite this negative image of the TVET system, there is still an increase in National Certificate Vocational programmes' enrolment numbers year on year.

Research suggests that employability is one of the major challenges affecting the TVET sector across the world, due to the current economic environment and ever-increasing market pressures (De Vos, De Hauw, & Van der Heijden, 2011). Countries in the European Union have adopted policy initiatives that embrace the notion of lifelong learning, enabling individual employees to adapt to a changing labour market by providing mechanisms that facilitate learning and occupational mobility, a model that prepares students for the world of work but also for future development in their occupations.

Poor quality, extremely high cost training that is not appropriate for current socioeconomic situations, and disdain for the demands of the informal sector are the main factors Oketch (2007) highlighted as having an impact on TVET in Africa as a whole, and that the link between academic and occupational skills should be strengthened. The National Skills Development Strategy 3 (2013) mentions poor work readiness and inadequate skills levels of TVET graduates, which impacts negatively on young people entering the labour market for the first time. The relationship between TVET colleges and workplace learning is thus a major issue in attempting to address these concerns.

The need for students to acquire practical skills is at the core of occupational education and training, as envisioned by policy:

> For much education and training, a combination of both theoretical knowledge and practical experience is important, indeed essential. Theory provides knowledge of general principles and laws, which allows additional learning and adaptation to new technologies and circumstances. Practical experience builds applied knowledge and develops self-confidence in someone's ability to act effectively (Department of Higher Education and Training, 2013c, p. 9).

While TVET college students' theoretical knowledge is measured by the administration of examinations, practical skills should also be measured in order to determine the range of skills that students have obtained for the diverse demands of various occupations. The training and transfer of skills is vital to ensure that students receive the requisite skills which will allow them to flourish in the workplace. The transfer of such skills also trains the spotlight on lecturers' competence, and the methods and techniques lecturers use to ensure that students receive proper training. The nature of the curriculum for developing skills based on the demands of the particular occupation must be understood by lecturers. For students to be classified as competent after completing an occupational programme, it is crucial that they complete the entire process of learning through theory and practical training.

The issue of occupational competence is identified by the National Skills Development Strategy 3 (NSDS III) (2013) as being amongst the hindrances that affect the expansion of the South African economy negatively and on its ability to increase employment. Occupational competence can be measured in various ways, for example through examinations, practical assignments, and other means, all of which have their own shortcomings. Amongst the various holistic problem-solving models developed for the measurement and interpretation of occupational competence, the COMET (Competence Measurement in Electrical Technology) diagnostic model has been shown to be a valuable tool for assessing and developing occupational competence in TVET (Rauner, 2021). This model offers a

> theoretically sound and empirically verified competence model…[with]… corresponding testing methods in order to gain a better insight into the strengths and weaknesses of teaching and training. From this perspective the competence model and the methodology of competence assessment should be applicable as an

> immediate support for the pedagogical work… [of TVET lecturers] (Rauner, Heinemann, Maurer, Haasler, Erdwien, & Martens, 2013b, p. xiv)

Accordingly, this thesis empirically explored how the COMET diagnostic model might didactically enhance occupational competence of Electrical Engineering students as well as lecturers' teaching practices at TVET colleges.

1.3 Research Problem and Rationale for this Research

In previous research applying the COMET methodology it was found that the application of the COMET competence diagnostic model offered the opportunity to enhance classroom teaching and learning through a didactic approach that focused on developing students from beginners to advanced levels. In addition, the study revealed the poor holistic problem-solving competence of students within the conventional 'teaching to the test' didactic approach (Jacobs, 2016). But to date, no other research study has specifically investigated the didactic application of the COMET diagnostic model for the development of occupational competence amongst Electrical Engineering students within the South African TVET landscape – a knowledge gap that the current investigation intended to address by means of a mixed-methods research initiative. This thesis aspired to contribute towards the testing and continued application of the COMET model within TVET, and to add to the existing corpus of knowledge in the area of occupational competence development.

The production of competent workers with cutting-edge knowledge and skills needed by industry is currently one of the biggest challenges facing South African TVET colleges. (Makgato, 2019; Nzimande, 2021; Teis & Els, 2021). The pass rate has been variable, fluctuating between 34% and 42.8% during a five-year period, despite the Government's increase in financing to colleges of 50% (DHET, 2016). This pass rate was below the DHET's targeted pass rate of 50% for NCV programmes in 2018/2019. Electrical Engineering has been identified as one of the underperforming programmes in public TVET colleges (Statistics South Africa, 2018), which has a negative impact on the numbers of TVET students who could potentially be employed in Electrical Engineering occupations and raises questions about the quality of graduates' skills. This is also considering the South African Government's commitment to producing 30 000 artisans by 2030 (Department of Higher Education and Training, 2013a).

Hauschildt (2016) found that electricians performed poorly in a study undertaken to investigate occupational competence development, in that only 1% of electricians who participated, managed to achieve holistic shaping competence, which is the highest level of competence in the COMET conceptual framework. The competence levels of Electrical Engineering students in TVET are cause for concern and requires further investigation.

The following research aims and questions were prompted by earlier studies in this domain.

1.4 Research Aim and Objectives

The aim of this research was to explore how the didactic application of the COMET diagnostic model for teaching and learning might enhance the development of occupational competence of National Certificate Vocational Electrical Engineering students at TVET colleges**.** More specifically, the objectives of the study were:

Objective 1: To determine the occupational competence levels of electrical engineering TVET students prior to the application of the COMET diagnostic model.

Objective 2: To determine to what extent the didactic application of the COMET diagnostic model enhanced the occupational competence levels of Electrical Engineering students.

Objective 3: To determine how TVET lecturers implemented and applied the COMET diagnostic model in their classrooms.

Objective 4: To determine the vocational identity, attitudes, and occupational commitment of TVET students in the study.

Objective 5: To explore the strengths of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET Colleges.

Objective 6: To explore the weaknesses of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET Colleges.

1.5 Research Questions

Considering the aim and objectives stated above, the main research question that this investigation sought to answer, was: How can the COMET diagnostic model be didactically applied in teaching and learning to enhance the occupational competence of National Certificate Vocational Electrical Engineering students at TVET colleges?

Sub-questions that arose from this main question were:

Sub-question 1: What were the occupational competence levels of electrical engineering TVET students prior to the application of the COMET diagnostic model?

Sub-question 2: To what extent was the occupational competence of electrical engineering TVET students enhanced through the application of the COMET diagnostic model?

Sub-question 3: How did TVET lecturers implement and apply the COMET diagnostic model in their classrooms?

Sub-question 4: What were the vocational identity, attitudes, and occupational commitment of TVET students in the study?

Sub-question 5: What were the strengths of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

Sub-question 6: What were the weaknesses of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

1.6 Research Design and Methods of Investigation

This research followed a mixed-methods sequential explanatory research design, and both quantitative and qualitative methods were used to collect data from TVET Electrical Engineering students and teachers at five TVET Colleges in four South African Provinces. For the purpose of the main quantitative research component, the COMET diagnostic model was implemented amongst Electrical Engineering students at purposefully selected TVET colleges, in order to obtain empirical data relating to their development of occupational competence. In the qualitative research component, focus-group interviews were conducted with participating lecturers in order to obtain qualitative data about the perceived strengths and weaknesses of applying the COMET diagnostic model for competence development in Electrical Engineering. The research was conducted in five public TVET Colleges in South Africa, situated in the Western Cape, Eastern Cape, Gauteng, North-West and Kwa -Zulu Natal involving a total sample of 238 students and 9 TVET college lecturers. The targeted student groups were students in Electrical Engineering NCV Courses. Lecturers from TVET colleges and industry were selected and trained to serve as subject experts to develop and rate the COMET Tests Tasks. 18 COMET Test tasks were developed at a COMET workshop in Cape Town of which 12 were selected for the COMET main test. Notwithstanding that 238 TVET students participated, 39 students had to be excluded from the data analysis as the COMET diagnostic model does not cater for students who obtain a total professional competence score < 5. Therefore a total of 199 students participated in the study.

A comprehensive outline of the various methods used in this investigation is provided in Chapter 4 of this dissertation.

1.7 Chapter Synopsis and the Structure of this Thesis

Chapter One has sketched the background and framed the vocational education context of this research initiative. The research problem was identified, the need for the current research motivated, and the objectives and research questions were stated. The remainder of this thesis is structured as follows:

Chapter Two presents a literature review of the available corpus of knowledge pertaining to various aspects of competence, the measurement of occupational competence in TVET, occupational didactics, and furthermore provides a critical analysis of three major competence models.

Chapter Three provides a comprehensive outline of the conceptual research framework used in this investigation, i.e., the COMET Diagnostic Model.

In Chapter Four, the research design and methodology of this investigation are elaborated upon, including explanations regarding validity, reliability, and ethical considerations.

Chapter Five presents an analysis of the data and findings arising from both the quantitative and qualitative research components of this study.

Chapter Six presents conclusions and recommendations drawn from the findings reported in Chapter Five, to holistically answer the main research question.

Chapter 2

Literature Review

2.1 Introduction

In this chapter, a review of relevant scholarship pertaining to salient concepts within this thesis, has been undertaken. This study adopted a thematic literature review in which only the main outcomes are reported on, and was structured around various themes (UCT, 2006, p. 21) as indicated in my study. The concept of competence, a central concern of this research, is defined in terms of the literature, followed by a more in-depth exploration of aspects of competence. Three major competence models are then critically discussed. In addition, the measurement of competence in TVET is comprehensively outlined, including reference to issues of quality and quality assurance in TVET assessment, and award of qualifications. Chapter Two ends with a short synopsis of the content that has been covered.

2.2 Defining Competence

Due to the various disciplines and theoretical frameworks that have sought to define the term, a wide range of definitions of 'competence' may be found in the pertinent literature. The term 'competence' involves a specialized system of abilities, proficiencies, or skills that are necessary or sufficient to reach a specific goal (Weinert, 1998). Holistic competence is an umbrella term inclusive of different types of generic skills for instance critical thinking, problem-solving skills, positive values, and attitudes such as resilience and appreciation for others, all of which are essential for students' life-long learning and whole-person development (Chan & Yeung, 2020, pp. 622-642). Pfadenhauer (2013) asserts that education and psychology are the two disciplines that apply to the understanding of the concept of competency. Cognitive abilities are a component of the field of education's approach to competence, and in a professional sense, these abilities must be tied to a particular vocation. Rauner (2021) references the foundation work of Roth (1971), who viewed competence in three ways:

- Self-competence – the ability to be responsible for your own action.
- Professional competence – the ability to act and judge in a particular profession and hold responsible.
- Social competence - the ability to act and judge, and take responsibility, in professional or social areas that are relevant in social, societal or political terms (Roth, 1971, p. 180), as cited by Rauner (2021, p. 40).

The first area relates to the person developing skills about things, circumstances, and relationships with other people. The second area pertains to situations in which the skills of the subject are developed; while the third area is the person's "readiness", which concerns his/her attitude (motivation), as well as his/her volition (will-power) to address challenges instead of avoiding or rejecting them.

The Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland (2000. p. 9) defines competence to act as "the readiness and ability of the individual to act in an appropriately thought-out as well as individually and socially responsible manner in occupational, social and private situations. Competence to act unfolds in the dimensions of specialized competence, staff competence and social competence".

The concept of competence in the field of TVET education and work, is a complex concept which has attracted the attention of both proponents and opponents of its use and application. In TVET education, academic competence and professional competence are often treated separately (Pfadenhauer, 2013). Rauner (2013) emphasises that professional competence can only be acquired through experience in a real work environment. Oser (2013) agrees that the acquisition of occupational competence (professionalism) requires reflective work experience which is the crucial point of occupational learning and development processes. Professional work experience, as well as subject-specific theoretical knowledge are therefore equally important for mastering an occupation.

Mulder (2006) asserts that the context in which the concept of competence is used, must be considered. This implies that certain contextual factors such as culture have an influence on how the concept of competence is understood. The cultural factors include group identities such as race, gender, age, and class. According to Hager (2008), both proponents and critics of the competence concept fail to adequately articulate the constituents of competence, such as performance and its results, the underlying constituents of competence (capabilities, abilities, and skills), and the education, training, or development of people to become competent performers. Hartig, Klieme and Leutner, (2008) describe competence as a complex ability that is associated with performance in real-life situations. They imply that for one to acquire professional competence in addition to academic competence, exposure to the work environment is key. Therefore, it is crucial to address both the cognitive and performance aspects of competence. Sadler (2013) describes competence as an integrated and large-scale characteristic, capability or attribute or skill in performing a task. Delamare le Deist and Winterton (2005) concur and hold that competence is a multi-dimensional concept, relying on the integration of a person's occupational knowledge, practical know-how and social and personal qualities, such as the ability to take responsibility for and reflect upon one's own actions.

For Bergmann (2000, p. 21), "Competence refers to the motivation and ability of a person to further develop know-how and skills in a field independently such that a high level is achieved that can be characterized as expertise". One refers to expertise if the result of competence development was successful. Professional expertise as the result of successful competence development is of particular interest for occupational training and research (Röben, 2008).

For Ellström (1997, p. 267), the term competence refers to the potential capacity of a person (or group) to successfully accomplish a task or job (in accordance with formal or informal standards established by themselves or by another person). More specifically, Occupational Competence refers to:

> a relationship between the capacity of an individual (or a collective) and the requirements of a certain (class of) situation(s) or task(s)", which includes "knowledge and intellectual skills (e.g. inductive-logical ability), but also, contrary to more restricted definitions, non-cognitive factors (e.g. motivation, self-confidence)", and is "a capacity that is a complex function of five classes of components, i.e., perceptual motor skills (e.g. dexterity), cognitive factors (different types of knowledge and intellectual skills), affective factors (e.g. attitudes, values, motivations), personality traits (e.g. self-confidence); and social skills (e.g. communicative and cooperative skills). Occupational competence is "a potential rather than an actual capacity, i.e., a capacity that is actually used if and only if certain conditions are present (e.g., a challenging task or a work organization with a certain autonomy) (Ellström, 1997, p. 267).

Ellström (1997, p. 267) points out that a functionalist, adaptive approach appears to be implicitly assumed in many definitions of occupational competence. According to this perspective, occupational competence is defined and assessed in terms of the successful completion of a set of planned or provided tasks, i.e., tasks that the individual is not permitted to attempt to alter or enhance. One of the main criticisms of this perspective is that it largely ignores the constant and necessary active modification and subjective redefining of the work task that take place when performing a job.

Norros (1991) for example, points out that operators in many complex production systems are, in a certain sense, involved in a continuous redesign and improvement of the system. In contrast to an adaptation view, the innovative capacity for self-management that people possess, as well as the ability and expectation that they will use this capability, are both stressed by the developmental perspective. Individual competence is thus described in this perspective as the ability to consider and influence the work environment, thereby transforming it into what the individual desires (Ellström, 1997, p. 267).

The importance of theoretical, explicit knowledge in contrast to experience-based, implicit know how (sometimes called tacit knowledge), is a crucial aspect as it attempts to depict skilful performance or competence in various disciplines. Other important dimensions concern the relationships between knowledge (theory) and practice (action), and the character of the problem-solving and learning process involved. There are two complementary, rather than mutually exclusive or contrasting approaches to skilled performance and expertise, called the cognitive-rational and intuitive-contextual perspectives, respectively. The intuitive-contextual viewpoint seems to provide a more accurate representation of the work done by experienced professionals managing unstructured, uncommon, and poorly understood challenges while working under pressure in difficult scenarios (Ellström, 1997, p. 270). On the other hand, the "cognitive-rational perspective seems to fit the activities of less experienced employees, using abstract information in handling more structured, well-defined tasks that can be more fully analysed into their components; and in situations where there is a strong pressure to justify the decisions made to significant persons not directly involved in the problem-solving efforts, e.g., the management" (Ellström, 1997, p. 270). However, Ellström (1997, p. 271) argues that:

> developmental expertise cannot be equated with the one or the other of the two perspectives discussed here. Rather, a change-oriented competence is probably best described as an individual capacity to move between a theoretical-analytical and a more experience-based, intuitive competence depending on context; or perhaps rather as a synthesis between these two sets of competence. In many cases, however, this may only be accomplished using work teams composed by individuals with different competence and experiences.

Competence is generally associated with the world of work. This implies that individuals must be associated with a specific occupational domain. An individual will be able to exhibit competence through that particular occupational domain, which may be seen in how they perform (Mulder, 2014). Lajoie (2009) suggests that competence can be generalised, however it must be achieved within a specific domain of activities (Lajoie, 2009).Therefore, locating competence within a specific domain presents the possibility of distinguishing a competent and not yet competent individual within an occupational practice. These occupational practices are specific sets of activities that have developed across human history arising from human, cultural and societal needs (Scribner, 1985).

Despite the suggestion that individuals need to be located within a specific domain to demonstrate competence, the societal standing of that specific occupation needs to be taken into consideration. Higgins (2005) describes occupations as a specific field of activity that have particular societal and personal standings. Social connotations include identifiable occupations and occupational communities. Personal connotations include individuals' vocations that are associated with a particular occupation (Rehm, 1989). Another factor that contributes to occupational competence development, is how individuals identify themselves within an occupational practice (Dewey, 1916) However, individuals have to assent to that occupation becoming their vocation (Higgins, 2005). What these two distinct connotations suggest is that occupational competence needs to be considered on both the societal or social plane, and also on the personal one, all of which extends to the formation of that knowledge.

Billett (2017) suggested three domains of occupational knowledge. The first domain is the canonical domain of knowledge, while the second is the situated domain of professional knowledge and third is the personal domain of occupational knowledge. The expectations of society towards a profession serve as the foundation of the canonical domain of knowledge. The situated domain of professional knowledge includes how performance in professional practice is manifested in certain circumstances (Gherardi, 2009). The third domain is the personal domain of occupational knowledge that individuals construct and use within and across specific instances of their professional practice, as they encounter and respond to it (Billett, 2009b).

These domains of occupational knowledge led to what Billett (2017) refers to as 'expert performance'. According to Billett (2017) expert performance are sets of personal capacities and qualities of individuals. These capacities and qualities are developed through interacting with domain-specific knowledge of that occupation in a specific environment (Ericsson, Charness, Feltovich & Hoffman, 2006). For Gardner (2004), two broad perspectives on human learning and development exist, i.e. the nativist and the empiricist perspectives. The nativist assumes that humans are born with a range of capacities that form the basis for learning and development (Chomsky, 1968). The empiricist, on the other hand, argues that individuals learn everything through processes of experiencing. Therefore, human learning is an active process in which an individual must be involved (Bruner, 2001). During the learning process an individual does not only accept the experience, he/she must make sense and construct what has been experienced. The process of construction is bi-directional (Lawrence and Valsiner, 1993) or relationally interdependent (Billett 2006), not a one-way transmission of knowledge from sources outside of individuals.

This basic theorisation of learning lays the foundation for acquiring occupational competence. According to Billet (2017), occupational competence can be learned and demonstrated by individuals. For an individual to develop the personal domain of occupational competence, understanding, procedural capacity and dispositions need to be demonstrated. In developing these personal traits, experience within an occupation contribute to these developments, and also, learning from other individuals within the occupation (Gergen, 1994). Hodkinson (2004) describes this process as the product of experiences. Individuals must be involved in work related activities and interactions with others, to attain experience. Individuals' construction of personal domains of occupational knowledge is central to competent performance. This suggests that during an individual's working career, they must constantly adapt to the rapidly changing work environment. (Gergen, 1994).

2.3 Four Aspects of Competence

Röben (2008) explains 'competence' in terms of four aspects: the demand for competence; the supply side of competence; the determination of competence; and the realisation of competence. These four aspects of competence are further explored in the sections that follow.

2.3.1 Who demands competence and what is expected of those possessing competence?

Competence is demanded by industries with modern forms of organisation, which are exponentially transforming and developing in profound new ways (Baethge & Schiersmann, 1998, p.16). Industries with modern forms of organisation subscribe to new management concepts, inter alia the business process, lean production, and re-engineering, as well as organisational procedures, an example of which is the Continuous Improvement Process (CIP) and Total Quality Management (TQM) by which "high quality, greater proximity to customers, more rapid innovation and more inexpensive pricing" (Baethge & Schiersmann, 1998, p. 21) are to be achieved simultaneously. Regardless of the diverse ways in which these concepts are being implemented; the focus remains on professionally qualified skilled workers. Subsequently, such industries increasingly foster and demand professionally qualified workers with adequate skills that will enable them to adjust and respond appropriately and quickly to new and unforeseen situations, e.g., the growing and ever-changing skills demands brought forth by the fourth industrial revolution's digital transformation of production and manufacturing industries. This is best explained by Röben (2008, p. 372) as follows:

> In the past, "the individual duties of professionally qualified workers were defined as separate areas of responsibility based on a rather Taylorism division of labour; and unforeseen situations occurred less frequently because the inside of the company was systematically screened off from the random workings of the market´. Nowadays the areas of responsibility of professionally qualified workers are less segmented and less isolated from each other as well as with respect to the customers and thus the market. As a result, a stochastic element reaches deep into company organisations and a flexible and independent response to new and unforeseen situations is required of professionally qualified workers. However, the organisational ability to react flexibly to new situations cannot be realised through a single organisational development measure. Instead, a permanent development process, which can be designated as organisational learning, is required.

Even though industries still require employees to be in possession of formal qualifications, in most cases these qualifications do not translate into a worker being competent, and industries, to a greater extent, rather make use of the skills of working individuals. However, for Erpenbeck and Von Rosenstiel (2003), competence does not mean having a formal final qualification, but signifies that professionally qualified workers act in an active, self-controlled manner that is characterised by entrepreneurial thinking in organisations. Therefore, competence refers to the disposition of the subject, not a status, based on possession of formal requirements.

Table 2.1: Organisational Value of Qualifications vs Competence

	Qualifications	Competence
Object-subject-relations	Qualifications are objectively given by the work tasks and processes and the resulting qualification requirements.	Competence are sector-specific abilities and strategies in line with psychological performance dispositions that are application-oriented.
Learning	In the process of acquiring qualifications, the person is a carrier medium for qualifications, a human resource that enables people to perform specific activities through training.	The acquisition of competence is part of personality development and also includes the skills resulting from the educational goals.
Objectifiable	Qualifications describe the not yet objectified/mechanised skills and abilities and define people as carriers of qualifications that are derived from the work processes.	Professional competence are primarily aimed at the difficult or impossible to objectify skills or professional specialists, who go beyond current professional tasks and aims to solve and process future tasks.

(Rauner, 2021, p. 9)

Table 2.1 above, provides Rauner's (2021, p. 9) comparison of the organisational value of formal qualifications, as opposed to the value of occupational competence, in terms of object-subject-relations, learning, and objectifiability.

Companies demand that the acquisition of a qualification is no longer a means an end and must be used not only as a steppingstone to enter industries as workers, but also as life-long learners who continuously develop and acquire new knowledge and skills to adjust to the ever changing 21st century work environment. Employees, citizens, and leaders in the global economy, must possess twenty-first century skills, in order to be successful (Madhav, Simelane-Mnisi, Hardman, Dlamini, & Lilley, 2018, p. 115).

The G20 or Group of Twenty is an intergovernmental forum, comprising 19 countries (including South Africa) and the European Union, that address major issues related to the Global Economy, such as international financial stability, climate change, migration, and sustainable development (G20 Foundation, 2022, Online). The G20 leaders agree that training personnel to meet their unique contemporary needs, is no longer possible. Training programmes should instead emphasise the development of lifelong skills with future markets in mind. The requirement for non-routine analytical skills like creativity, problem solving, communication, teamwork, and entrepreneurship should be the driving force (International Labour Organization, 2011). Owens (2015) predicts the emergence of a new era in manufacturing, requiring a new type of elite worker, who possess reading, writing, and mathematics skills, as well as advanced problem-solving abilities. As a prerequisite for addressing the skills gap characterised by mismatched workers attempting to do 'today's work with yesterday's tools,' the supply of elite workers necessitates creative, resourceful, and tangible solutions (Owens, 2015, pp. 37-39 in Jacobs, 2026, p114)). The education and training system should, however, "not only provide knowledge and skills required by the economy. It should also contribute to developing thinking citizens, who can function effectively, creatively and ethically as part of a democratic society. They should understand their society, and be able to participate fully in its political, social and cultural life" (Department of Higher Education and Training, 2013, p. viii).

2.3.2 TVET colleges as developers/providers of competence

According to Lipsmeier (2013), occupational training, encompassing initial and further training, has focused on concepts for individual competence development for the past four decades, in addition to imparting know-how. As a result, the requirements of companies, social and family-related challenges were met. Jacobs (2016) posits that TVET students' readiness to respond adequately to a dynamic world of work known for innovation and life-long learning requires scrutinising existing quality assurance practices for qualifications and occupational competencies. In South Africa, the government, educators, and officials in TVET are seeking ways to develop a system that will engage and effectively capacitate students to address the technical skills challenges as outlined in policy and strategy documents such as the National Development Plan (NDP), White Paper for Post School Education and Training (PSET) and Sustainable Development Goals (SDG's) (Jacobs, 2016. P.16).

The most important indicator of the success of a (TVET) college is the quality of education offered by a well-educated, capable, and professional teaching staff *(DHET, 2013, p. 16)*.

This longitudinal study on the role of didactics in competence diagnostics and development yielded positive strides towards aligning TVET colleges with the envisioned mandate.

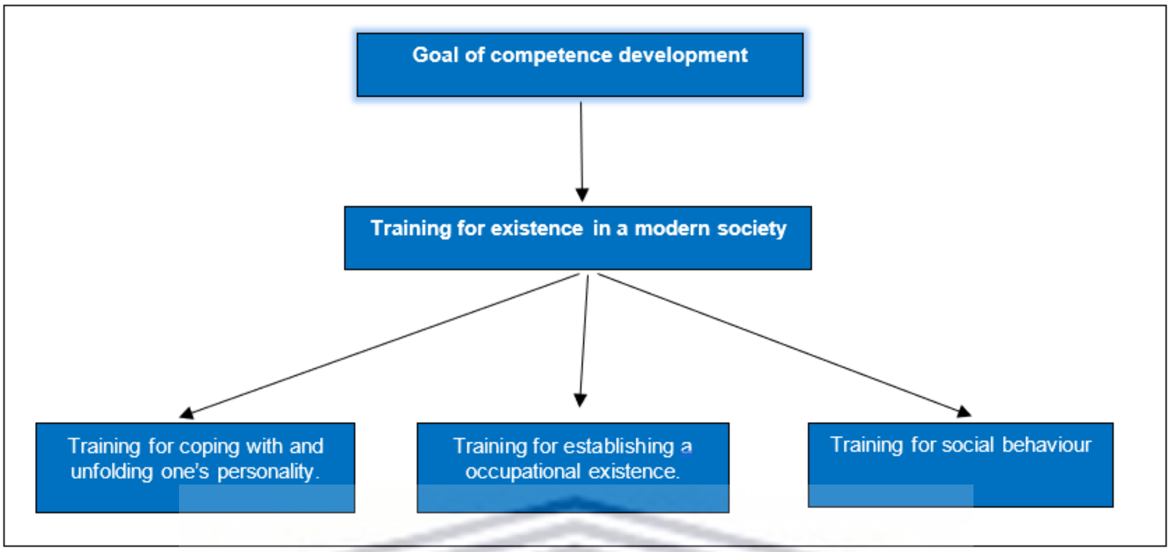
2.3.3 The Measurement of Competence

Formal qualifications, certification of which requires that knowledge and skills be demonstrated in previously defined situations, are not necessarily the best or only mechanism to measure competence. Observation is another method which can be used to assess someone's problem-solving skills or capacity to cope with unfamiliar situations (Bernien, 1997, p. 19). In the work-environment, various methods are used to evaluate, test and foster competence development of employees (Erpenbeck and Von Rosenstiel, 2003), however, the criteria to determine competence needs to be aligned with actual work requirements (Haasler & Erpenbeck, 2009). Students need to identify with the measures that are used to assess competence. It is easy to get caught up in endless arguments over what the correct measures of competence should be and what competence means when competence is exclusively assessed based on students' acquisition of theoretical information (Heyse and Erpenbeck 1997, p. 8). The measurement/assessment of occupational competence in TVET is further discussed in Section 2.7.

2.3.4 The Development of Competence

For Brater and Bauer (1990, p. 54), a fundamental requirement for effective competence development is the volition (will-power) of students to succeed, as well as their willingness to adapt to new work situations and to develop new competence. If individuals are forced or pressured to adapt, it becomes a fundamental barrier to the growth of competence. Rauner (2021) cites Mertens (1974), who asserted that there is confusion between the concepts of competence and qualification as both pursue similar goals. Mertens (1974: 36) described the goal of competence as training for existence in a modern society, which means training for coping with, and unfolding one's personality; training for establishing an occupational existence; and training for social behaviour, as visually illustrated in Figure 2.1 below.

Figure 2.1: The Goal of Competence Development



(Mertens, 1974: 36)

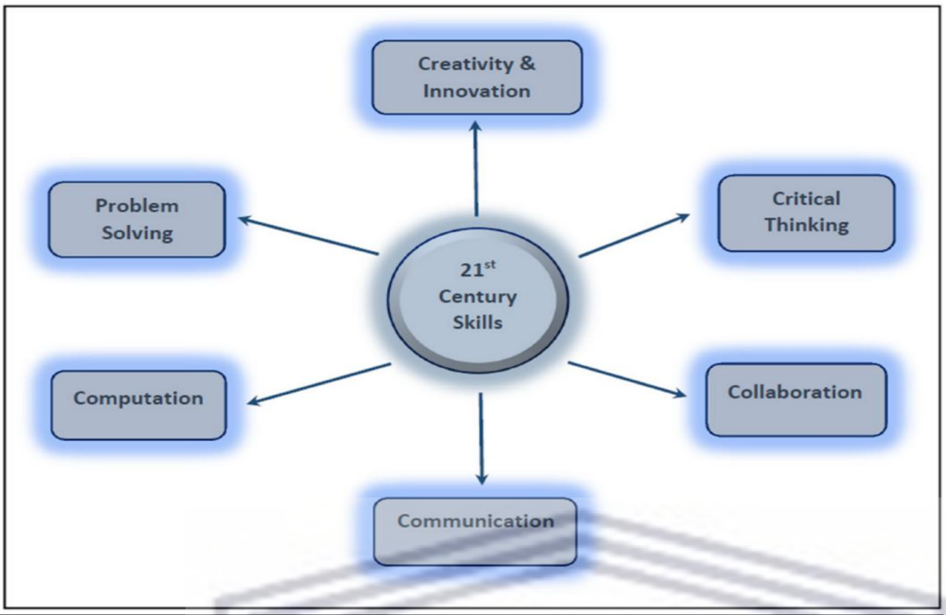
In the occupational field of electrical engineering, for example, one should be able to derive the properties and modes of the operation of specific components and circuits from the principles of electro-physics. Since the principles of electro-physics do not change, but the concrete components do, by studying the subject electro-physics one has created a 'basis' that is suitable for reacting to changing demands. However, this educational principle conflicts with the reality of learning, in that in the given training practice, students evidently do not acquire any of the universally applicable principles, but rather acquire 'inert knowledge' (Gruber & Renkl, 2000) that is not applied to coping with the dynamic work environment. In an alternative model, curriculum developers should strive to reconstruct the process of development from a beginner to an expert (Benner, 1995; Rauner, 1999). By so doing, two requirements are met. Firstly, the training period should be used for learning that contributes towards building up professional competence to act; and secondly, the competence to act should be expanded to a skilled level through the systematic extension of the required disciplinary knowledge. Rauner (2021) cautions that it is crucial to always consider the casual nature of the first requirement and the systematic framework of the second requirement. A systematic knowledge framework and the requirements for work should always be included in every set of training guidelines and competency-based curricula. Research shows that expertise based upon a combination of subject-based knowledge and empirical knowledge, creates new provisions of knowledge whose structures follow a different kind of logic, which differs from the logic used in subject-based systems (Bromme, 1992, p. 45). New generations of occupational trainees should develop sufficient occupational competence and skills to meet the specific requirements set by industries (Schröder, 2019).

2.4 Vocational Didactics

The modern work environment is changing exponentially due to rapidly advancing demands set by Fourth Industrial Revolution (4IR) industries. As a result, TVET systems need to adopt a modern approach to occupational didactics that can be utilised to the benefit and growth of a country's educational and economic sectors (Schröder, 2019). Globally, three over-arching traditional approaches to TVET education and training can be identified: (i) skills development with a focus on functional use in the world of work; (ii) technical education, which is predominantly theoretical and not very practical; and (iii) a combination of functional and theoretical education (Greinert, 1988; Schröder, 2019). The third approach, which is associated with dual cooperative TVET systems, combines theory and practice effectively, to successfully fulfil the increasing demands of industries, and this approach furthermore cultivates individual development through a process of lifelong learning (Chetty, 2017; Orozcoa, Gijbelsaand & Timmerman, 2021). Occupational training should not only raise the competence or skills level of students but should also offer students continuous life-long learning opportunities that are flexible. Schröder (2019) avers that "Permeability, recognition, and lifelong learning can be achieved if the objectives of TVET and professional didactics are consistent and interrelated so that informal, non-formal, and formal learning can be equally conceptually involved".

Twenty-first Century skills (see fig 2.2 below) are required to meet future demands placed on educational systems by fast transforming digital 4IR industries (Ledward & Hirata, 2011; Schröder, 2019; Scott, 2015; Trilling & Fadel, 2009).

Figure 2.2: Essential 21st Century Skills



***Adapted from** Madhav, Simelane-Mnisi, Hardman, Dlamini and Lilley (2018a; 2018b, p. 115)*

To effectively facilitate the development and acquisition of these skills among their students, electrical engineering lecturers should become specialists in the important 21st Century skills depicted in Figure 2.2. (Teis & Els, 2021). TVET college lecturers can cultivate these 21st Century Skills in a variety of creative ways. In order to develop communication skills, lecturers could, for example, ask students to share with the class how they solve problems, and what their thinking was in doing so. Creativity requires the generation of new ideas and novel solutions to problems. Students could, for example, be provided with open-ended design challenges to get them to develop novel ways to solve established problems. Collaboration should be encouraged in the information age, as people no longer work individually to solve problems, but rather work together. Collaboration could be cultivated by giving students group work problems that require the input and the collaboration of all the students (Madhav et al., 2018, p. 115).

Digital competence is also important in the occupational context, in terms of 21st century competencies. According to Dakers (2018, p. 23), being technologically literate "is something that one never actually becomes. One is, rather, always in the process of becoming, just as technologies are always in the process of becoming". Digital competence cannot be assessed in terms of right or wrong, as one is always in the process of becoming more technologically literate and more digitally competent. Furthermore, technological skills are not the defining factor for determining effective digital pedagogy, or for measuring occupational competence. Rather than referring to a set of established technological abilities, the phrase "digital competence" refers to one's attitude and aptitude toward digital technologies. The development of digital competence and its' didactical application requires a willingness to use new technologies for teaching and learning effectively, and furthermore, to understand why, how, and when such technologies should be used (Burtris, 2016; Hardman, Molotsi, Lilley, Madhav, Simelane-Mnisi & Dlamini, 2018; Teis & Els, 2021).

Schröder (2019) argues that these 21st Century Skills (Figure 2.2) are didactically valid competence skills that still need to be specified and concretised for TVET education and should be integrated into a holistic concept of competence development that will embrace individuals´ responsibility and autonomy, while promoting sustainable economic growth. Furthermore, competence is something that cannot be taught through instruction alone, but which students can only develop through actively engaging with learning tasks (ibid).

Tasks and learning scenarios should be didactically structured in a comprehensive way to incorporate a variety of occupational activities that can be used to effectively develop occupational competence skills in students (Rommel & Michele, 2020).

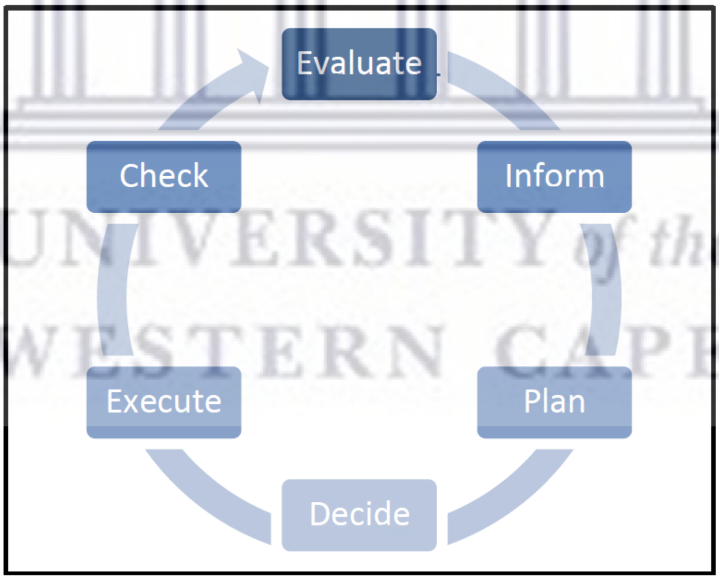


Figure 2.3: Cycle of occupational actions to develop the competence skills of students (Rommel & Michele, 2020, p. 31)

Figure 2.3 shows the complete cycle of various occupational actions that are used to effectively develop students' occupational competence (Rommel & Michele, 2020). The learning process that is based on this cycle must go through various individual steps, each of which fulfils its own purpose in the circular process, that is:

(i) Inform: The student should independently gain an overview of the work order/the situation/the task, to identify the necessary steps and gather and sort information.
(ii) Planning: Various options appropriate to the situation can be worked out and weighed against each other.
(iii) Decide: The options are finally weighed against each other and brought to decision alone or in a group based on the necessary parameters
(iv) Execute: The trainee carries out the necessary work steps as independently as possible.
(v) Check: The object of learning should be checked by the trainees in an independent way as far as possible. Questions such as the proper handling of the assignment and the goals to be achieved are also addressed during the evaluation process.
(vi) Evaluate: the concluded occupational action is always completed by the reflection of the entire work process. Here, the trainees should reflect on their own learning process and become aware of their actions and learning successes so that the result does not remain coincidental (Rommel and Michele, 2020, p. 31).

From a systemic perspective, the question that needs to be addressed is how a traditional input-oriented logic of subjects deriving from a scientific subject classification system, and an action learning process based on work tasks and processes can be combined in a didactically sound manner to enhance experiential learning (Dewey, 1938). Holistic problem-solving skills and understanding the inter-connectedness of criteria related to occupational competence could enhance a systemic approach amongst TVET college staff and students.

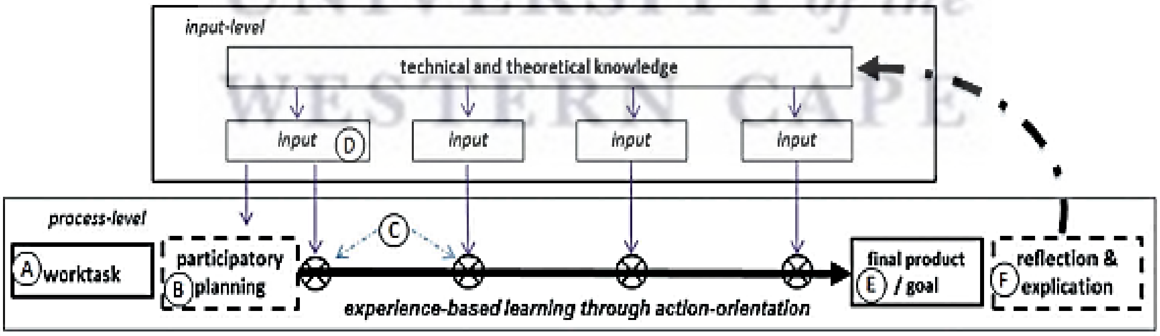


Figure 2.4: Didactical Process of Experiential Competence Development (Schröder, 2019, p. 88)

The didactical process of experiential competence development, as depicted in Figure 2.3 combines theoretical input with an experiential action and learning process that is helpful for the implementation of competence-oriented occupational didactics. Holistic occupation-typical work tasks (A) are transformed didactically into learning tasks. Their complexity corresponds to the level of competence of students. These work tasks also serve as the subject of learning, which must be worked on in action-oriented and experiential learning settings. Students should be given sufficient latitude for making decisions and acting, and they should actively participate in the planning, implementation, and evaluation of work outputs. Participatory planning (B) is a process in which the result (E), work steps, resources, work equipment, and so on are jointly anticipated. The process is carried out by the student. Students are confronted with challenges and problems (C) that they could not anticipate. To solve the problems, they will need information that they either find themselves or that is conveyed as input (D).

The work process is completed with a performance assessment and a qualitative evaluation of the work outcome (E), which are completed by the students and the teacher. The entire process concludes with a reflection (F) on selected sub-competencies such as problem-solving, cooperation, teamwork, and occupational competence. Furthermore, reflection allows for the analysis of implicit competence. Didactical concepts as outlined above follow the principles of work-oriented learning if employed in occupational schools or in occupational training centres, and work-based learning in the workplace or in companies (Dehnbostel & Schröder, 2017). The concept of employing suitable work tasks to design learning, i.e., competence development processes, provides a sound basis for the validation and recognition of informally acquired competence, and thus lays a basis for lifelong learning.

Within the South African TVET context at present, occupational pedagogy and practical skills training are not effectively responding to workplace needs. Makgato (2019) advocates for more focused occupational skills which are adapting to the changing technology environment. Consequently, Makgato (2019) argues for a massive upskilling and reskilling of TVET college lecturers. Currently, theory and practical training are not sufficiently integrated in TVET subjects, and in some cases, the TVET curriculum is irrelevant for modern industries and requires urgent review in order to respond to the current workplace. Makgato (2019) reported that 85% of the students who participated in his study agreed that while TVET pedagogy aimed to enhance their capacity as independent thinkers, TVET lecturers require a different didactic approach to develop competence for 4IR industries. That study also found that the didactics used at TVET colleges was not sufficiently focussed on the competence and characteristics that will be required for students to enter industries successfully.

2.5 Development of Occupational Competence in TVET: International Didactical Approaches

This section provides an overview of three International didactical approaches to competence development in TVET, as identified by Delamare le Deist and Winterton (2005), namely, the Behavioural Approach used in the United States of America, the Functional Approach in the

United Kingdom, and the Multi-dimensional Holistic Approach used in France, Germany and Austria. Since this investigation was concerned with implementing a holistic model of competence, it was imperative to look at other competence models as discussed in this section.

2.5.1 The Behaviourist Approach: The US Tradition

The behaviourist approach to competence development focuses on personality traits which are linked to strong motivation and superior performance. The term was first introduced to describe the relationship between cognitive competence and motivational action tendencies. In terms of paradigm, White (1959, p. 397) defined competence as an 'effective interaction (of the individual) with the environment' and argued that there is a 'competence motivation' in addition to competence as 'achieved capacity'. This approach is linked to the generic approach in traditional research within occupational education (Mulder, 2006).

McClelland (1976) developed test tasks that could predict competence rather than intelligence and described this characteristic of underlying superior performance as competence. In the behaviourist approach, successful job performers and less successful performers are compared to determine how they differ in terms of their characteristics and personalities.

Competence in the behaviourist tradition refers to skills beyond cognitive ability such as self-awareness, self-regulation, and social skills. These competencies are said to be behavioural in nature and can be learned through training and development. As per Rauner (2007), the analytical focus is directed at learning processes beyond the pedagogical and organisational continuum of systematic instruction, as well as the subject of learning, i.e., the person whose skills are being developed from inadequate to competent. Boyatzis (1982) proposed an integrated model that included managerial competence. This model attempted to establish a link between personality characteristics, management functions and the internal organisational environment. Similarly, Spencer and Spencer (1993) applied the McClelland/McBer Job Competence Assessment (JCA) methodology to an analysis of 650 jobs to propose generic job models. Their competence model included motivations, traits, self-concepts, attitudes or values, content knowledge, and cognitive or behavioural skills. They further suggested that individual performance must be measured and using these as criteria.

Delamare Le Deist and Winterton (2005) asserted that competence is functional, and behavioural. They suggested that there is a link between core competence and generic competence, and that a relationship can be viewed through competence modelling and competence assessment. Competence modelling is used to identify the critical success factors driving performance in organisations. However, competence assessment is used to determine the extent to which individuals have developed critical competence. Gangani (2004) noted that over the years the development of the Behavioural approach in describing competence, has included knowledge and skills alongside attitudes, behaviours, work habits, abilities, and personal characteristics.

Holton and Lynham (2000) developed a leadership competence model with six 'competence-domains'. This model describes what performance must look like within the organisation and describes performance criteria that must be met by individuals in the organisation and the process of attaining them. These domains are broken down into 'competence groups' and then further divided into 'sub competencies' (Delamare le Deist and Winterton, 2005).

At organisation performance level, the two competence domains identified are strategic thinking and strategic stewardship, sub-divided into four and five sub-groups of competence respectively (Collins et al., 2000). Similarly, on a process level, two competence domains were identified, i.e., process management and process planning, with each broken down further into three sub-groups of competence (Baker et al., 2000).

There are two competence domains identified for the individual level, employee performance and employee appraisal, each of which is subdivided into four sub-groups of competence (Wilson et al., 2000), which comprise of functional job-related standards, rather than behavioural competence. For Marques (2018) the approach of classical behaviourist theory does not adequately address the full spectrum of learning needs, which requires a constructivist approach.

2.5.2 The Functional Approach: The UK Tradition

The functional approach originated in the United Kingdom when new occupational qualifications (National Occupational Qualifications or NVQs, in England and Wales, and Scottish Occupational Qualifications (SVQs) in Scotland) were established. The competence model was envisaged to improve the occupational education and training system in these countries and is based on a competence framework with occupational standards of competence. The competence frameworks were grounded in functional in the analysis of occupations in different contexts (Mansfield and Mitchell, 1996). Key performance areas were broken down into units of competence according to occupational standards that were grounded in the actual work situation.

The UK Functional model was the product of different stakeholders that included employers and trade unions. These stakeholders were also involved in approval of qualifications and occupational standards. Assessment for Occupational Qualifications involved accrediting the competence of individuals against actual performance in the workplace, which was designed to ensure continued relevance in the work situation (Delamare le Deist and Winterton, 2005). The lack of theoretical grounding was identified by Delamare le Deist and Winterton as a major weakness as a major weakness of the UK Functional competence-based approach, as the model was only concerned with demonstrating job competence but neglected the 'learning process of acquiring knowledge' or disciplinary knowledge.

2.5.3 A Multi-dimensional and Holistic Approach: France, Germany and Austria

Winterton et al., (2005) asserted that the European models of competence tend to be multi-dimensional and holistic in nature. In the German context, competence is understood as the ability or capacity of the individual to act within the labour process of a defined 'Beruf' or occupation. According to Delamare le Deist Winterton et al., (2005) the multi-dimensional and holistic model originated in the German and French's tradition of occupational training and apprenticeship.

French competence-based models focus on both an individual approach, based upon individual behaviours, and, a collective approach, based upon building the required competence in an organisation. The individual approach to competence is also referred to as the educational approach (the development of skills, achievement of standards, award of credentials*)*, while the organisational model is called the business approach (organisational competence for competitive advantage. According to Delamare le Deist and Winterton (2005) knowledge, functional competence, and behavioural competence as competence dimensions, depend on the concepts of knowledge, experience, and a behavioural component.

In Germany, occupational competence is rooted in the concept of 'Beruf'. Beruf refers to occupation, however, it inculcates the traditions of the craft which are embedded in occupational training theory and pedagogy. According to Le Deist and Winterton (2005) the German traditional model includes the concepts of 'key qualifications', personal competence, such as 'ability to act autonomously and to solve problems independently', 'flexibility', 'ability to cooperate', and 'practical ethics and moral maturity'. A qualification signifies the ability to master concrete (generally professional) situation requirements and is clearly application oriented. Competence was initially conceptualised and implemented in the form of key qualifications ('Schlüsselqualifikationen') (Mertens, 1974), which resulted in an educational renewal of the German TVET system, by promoting de-specialisation and a higher degree of abstractness of knowledge and skills (Lauer-Ernst, 1983; Dubs, 1995). Since 1996, the German TVET system has adopted an action competence ('*Handlungskompetenz*') approach to TVET education and training, expressed as 'occupational action competence' or the readiness and capacity of the individual to act thoughtfully, individually and in a socially responsible manner in professional, societal, and private situations (Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, 2000). The German TVET system recognises three main categories of competence: (i) subject competence (‘*Fachkompetenz’*), (ii) personal competence (‘*Personalkompetenz’),* and (iii) social competence *(‘Sozialkompetenz’*) (Arnold & Schüssler, 2001; Rauner & Bremer, 2004; Breuer, 2005), and has allowed for the development of another competence: the methods and learning competence *(‘Methoden-, Lernkompetenz’).* This is competence in the field of methods (the competence to work with methods, techniques) and learning (the ability to learn new things). In order to implement an action competence approach, Germany introduced a curricular framework in 1997 in the form of Learning Areas (‘*Lernfelder’*). Learning areas are thematic units defined by designating targets, content and specific teaching times. They follow professional tasks and actions (Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, 2000). The essential criteria for the learning areas are: (a) they should be derived from occupational fields; (b) they should be related to work and business processes, and (c) they should describe competence (Bauer & Przygodda, 2002). Furthermore, the learning areas and their contents are structured towards the needs of individual students; and thus subject-orientated by nature (Rauner, 2004).

The German and the Austrian models share some common elements such as having content, action and requirement (output) dimensions. These dimensions help to shape the inputs of trainers at the various levels of learning (Delamare Le Deist & Winterton, 2005). Over and above the three-dimensional model the holistic approach places significant emphasis on problem solving as a pedagogic tool (Rauner, 2007; Delamare Le Deist & Winterton, 2005). Delamare Le Deist and Winterton (2005) state that the holistic competence approach is an approach to teaching and learning that presents the whole range of skills and knowledge of a particular discipline at all levels. Furthermore, Drisko (2015, p. 111) argued that “holistic competence addresses entire professional activities rather than specific elements of these activities. Holistic assessment also requires professional judgment, so it generally reflects actual professional activities more effectively than does individual assessment of the component elements of a competency”. It is crucial that the development of competencies is understood as “an integral part of all vocational education and training processes in all learning venues, in holistic, explicitly not Taylorist, learning arrangements. Since competencies cannot be taught through instruction, but have to develop as the student actively engages with a task, learning situations must be designed didactically in such a way that they have a holistic character comprising planning, decision, execution, evaluation, and reflection, in that sequence” (Schröder, 2019, p. 88). From a systemic standpoint, the question of how to combine a traditional input-oriented logic of subjects derived from a scientific subject classification system and an action and learning process based on work tasks and processes, in a didactically sound manner to enhance experiential learning, must be addressed (Dewey, 1938).

Rauner (2007) suggested the need for the development of a holistic competence model that shifts from a dominantly theoretical focus to include a practical and occupation related focus. In this model, emphasis must be on integration rather treating occupational education as bits and pieces of curriculum content. This implies that occupational education and training must be a technical and developmental process, moving from novice/ beginner to reflective expert. Cheetham and Chivers (1998) set out a holistic model of professional competence, comprising five sets of inter-connected competence. Their competence framework comprises five dimensions: First, cognitive competence includes underpinning theory and concepts, as well as informal tacit knowledge gained experientially. Here, knowledge (know-that), underpinned by understanding (know-why), is distinguished from competence. Second, functional competencies (skills or know-how) are what 'a person who works in a given occupational area should be able to do and demonstrate'. Third, personal competence (behavioural competence, 'know how to behave'), was defined as 'relatively enduring characteristics of a person causally related to effective or superior performance in a job'. Fourth, ethical competence, was defined as 'the possession of appropriate personal and professional values and the ability to make sound judgements based upon work-related situations. Finally, there is meta-competence, concerned with the ability to cope with uncertainty, as well as with learning and reflection.

The complexity in defining the concept of competence, referring to the many applications thereof and terminology to express competence is evident. Included in the discussion of competence is the economic, technological, technical, and methodological competence; social competence; creativity and innovation skills; and mobility and flexibility combined with persistence, reliability, and precision (Weinert, 2001).

2.6 Occupational Competence-Based Models for Teaching and Learning in TVET

Thilakaratne and Kvan's (2006, p. 320) review of four widely adopted competence-based models, as described by Fletcher (2000) and Wolf (1996) are depicted in Table 2.3 below. Amongst the four competence-based models, two main approaches come to the fore: one focusing on the assessment of occupational performance, and the other focusing on learning and instruction, or competence development (Fletcher, 2000).

Occupational competence is a prime consideration in models that were adopted in occupational training settings, and competence development was the focus of the models that were found in professional education settings. The outcome of the competence-based model adopted in occupational settings was mastery of skills, whereas the competence-based model adopted in professional education settings considered students' attributes as evidence of achievements in their professional role. These two subsets follow different assessment bases: criterion-referenced and criterion-validated (Fletcher, 2000). Key differences between criterion-referenced and criterion-validated systems are elaborated upon in Section 2.8, Table 2.2.

Table 2.2: Thilakaratne and Kvan's (2006, p. 320) Review of Widely Adopted Competence-Based Models as cited in Fletcher (2000) and Wolf (1996)

Attributes	CBET model (competence-based education and training)	Elam's model	USA Hay McBer model	UK NVQ model for industry and commerce
Field of application	US teacher education.	Vocational education and training.	McBer Corporation and Harvard Business School.	Vocational education and training.
Key focus	Emphasis is on learning and instruction (competence development).	Emphasis is on workplace performance.	Emphasis is on learning / development of soft competencies.	Emphasis is on workplace performance.
What is assessed?	Assess individual's achievements in learning in related to professional role.	Assess individual's rate of progress.	Assess individual characteristics as evidence of soft competencies.	Assess individual's accomplishments at work.
Criteria development	Criteria are based on an analysis of professional role: outcomes that describe knowledge, attitude, skills etc. related to that role.	Criteria are specified in terms of behaviours that require in a specific employment role. Performance is the evidence for assessment.	Criteria are based on research on best performances.	Criteria are based on a range of work-related skills and the knowledge of how they relate to performance.
Standards	Precise specification of competence or behaviour to be learnt.	Specify mastery levels.	Competences are defined in terms of individual characteristics.	Emphasis is on exit qualifications rather than admission requirement.
	Competence specifications serve as criteria for instruction.	Emphasis is on exit requirements.		Results is either competent or not yet competent.
Validation of criteria	Competences subject to continual validation.			
	Criterion referenced assessment. Provide feedback to the learners.	Provides feedback to learners.		

2.7 Assessment of Occupational Competence in TVET

Assessment of occupational competence in TVET is a complex exercise, which provides information that can help improve students' learning and help lecturers in teaching (Hills (2008). Another role of assessment is that it gives lecturers the insight on how to assist students to fulfil their potential. Therefore, assessment an integral part of teaching (Hills, 2008). Bloemeke (2017) stresses that there is a need to continuously search and develop reliable instruments for measuring or assessing occupational competence. Assessment is the process of identifying, gathering, and interpreting data in relation to the competence necessary for a qualification, part qualification, or professional designation, so as to assess the student's progress. For a fair and accurate assessment to take place, the right tools must be used. The evidence of competence can be gathered and analysed using these tools. The assessment process is used in making decisions such as whether the execution of a task is successful.

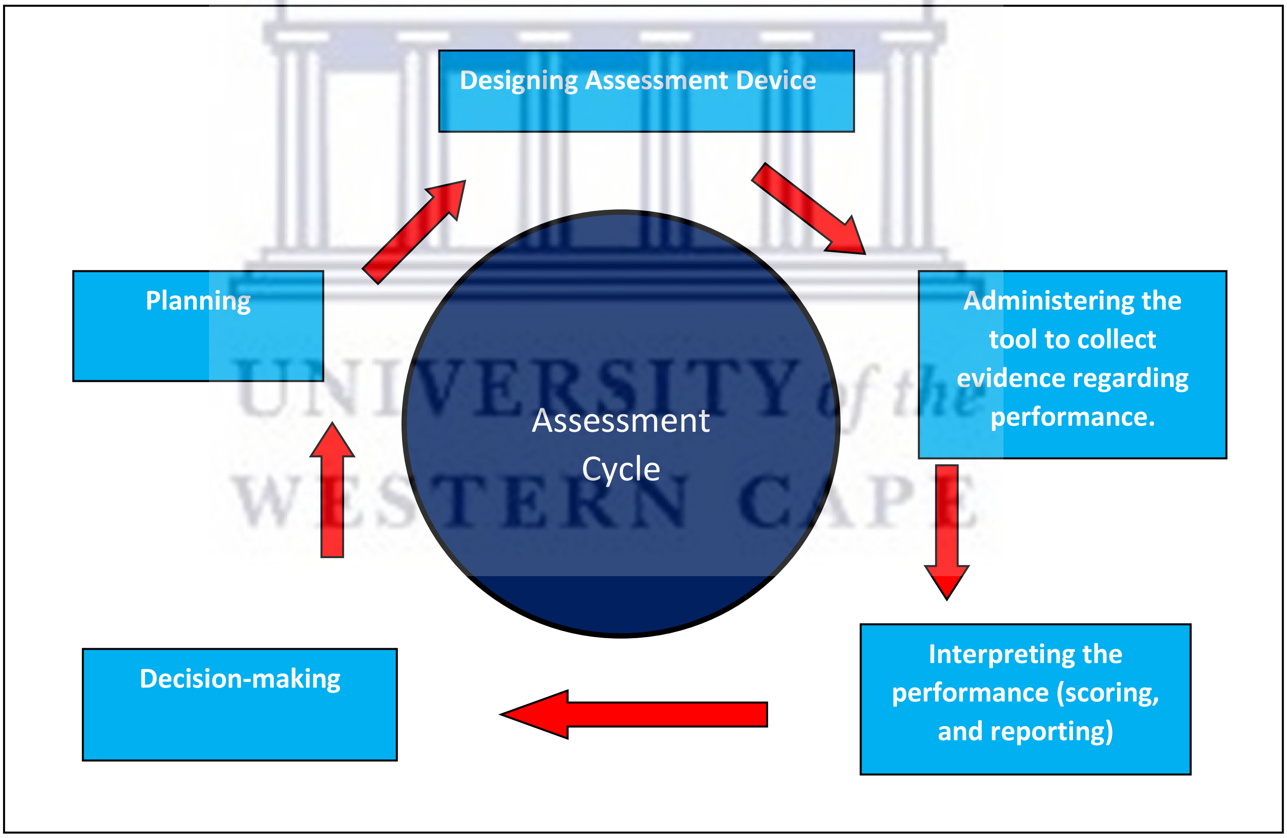


Figure 2.5: Five phases of the assessment cycle (Birenbaum, 2007)

For Birenbaum (2007), these decisions can be made within the assessment cycles. Figure 2.5 provides a visual outline of the assessment cycle, consisting of five phases which are (i) planning; (ii) designing the assessment device; (iii) administering the tool to collect evidence regarding performance; (iv) interpreting the performance (scoring, and reporting), (v) decision-making.

Fretwell, Lewis, and Deij (2001) distinguish between two types of assessment methods: norm-referenced assessment and criterion-referenced assessment. Although norm referencing compares a test taker's performance to that of other test takers taking the same assessment, criteria referencing measures performance against a set standard (Fretwell, Lewis, & Deij, 2001). Table 2.3 that follows, shows Fletcher's (2000) comparison of the key differences between criterion referenced and criterion-validated systems. Criterion-referenced systems are often used in occupational settings or workplaces to assess occupational competence where standards are based on the requirements of the assessing body. Criterion-validated systems are more apparent when assessing learning or competence development with criteria based on research on superior performers (Rauner, 2021).

Table 2.3: Key differences between criterion-referenced and criterion-validated systems

Criterion-referenced systems	Criterion-validated systems
Performance standards are developed and agreed by the assessing body	Performance standards are based on educational research on excellent performance
Assessment focuses on workplace performance; competence criteria reflect expectations of employment.	Assessment focuses on learning and competence development; competence criteria reflecting on personal characteristics.
Standards are outcome-based; hard competence.	Standards are output-oriented, soft competence.

(Thilakaratne & Kvan, 2006, p. 321, based on Fletcher (2000)

Two primary applications of competence-based assessment in occupational and professional education settings can be identified: one that focuses on occupational performance and the other on learning or occupational competence development. Work environments typically value occupational performance, while educational settings value learning development of occupational competence. Ilott and Murphy (1999) introduce three different applications of competence-based assessment, i.e., task-based or behaviourist, transferable attributes and an integrated approach. The task-based approach specifies competencies that are required in workplace performance, e.g., occupational competence. Transferable attributes refer to attributes such as critical thinking, problem-solving, knowledge, ability to learn and intellect, and the integrated approach refers to a combination of both the task-based and transferable attributes approaches. Although Fletcher (2000) and Ilott and Murphy (1999) use different terminology, their ideas are based on a similar typology: occupational performance and competence development or learning. Although Eraut (1994) does not present a classification of different competence-based approaches, his interpretation of competence is complementary to 'competence development or learning' as defined by the other authors.

Gillis and Griffin (2008) suggest that the following criteria should be considered when designing assessments for occupational competence: (Define the purpose of the assessment; Use appropriate methods to gather evidence of competence; Interpret the evidence against the competence standards; Make a judgment to infer competence; and record and report the outcomes of the assessment to key stakeholders. Gillis and Griffin (2008) furthermore assert that of every step of assessment must be guided by evidence. Assessment can also be useful in support of student learning. When assessment is part of the learning process, the gap between students' current achievement and their expected goal can be closed (Mukhtar and Ahmad, 2015). The approach of integrating assessment into the learning process is called assessment for learning. The advantages of assessment for learning are that students gain motivation, self-esteem and are encouraged to actively participate in their learning. Also, TVET lecturers could extract the competence profiles of individual students by means of competence assessment, in order to effectively design differentiated teaching and learning support programmes and individualised support plans according to the unique educational development needs of individual students (Rauner, 2021, p. 443). Rauner (ibid) holds that, "Trainees grow into a profession by learning to solve increasingly complex professional tasks completely and responsibly, i.e., the professional skills as well as the understanding and responsibility of what one does is an indissoluble connection. Professional competence arises from the reflected work experience".

Poor performance in an assessment is not an indicator of poor competence (Chomsky, 1984) as students' competence might not be accurately revealed due to certain factors that affect behaviour. Birenbaum (2007) suggests that in order to accurately assess competence, a prolonged time period is required, otherwise it will be difficult to arrive at a valid conclusion. Accuracy of competence assessment is also associated with the clarity of the outcome specifications. This suggests that outcomes should be made clear to TVET students in advance, and that they should at least be aware of how they will be evaluated and what they should be able to achieve (Wolf, 1995).

The better the match between the objectives and the instructional methods selected, the more successful assessment will be (Diamond, 1998). Palomba and Banta (2001) argue that there should be visible links between outcomes of assessment and the process of assessment. These views are also supported by Van der Vleuten, Sluijsmans and Brinke (2017), who asserted that courses and assessment outcomes shifted due to the paradigm shift of education, from an input model of education to an outcome-based model of education (Chappell, Gonczi, & Hager, 2020). In an outcome-based model of education, competences are measured beyond the mere knowledge domain, towards more complex assessment of skills in authentic contexts, and more general competence that is relevant for success in the labour market (Semijn et.al, 2006). Being able to work in a team, being able to communicate, being able to write academically and being able to behave professionally, are typical examples of such general competencies. The third major change is a didactical one, where education is moving from atomistic to holistic learning, i.e., from teacher-centred learning to student-centred learning, from an exclusive focus on lecturing to more active learning methods, and from highly teacher-led structured learning to self-directed learning (Merrienboer and Kirschner 2007). Seger, Dochy and Cascaller (2003) draw a distinction between testing and assessment, where testing refers to a more classic approach of standardised testing of mainly cognitive functions, and assessment which involves more modern and authentic forms of assessment.

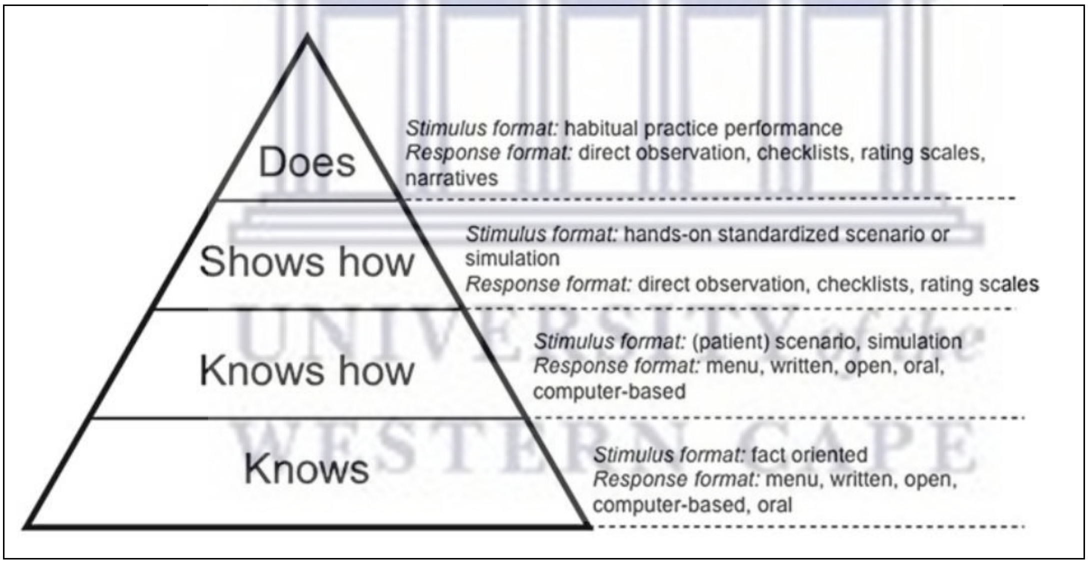


Figure 2.6: Layers of Assessment Pyramid (Miller, 1990)

Miller (1990) proposed a four layered pyramid of competence (Figure 2.6). The bottom layer of the pyramid, i.e., 'knows', represents the assessment of factual knowledge, mostly determined by means of written or computer-based testing for facts. On the second layer, i.e., 'know how', students should be able to use the knowledge (of the first layer) and apply it. On the third layer, i.e., 'show how', behaviour is assessed through a simulation of professional tasks judged against checklists, rating scales, or through narratives. The top layer of the pyramid, i.e., ‘does’, is where students’ actual behavioural performance is assessed in real-life work settings.

Van der Vleuten, Sluijsmans and Brinke (2017) outlined three major perspectives on assessment: assessment of learning, assessment for learning, and assessment as learning. These three perspectives on assessment can be briefly described as follows:

- In an assessment of learning perspective, the emphasis is on the credibility of the decision-making function of assessment and on optimising appropriate decisions regarding our students that are connected in the literature, with the term summative assessment.
- In the assessment for learning approach, also referred to as formative assessment, the focus of assessment is on its effect on learning. In order to improve teacher and student activities that offer information used to change learning, formative evaluations may be incorporated into all learning scenarios. In assessment for learning the assessment should be able to provide meaningful feedback of learning, support the on-going learning process, and promote deeper learning strategies or certain developmental outcomes.
- In the assessment *as* learning perspective, both the decision function and the learning function are united in one single approach to assessment. Assessments are seen as an integrated approach by looking at the design of full assessment programmes. Limitations of individual assessment methods can be overcome by looking at assessment from a programmatic approach where assessment programmes are planned, implemented, governed, evaluated, and adapted.

The latter approach led to the suggestion to optimise a collection of methods in a programme of assessment (Van der Vleuten and Schuwirth, 2005). Within a curriculum, a set of assessment methods are purposefully and coherently selected, based on the intended learning effects. Any method of assessment may be used (classic or modern) depending on its purpose within the total assessment programme. The shift from an assessment of learning approach to an assessment for learning approach (Assessment Reform Group, 2002), has led to an increased interest in new formats and tools of assessment. These tools have become more widely adopted in classrooms, as they are meant to support a better integration of teaching/instruction with assessment of progress in learning (Birenbaum, 2003; Brown, 2004; Shephard, 2000).

Boud (1995) and Sadler (2005) noted that new methods of assessment must be introduced along with new criteria for measurement, to ensure the quality of the assessment itself (Carless, 2005). This will assist in the design of new modes and tools of assessment aligned with instruction and student learning processes (Assessment Reform Group, 2002). The focus on quality of measurement, therefore, is directed towards displaying and documenting achievement gains relative to the student's goals (Seger et al., 2003).

Toohey, Ryan, McLean and Huges (1995) conducted a comprehensive literature review of issues related to the assessment of occupational competence-based education and training that affirmed the complicated nature of the assessment of occupational competence and the need for an authentic measurement tool. They also stressed that occupational competence assessment should be linked to 21st century competencies. The Organisation for Economic Co-operation and Development's (2023 Online) definition and selection of key competencies (DeSeCo) are fundamental in this framework. Another distinguished framework is Key Competence for Lifelong Learning, a European framework that supports the OECD-DeSeCo programme (Organisation for Economic Co-operation and Development, 2023 Online).

Schuhfried (2022), identified the following as measurable dimensions of occupational competence:

- Attention to mechanical accuracy, referring to work accuracy versus work speed as well as attentiveness.
- Cognitive abilities, such as anticipation of movement, knowledge of English, memory, logical reasoning, multi-tasking, capabilities comprising numerical, spatial, technical comprehension and verbal ability.
- Reactive behaviour and Visual functions as an overarching term for stress tolerance, reactive conduct, peripheral perception, reaction time, overview, and visual perception.
- Sensomotor functions that include perceptual skills such as eye-hand coordination, eye-foot coordination and fine motor skills.
- Work-related aspects of personality alluding to resilience, emotional wellness, extraversion/introversion, frustration tolerance, leadership skills, thoroughness, interest, customer orientation, motivation, openness, stress/burnout syndrome and sociability.

These are personality and ability attributes, but competence should not be confused with intelligence, therefore, a distinction should be made between the concepts of competence and intelligence (Rauner et al., 2013; Rauner, 2021). According to Ploegh, Tillema and Segers (2009), the following criteria can be used to ensure the quality of assessment:

- Authenticity: This generic criterion is intended to convey that assessment tasks/assignments include relevant knowledge, skills, and attitudes required to operate in realistic contexts. First, representativeness refers to the requirement that assessment goals and selected assessment tasks must resemble the reality domain. Second, cognitive complexity highlights the inclusion of higher order skills in assessment tasks. Third, content coverage intends to stress breadth and completeness of assessment tasks in reference to the content taught. Fourth, authenticity is often equated with meaningfulness, which in more specific terms focuses on the importance of assessing particularly relevant and worthwhile student accomplishments. Most of the criteria included under authenticity refer specifically to the proper selection of assessment goals and tasks, except for meaningfulness, which refers to other aspects of the assessment process as well, such as the appraisal and interpretation of scores.

- Transparency: This criterion indicates that the assessment needs to be clear and comprehensible to all participants involved.
- Fairness: As a quality criterion, this implies the absence of bias against certain groups and the exclusion of irrelevant variance in the assessment process. In essence, it requires that each student receive the same opportunity to demonstrate acquired knowledge, skills, abilities, and competence. As a criterion, it refers to the entire assessment process.
- Generalisability: As a generic criterion, it describes the extent to which assessment covers a broad universe of tasks that measure the same content under different task performances. There are three specific components under generalisability: comparability, defined as the selection of similar tasks measured under the same condition's reproducibility, defined as the accuracy and consistency in interpreting scores over time and assessors and transferability, referring to judgements and decisions of measured performance in other situations or tasks.

Each of these criteria refers to different aspects of the assessment process. Further, educational consequences can be identified as an overall criterion equated with the consequential validity of an assessment which entails the (intended and unintended) effects of the assessment on learning and instruction. The assessment of domain specific professional competence opens a new dimension for quality assurance in TVET in which a diagnostic model holds the potential to use holistic problem solving to empirically measure TVET college students' learning as well as occupational competence. Until recently, no valid and standardised occupational competence diagnostic measurement tool has existed. In the chapter that follows, the COMET diagnostic model is explained as the conceptual model in within which the current investigation is embedded.

2.8 Critique of the Competence-Based Learning Approach

Amongst others, Adam (2008), Petkutė (2016), and Winch (2010), point out that the term competence is often used interchangeably and, thus, has an obscure relation with terms like skill and outcome, as well as terms such as graduate attribute, capacity, and capability. All these terms are used to denote different kinds of practical knowledge that have crucial epistemological curriculum implications. The lack of consensus regarding the definition of competence causes confusion and has encouraged critique from opponents of the concept who suggest that the concept is impossible to identify and attach theory to (Mulder, 2006). Norris (1991) argued that the lack of consensus has deflected attention from the benefits of the concept, and instead more attention has been given to attempting to define competence. Boon (2002) saw competence as a 'fuzzy concept', even while acknowledging it as a useful term, bridging the gap between education and job requirements. According to Mulder (2006), lack of coherent definitions and clear relationships between competence and performance is problematic in reaching a consensus. This lack of consensus leads to what can be described as conceptual 'inflation' (Weinert, 2001, p. 47). Dulewicz (1992) found that firm-specific competence represented only 30 per cent of the total competence basket, and the remaining 70 per cent were common to a wide range of organisations. Despite the evidence, critics of competence argue that it is impossible to identify a set of universal management competencies, as a study revealed that most companies use the same terminology. Critics argue that competence models use rationalist approaches, or are abstract, narrow, and too generic, making the manner, in which competence is identified, unable to reflect the complexity of competence in work performance.

Within the field of Sociology of Education, Bernstein (1999, 2000) emphasises the fundamental significance of the relationship / inner link that exists between disciplinary knowledge form or structure and curriculum form or organisation. While Bernstein (1999) holds that curriculum is a mix of knowledge elements which have different qualities, contrary to the competence-based approach he stresses the primary significance of the role of propositional or conceptual disciplinary knowledge within curricula. For Bernstein (2000, p. 30), disciplinary conceptual knowledge "takes the form of a coherent, explicit, and systematically principled structure… [and] …is a precondition for a coherence of curriculum in a particular discipline". Furthermore, Bernstein (2000) argues that the structure of disciplinary knowledge provides the curriculum with a certain identity or distinctness, while the current reconfiguration of curricula towards generic competence implies a uniform shift from propositional or conceptual knowledge towards "know how" or more applied kinds of knowledge irrespective of the inner logics of different, or even contrasting, disciplines (Petkutė, 2016, p. 27). Bernstein contends that a competence-based approach to curriculum is an expression of a recent complex phenomenon of genericism or generic mode of knowledge organisation, in which the focus shifts from discipline-specific knowledge to generic forms of knowledge constructed independently of academic disciplinary contexts and "are essentially directed to extra-school experiences" (Bernstein, 2000, p. 53). While acknowledging the importance of competence and outcomes within curricula, there is a growing need to rearticulate the significance of disciplinary conceptual knowledge, which is a prerequisite for maintaining the coherence of fundamental curriculum knowledge, as well as differentiation of curricula across disciplines (Petkutė, 2016, p. 28).

Bernstein (2000) maintains that students need access to theoretical knowledge as a condition of democracy, as it enables students to participate in the conversations of society, as well within their occupational fields regarding what have been done in the past, what needs to be done differently in the future, and for what reason. Theoretical knowledge supports democratic participation in society, social inclusion, and social mobility because it is the basis for occupational and educational progression. Workers need to be able to apply theoretical knowledge in different ways, and within different contexts, as their work increases in complexity and level of difficulty. Occupational progression is strongly related to educational progression, as it provides access to theoretical, disciplinary knowledge. Bernstein argues that all qualifications should provide students with the disciplinary knowledge they require to attain higher levels of progression within their field of specialisation, as well as for immediate occupational outcomes (Petkutė, 2016, p. 28). Students require a sound theoretical basis for their occupations which will enable them to participate fully as agential workers. Without the fundamental theoretical knowledge that underpins their practice, workers have limited autonomy because they generally only have access to procedural knowledge that they can apply in specific circumstances, and they must rely on others for instruction in what they should do if different circumstances arise (Bernstein, 2000). For Wheelahan (2019, p.104), the challenge that occupational curricula faces are "to provide students with access to the theoretical knowledge that underpins occupational practice within a field, and to the tacit, context-dependent knowledge of the workplace. Trying to collapse the distinction between each type of knowledge does violence to both". An exclusive focus on competence-based learning in the workplace denies students access to disciplinary systems of meaning, as students are only exposed to contextually specific applications of theoretical knowledge in the workplace, and not to the system of meaning in which theoretical knowledge is embedded. Similarly, an exclusive focus on learning theoretical knowledge at TVET colleges does not provide students with access to the tacit, context-dependent knowledge of the workplace. Therefore, both discipline-specific knowledge and competence-based learning are needed.

The Bernstinian critique of competence-based curricula is that the focus on procedural knowledge in which the actor is envisaged as a supervised worker rather than an agential actor who exercises autonomy and judgment disempowers workers and contributes to fragmentation of the concept of work itself. From this viewpoint, units of competence are based upon an atomistic conception of work and knowledge in which the whole consists of various generic parts, thus in breaking down units of competence into elements and performance criteria, the required knowledge and skills are fragmented and atomised. This paradigm assumes that workplace tasks and roles can be defined independently of other requirements and the theoretical basis of the occupation.

While acknowledging the critique above, it can be stated that the purpose of the competence diagnostic model (COMET) presented in the chapter that follows, is not to replace discipline-specific Electrical Engineering knowledge. Rather, it is offered as a didactic tool to be implemented in support of the existing TVET curriculum that comprises both disciplinary and contextualised knowledge. Exponential digital automation of industries will displace an estimated 800 million workers by 2030 who will then be compelled to learn new skills and change their work categories (McKinsey Global Institute, 2017). Fast devolving manufacturing industries will demand that TVET graduates are flexible and adaptive to increasingly complex and ever-changing skills demand. In addition to the discipline-specific knowledge that TVET Engineering students gained from the existing curriculum in their institutional learning, the domain-specific nature of the COMET diagnostic model provided student participants in my research with a unique opportunity to develop the range of competencies that are needed to adapt to the rapidly advancing world of work.

2.9 Chapter Synopsis

Arriving at a conclusive definition of the concept of competence seems unlikely from the review of the literature. However, imperatives in the TVET domain present the opportunity to suggest a holistic, multi-dimensional competence model that may assist in understanding the current TVET problem of occupational preparedness. The COMET diagnostic model can provide both theoretical and practical approaches to teaching and learning activities in TVET that are domain specific and grounded in theories that account for both types of knowledge (work-process/theoretical knowledge and practical knowledge) and can represent the occupational development of students holistically. In the next chapter the COMET Model is explained in more detail as this was the lens through which my research process and analysis was undertaken.

Chapter 3

Conceptual Framework: The COMET Diagnostic Model

3.1 Introduction

In this chapter, the COMET diagnostic model, used for the development and assessment of occupational competence, is presented as the conceptual framework applied in the investigation. Theoretical underpinnings and a brief historical account of the development of the COMET diagnostic model is provided, as well as the rationale for using the COMET model developed by Rauner et al. (2016) for diagnostic and didactical purposes. The COMET model is then outlined in terms of its three dimensions and eight professional competence criteria. The focus of my study, which was to explore how the application of the COMET model might enhance occupational competence of Electrical Engineering students at TVET colleges, is then contextualised within the conceptual framework of the model. The chapter continues with an overview of occupational didactics in terms of the COMET model, including the designing of competence-promoting learning tasks, the structure and designing of teaching-learning and work processes, the definition and development of evaluation criteria, and the evaluation of task solutions. Lastly, the chapter provides directives for the presentation and evaluation of task solutions, the work and learning process, as well as learning outcomes.

3.2 Historical Development of the COMET Diagnostic Model

Between 1996 and 1999, the Kultusministerkonferenz (KMK), i.e., the Conference of Ministers of Education in Germany, formulated the following guiding principle as an educational mandate for dual occupational training:

> "Occupational schools and training companies fulfil a joint educational mandate in dual occupational training. The occupational school is an independent place of learning ... [it] aims at basic and specialised occupational training and expands previously acquired general education. in this way, it aims to enable people to fulfil their professional tasks and to play a part in shaping the world of employment and society with social and ecological responsibility" (Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, 2000, p. 3).

Both Roth (1971) and Rauner (1988), viewed the concept of comprehensive occupational competence as follows:

> "…the ability and readiness to pursue an independent, proper, professional as well as personally thought-out acting for social responsibility. Occupational competence encloses the dimensions of professional, social, human, and methodical competence and moves the individual development of the personality into the focus of the occupational training processes" (Rauner, 2008, p. 539).

Training in occupational competence can be structured both conceptually and practically, from the novice level to the level of reflected mastery (expert) (Benner, 1997; Dreyfus & Dreyfus, 1987; Lave & Wenger, 1991; Rauner, 1999). Dreyfus and Dreyfus (1987) identified five levels of competence development, with four corresponding learning areas to represent development theory that were adapted by Rauner (2021) as part of the content dimension of the COMET model. The levels are summarised in Figure 3.1 on the next page.

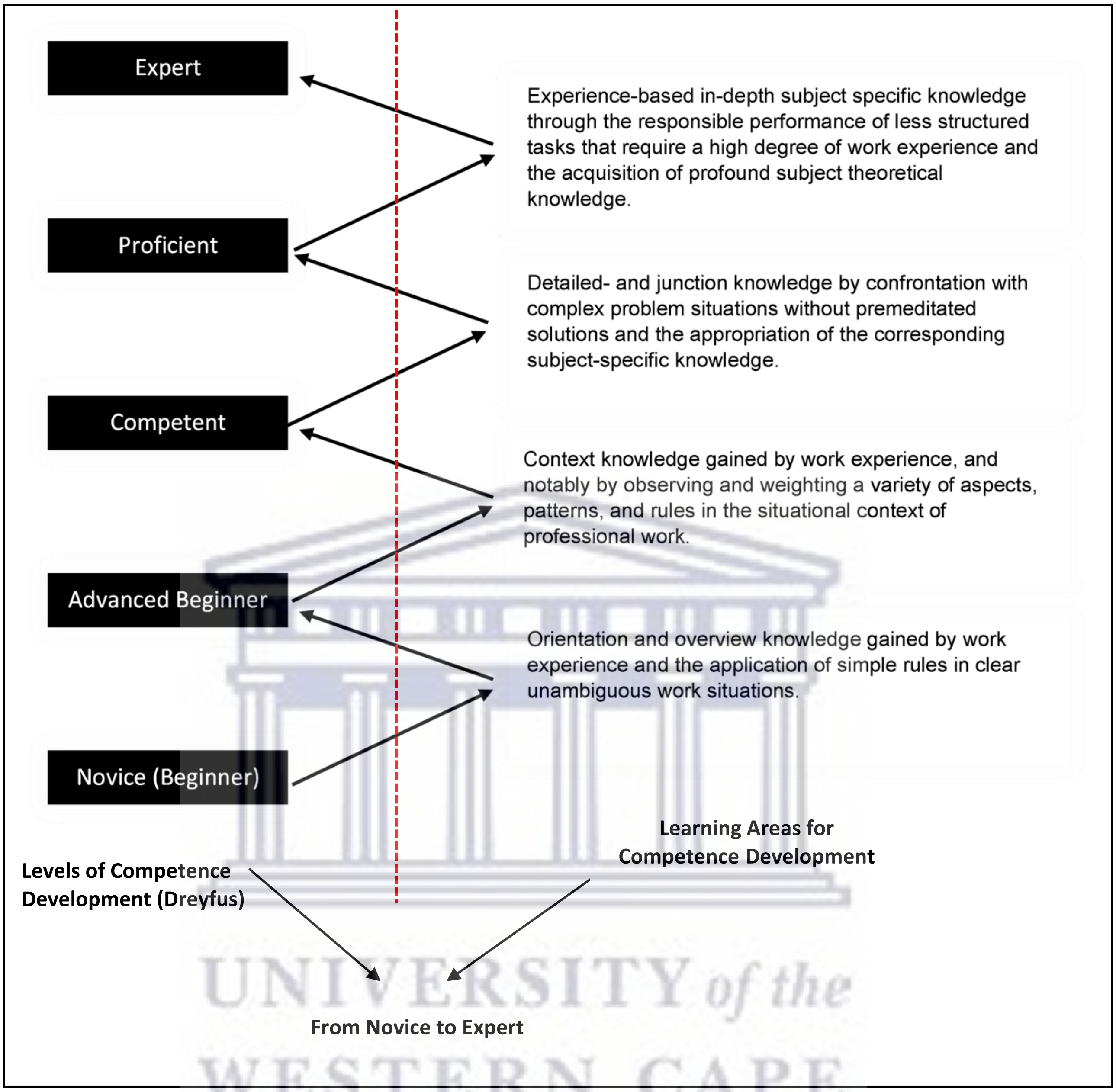


Figure 3.1: Professional Competence Development "from beginner to expert" (Rauner, 2021, p. 45)

The five levels of competence development identified by Dreyfus and Dreyfus (1987) and the corresponding four learning areas for occupational competence development together represent a key element of occupational competence development theory (Figure 3.1). The four learning areas for occupational competence development and the five levels of competence development identified by Dreyfus and Dreyfus (1987), serve a didactic function in the development of work- and design-oriented occupational training programmes, as well as a hypothetical function in identifying thresholds and levels in the development of occupational competence and identity (Rauner, 2021, p. 43). The five levels of competence development are incorporated in the content dimension of the COMET diagnostic model, as explained below in Section 3.3.1 (Figure 3.2) In expertise development research, developmental tasks and their functional equivalents are essential for occupational competence development. Benner (1997) emphasised the paradigmatic importance of development tasks in nurses' gradual development of professional competence. These development tasks were based on 'paradigmatic work situations' that put the nursing staff's skills to the test. It took almost two decades in Germany before the impetus given by the attempt to justify competence development in occupational education and training in terms of development theory, was translated into didactic concepts. Euler (2011, p. 60) critically assessed occupational education’s attempts to model occupational competence and found that “developments remain partial with regard to a comprehensive concept of competence, i.e., only individual dimensions and facets of competence were taken up and covered”. “There is a close focus on expertise, particularly in the developments for the commercial sector. The alleged references to social competence, however, lack a sound theoretical foundation” (Winther & Achtenhagen, 2008, p. 531).

The KIieme Commission (Klieme et al., 2003) have made a strong case for the idea that a competence model's role is to serve as a mediator between the guiding principles and objectives of a subject or learning area and the creation of test tasks (and learning tasks). This is necessitated by the fact that that general educational didactic models were not suitable for development of occupational competence development in the TVET educational context. The Klieme Commission suggested that competence models should be characterised by a fundamental didactic function (Katzenrneyer et aI. 2009). “Educational goals and their classification, for example, according to Bloom’s learning goal taxonomy” (Anderson & Krathwohl 2001; Brand, Hofmeister, & Tramm, 2005; Lehmann & Seeber, 2007, p. 26), can be used as explanatory frameworks applicable to diverse educational contexts. It is crucial to empirically test and reconfirm the reliability and validity of occupational competence models for diverse study samples, in order to standardise the use of such models for generalised application across various study contexts. This is important as some occupational competence models might not necessarily be universally applicable to all study samples, due to variances in contexts, which necessitates additional requirements or adjustments from competence models and their assessments.

Occupational competence models, according to Rauner (2021, p.14), need to firstly include general educational goals and guiding principles that can be justified by educational theory, and which can be taught internationally, as well as the domain specific educational goals of training systems and training courses. Furthermore, occupational competence models should be in line with the basic findings of teaching, learning, development, and evaluation research, and need to be tailored to learning areas so that it allows the content dimensions of the competence models to be sufficiently concrete, and to sufficiently represent concrete instructions for the development of test tasks. Effective models of occupational competence should be able to measure students' levels of occupational competence acquisition as well as give them the tools they need to develop their occupational competence and succeed in their future careers. These requirements imply the need for simplified models that could readily be applied and adjusted across diverse educational contexts (Rauner, 2021, p. 45).

Large-scale domain-specific assessments like the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) are mentioned by Koeppen, Hartig, Klieme, and Leutner (2008) as motivators for increased discussion of educational outcomes and their evaluation. They emphasise the change from a fixed set of specialized competencies to the development of competencies that are applicable in numerous situations, some of which may be complicated, and they draw attention to the disparities between competencies gained and the goals of the educational system. The development of a priority research initiative with the working title "Competence Models for the Assessment of Individual Learning Outcomes and the Evaluation of Educational Processes" was authorized by the German Research Foundation (DFG) in 2007 (Klieme and Leutner 2006). This priority programme was designed to create competence models, which are essential for coordinating learning goals with test development, as well as for interpreting test results considering pedagogical theory and lesson preparation. The priority programme's research project was essential for competence diagnostics. Many workshops were presented by Klieme and Leutner in 2006 with assistance from the Federal Ministry of Education and Research. The Institute Technology and Education, University of Bremen (ITB), in collaboration with the German Institute for International Educational Research (DIPF) in Bremen, conducted the workshop on the state of the art of competency research in occupational education and training from July 11 to 12. (Grollmann & Jude 2008). The evaluation of the applicable Vocational Education and Training (VET) research initiatives revealed that occupational education is characterized by several characteristics that make the implementation of an international comparative large-scale competence assessment rather challenging. Three causes stood out:

a) Because there are so many different occupations, it is impossible to categorize them into comprehensive competence fields across occupational domains due to their very varied qualification and competence profiles. The concepts of general technological literacy for jobs in engineering and technology and economic literacy for jobs in business and administration did not work to transcend the multiplicity of professional duties. As they fall short of the standards for professional knowledge and abilities, the notions of technological and economic literacy must be attributed to general education rather than occupational education.

b) As a result of technological advancements, the qualification requirements for a significant number of vocations are subject to constant and quickening change. As a result, creating occupational profiles and training programmes continues to be difficult. This prevents the contents of training programmes from being used to assess professional competence.

c) International comparison research and testing are difficult because professional competency is promoted by various approaches. In a dual training program, trainees in country X learn skills that are then taught to trainees in country Y through school-based training programmes or even through higher education and in-service training. As the competence gained in the first scenario is based on actual work experience and the second case on theoretical information and abilities that were acquired in a school environment, it is difficult to compare the competence gained through these different learning routes. Both have, at most, a conceptual relationship with one another (Rauner et al., 2013b, pp. 1-2).

Occupational education and training, on the other hand, is equipped with well-developed techniques for assessing professional competence to act. For instance, proving that a prospective pilot can fly an aircraft, is crucial. This example highlights the importance of practical exams in determining a person's professional aptitude. High standards are placed on the examination methods when it comes to the evaluation of critical skills required to get a license to practice a profession. Competence diagnostics in occupational education is a challenging because the requirements for evaluating professional competence differ by occupation. (Rauner et al., 2013b, p. 2).

Fischer et al. (2015) argue that competence diagnostics enable occupational education policies and training to:

- Plan and coordinate the transition from initial vocational training to higher education using evidence-based data.
- Examine the differences between dual education programmes (initial training) and dual education programs (variants) in higher education.
- To examine the empirical data supporting effective models, objectives, and education programmes in the field of occupational education and training in order to establish the overall quality of this field of study (Fischer et al., 2015).

Prenzel, Gogolin, and Krüger (2007, p. 6) emphasised a need for competence diagnostics as follows: “What is missing is a model of cognitive, but also of motivational and metacognitive components that are needed to master certain tasks and problems”.

The COMET Model of occupational competence, diagnostics was developed at the Universität Bremen by Prof. Dr. Felix Rauner to address existing challenges of assessing occupational competence in vocational education in Germany. The COMET (acronym for Competence Measurement in Electrical Technology) model was a result of Rauner’s life-long effort to create a competence diagnostics model for occupational education and training. In terms of occupational pedagogy, COMET sought to implement the idea of learning areas/ occupational domains adopted by the Conference of Education Ministers in Germany as the foundation for work- and business-process-oriented occupational education, with the aim of empowering trainees to influence the work and social environments in a way that was socially acceptable and contextually compatible (KMK 1996a, b; cf. Rauner 1988). First tested in the domain of Electrical Engineering, the COMET methodology was then applied to other professions in Germany. The field of occupational education and training has a high demand for large-scale assessment framework creation, especially for global comparative research and advancements (Rauner, 2021).

The COMET model is firmly rooted in earlier competence developmental theories, including Dreyfus and Dreyfus’ (1987) five levels of professional competence development from Novice to Expert, as defined by Lave and Wenger (1991) in their situated learning concept; and the concept of the ‘developmental structure of occupational education and training programmes’ (Benner 1995; Blankertz 1983; Bremer 2004; Dreyfus and Dreyfus 1988; Gruschka 1985; Rauner 1999). Professional learning tasks possess the potential and quality of effective developmental activities for the development of professional competence (Havighurst, 1972), and is therefore, of utmost importance for competence development. In addition to COMET being a diagnostic model for assessment of occupational competence, it is also regarded as a means to develop occupational competence, that is, a pedagogical function. In the section that follows, the didactic dimensions and criteria of the COMET model are elaborated upon.

3.3 Didactic Dimensions and Criteria of the COMET Diagnostic Model

The COMET diagnostic model for the development and assessment of occupational competence in teaching and learning meets the requirement for a differentiated concept of multiple competence in three ways as follows:

- The test assignments are derived from the elements of professional work tasks.
- Structuring professional work tasks in the occupational curricula according to developmental sequencing makes it possible to describe professional competence in terms of all its characteristics, not just as a process of quantitative increasing of technical competence.
- The competence model is multi-dimensional in the sense that three qualitatively defined competence dimensions are identified and can be described by means of eight competence criteria.

3.3.1 The Three Didactic Dimensions of the COMET Diagnostic Model

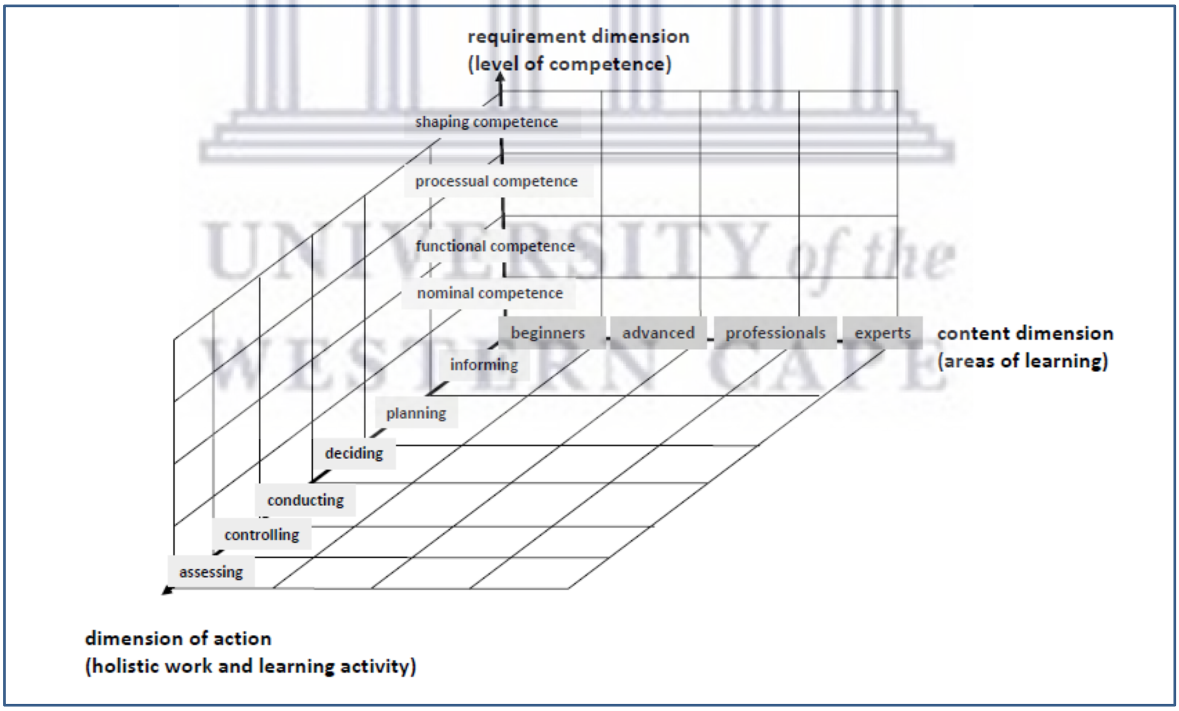


Figure 3.2: Three Didactic Dimensions of the COMET Diagnostic Model (Rauner, 2016; Rauner et al., 2013b)

As illustrated in Figure 3.2, the COMET Model has three didactic dimensions, namely: (i) the Requirement dimension, (ii) the Content dimension, and (iii) the Action dimension. These didactic dimensions imply teaching, learning and assessment, that is, inputs as well as outputs.

The three didactical COMET dimensions can be described as follow:

(i) *The Requirement Dimension (Levels of Professional Competence)*

The requirement dimension describes the product of the task after completion. By rating professional competence in this manner, professional competence levels can be measured quantitatively and qualitatively. The results can be used to generate the competence profiles of a professional according to eight competence criteria that will be discussed later in this section. In utilising the competence profiles of professionals, it can therefore be easier to track professional development of a worker from one level to the other.

The requirement dimension consists of four levels of competence that can be used to evaluate a task or professional solution. These four levels of professional competence, which encompass eight criteria of complete professional action, can be broken down as follows:

- ***Nominal Competence Level:*** this level is excluded in terms of COMET requirements for professional competence because students at this level are at risk.
- ***Functional Competence Level:*** consists of two criteria, namely clearness/ presentation and functionality.
- ***Processual Competence Level***: defined by criteria of sustainability, utility, efficiency, effectiveness, as well as business and work process orientation.
- ***Holistic Shaping Competence Level:*** this highest level of competence is characterised by criteria of social acceptability/ environmental compatibility and creativity, as explained in Section 3.3.2 below (Rauner, 2016, 2021; Rauner et al., 2013b).

As indicated in Figure 3.2, these competence levels are cumulative in nature. All eight COMET requirements must have been addressed didactically and satisfactorily for a student to obtain holistic shaping competence. It must be emphasised that the test tasks' complexity and degree of difficulty do not determine the borders between competence levels. It is a multi-level model, meaning that the three degrees of competence are ranked from lowest to highest, with one denoting the lowest level of competence and three denoting the highest level (Rauner et al., 2013).

(ii) *The Content Dimension*

This dimension provides some degree of orientation and guidance for the didactic activities of lecturers and trainers. The content of teaching and learning in a specific subject or learning area serves as a basis for test development, which distinguishes it from large-scale international comparative assessments such as PISA where a ‘world-curriculum’ is adopted. COMET is based on real-world occupational activities that act as criteria for the content development of test tasks. This dimension is justified by learning and development theories, e.g., the Novice to Expert developmental theory of Dreyfus and Dreyfus’ (1987), and the situated learning theory of Lave and Wenger (1991). This means that students' competence levels and development in various occupations, as well as different TVET systems, can be compared. Furthermore, competence development can be assessed systematically at various stages of an occupational training program. However, within the current South African TVET system, such occupational appropriate theories are not being used. Instead, South African TVET colleges are critiqued for adopting chalk, talk, and textbook-based didactic methods. Competence development is supported by typical work tasks being transformed into developmental tasks, in terms of the COMET methodology, but not across the board in college qualifications, for the various development levels of competence (Jacobs, 2016).

(iii) *The Action Dimension*

A fundamental, normative principle is the development of human potential in the workplace, which is underpinned by "complete professional action". Holistic tasks, or the shaping of work, are viewed as aspects of personality development characterised by the following five aspects: “(i) The independent definition of objectives that can be embedded into overarching goals; (ii) Independent preparatory activities in the sense of exercising planning functions; (iii) Selection of instruments including the relevant interaction for adequate goal attainment; (iv) Executive functions with process feedback for continuous opportunity to correct activities with defined objectives; and (v) Review and feedback on the outcomes with the opportunity to evaluate” (Ulich, 1994, as cited in Rauner, 2013, p. 50).

Professional actions are informing, planning, deciding, conducting, controlling, and assessing (Rauner, Heinemann, Maurer, Haasler, Erdwien, & Martens, 2013a, pp. 49-52). The COMET diagnostic model consists of eight criteria that constitute the requirement dimension, as illustrated in Figure 3.2.

3.3.2 The Eight COMET Criteria

Scholz and Heinemann (2013) state that the focus of competence development and assessment is on problem solving, project orientation and practical learning. Learning tasks are a fundamental component of occupational competence assessment and development.

The main purpose of learning tasks is to prepare students for the main COMET test, and to enrich the lectures/lessons because such complex and open tasks often better address the students' creativity and individual problem-solving capabilities than "ordinary" tasks that form a regular training curriculum (Rauner, 2021). Competence, skills, and knowledge of students, range from giving detailed help and specifications to beginners, to merely giving the task to advanced students. This must be done in a manner that safeguards reflection on practice and the establishment of complex work environment. The eight COMET criteria illustrated in Figure 3.3 below define the three levels of competence: functional competence, processual competence, and holistic competence. The competence levels are accumulative in nature but allows for the possibility of differentiating between students' competence in terms of the quality of the solutions within the levels as illustrated in Figure 3.3:

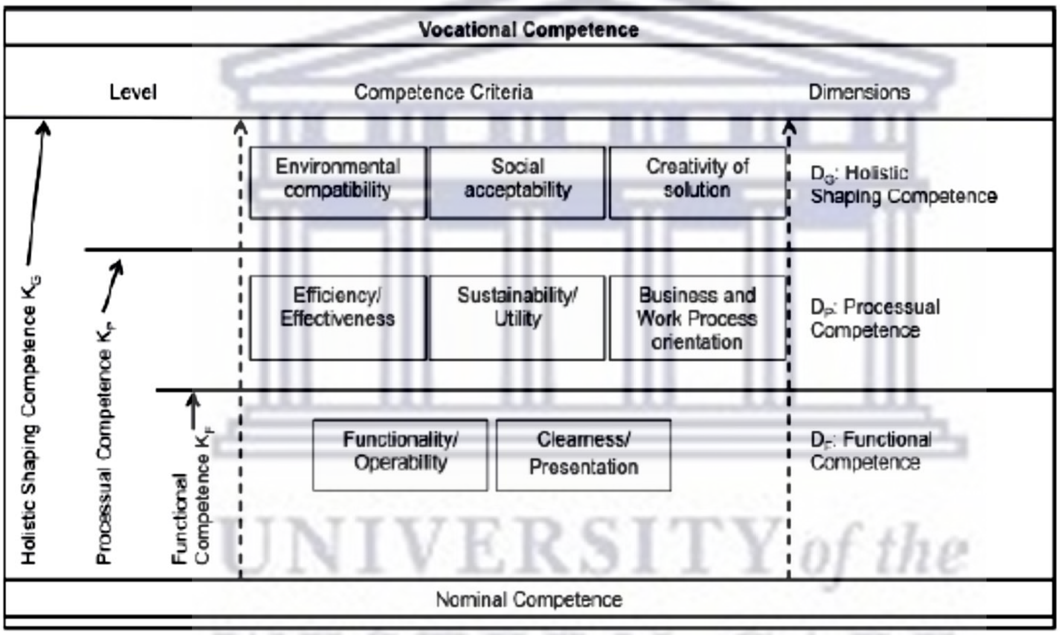


Figure 3.3: Levels and criteria of professional competence (Rauner, 2016, p. 66)

The Eight COMET criteria, which can be applied to assess the solution to a complex, domain-specific test task, are briefly explained below:

i. ***Functionality/operability*** – refers to technical competence of subject specific knowledge and skills. The proposed solution must be functional, before other criteria can be considered.

ii. ***Presentation/clearness*** – involves documentation and communication of ideas through diagrams, illustrations, and descriptions as evidence of every step that will be undertaken to arrive at a professional solution. This step is fundamental for vocational work and learning, in enhancing clear professional communication.

iii. ***Efficiency/effectiveness*** – the solution must incorporate context-specific economic aspects while taking into consideration the costs and benefits of the final product. The solution must be responsive to societal as well as company needs.

iv. ***Sustainability/utility*** – the professional activity suggested must reflect customer care and utility of the work outcome. "A high utility of a solution depends not only on its immediate applicability for the customer, but also on the prevention of liability to failure and the consideration of aspects of easy maintenance and repair. Sustainability of application and the perspectives for enhancement must also be considered when the utility is assessed" (Hauschildt, 2016).

v. ***Business and work process orientation*** – this criterion refers to how the organisation is structured hierarchically around business processes. The proposed solution must consider everyone involved in the process chain as well as everyone who might potentially contribute within and outside the organisation and profession. Networking within and among companies is a critical aspect to be considered for the solution.

vi. ***Social acceptability*** – issues of health, work safety and sensitivity to the humane aspect of the organisation and customers must be considered. Furthermore, the potential aspect of the professional solution to the environment must be factored into the solution.

vii. ***Environmental compatibility*** – is a criterion which is relevant to almost all work processes. It is not a question of general environmental awareness but of the environmental requirements specific to occupations and specialisations in so far as they affect work processes and their outcome.

viii. ***Creativity*** – an indicator that plays a leading role in the performance of occupational tasks. One reason for this is the extreme variations in the scope for creativity in the performance of occupational tasks in different situations (Rauner et al., 2013).

As shown earlier in Figure 3.3, Functional Competence is the second competence level that comprises the Functional Competence Dimension, which consists of two competence criteria, namely Functionality/Operability and Clearness/Presentation. The third, the Processual Competence level, comprises the Processual Competence Dimension, which consists of three competence criteria, namely Efficiency/Effectiveness, Sustainability/Utility and Business and Work Process Orientation. Finally, the fourth Holistic Shaping Competence Level comprises the Holistic Shaping Competence Dimension, which also consists of three competence criteria, namely Environmental Compatibility, Social Acceptability, and Creativity of Solution.

It must be emphasised that the boundaries between competence levels are not based on the complexity and degree of difficulty of the test tasks. It is a multi-level model implying a ranking from lowest to highest in three competence levels, 'one' being the lowest level and 'three' being the highest possible level of competence.

According to the model, to promote holistic problem solving, these eight criteria must be incorporated into TVET curricula and didactics. But before the other criteria can be considered, the solution's functionality and clarity must be in place. The solution must be practical and have undergone thorough deliberation. Diagnostic evaluation is possible with occupational competence measured at levels of Nominal, Functional, Processional, and Holistic competence. In contrast to outcomes-based assessment results, which rank students as either "competent" or "not yet competent," the opportunity for progress is therefore increased.

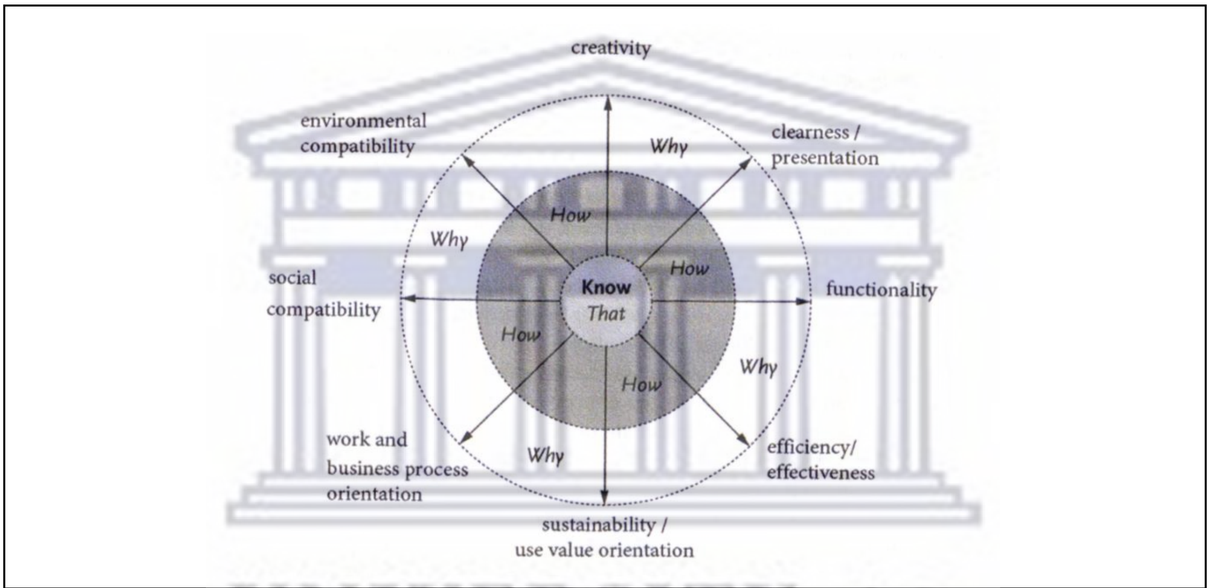


Figure 3.4: Work Process Knowledge (Rauner, 2021, p.56)

The eight COMET criteria required to solve problems holistically within the context of the specific task are illustrated in Figure 3.4. Work Process Knowledge levels that comprise *know that* (knowledge to guide action), *know how* (knowledge to explain action) and *know why* (knowledge to reflect action) (Jacobs, 2016) can be observed in Figure 3.4. Work Process Knowledge is further discussed in the section that follows (Section 3.3.3). These levels are applied in Chapter 5 to profile and visually present the occupational competence of the total group of participants per test site, the top five students who showed improvement, as well as for students who scored <5 in the baseline test and whose total competence scores increased with more than 20.

3.3.3. Work Process Knowledge

Work process knowledge is a type of knowledge that supports practical work; as context-related knowledge, it transcends context-free theoretical knowledge significantly (Rauner, 2021, p. 46). Work process knowledge was conceptualised by Wilfried Kruse (1986), in which this central aspect of vocational learning was identified and developed in numerous research projects as a fundamental form of knowledge for vocational learning (cf. Fischer, 2000a, 2000b). Work process knowledge, which results from the knowledge absorbed into practical work, is seen as a central knowledge category within the context of the change in the didactics of vocational education and training, in connection to work and work processes. The phrase 'Learning at the Workplace' is characterized by the ambiguous usage of words like workplace, work process, professional action, professional activity, and work situation. 'Learning in the Work Process' has largely replaced the phrase 'Learning at the Workplace' in recent years.

Work process knowledge can be characterised as the connection between practical and theoretical knowledge (Rauner, 2021). The development of a scientific and pedagogical knowledge framework used to model vocational competence, suggests the introduction of distinctions which enable the differentiation between three successive levels of work process knowledge based on Hacker (1996): action-guiding, action-explaining and action-reflecting knowledge, as illustrated in Figure 3.5.

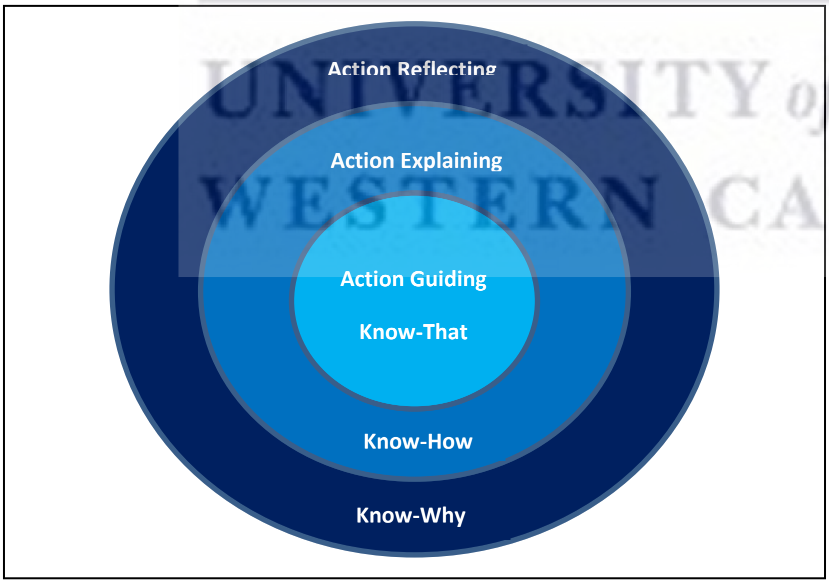


Figure 3.5: Three Successive Levels of Work Process Knowledge (Rauner, 2021, p.47)

The rules and regulations that are important for professional action are included in knowledge that guides action, also described as rule-based knowledge. The traditional approach to in-house training emphasises rule-based knowledge, or "know that" (Rauner, 2021, p. 47). Understanding the regulations that must be followed in a career is the goal of the action-explaining knowledge level, Professionals need to understand their professional tasks as well as the knowledge that informs their activities. Based on their understanding of their professional tasks, individuals know what they are doing and can take responsibility for their own actions. This level of knowledge resembles the idea of "know-how" in certain ways (Rauner, 2021, p. 47).

The use of a smaller or larger scope for professional work projects, varied situation-based approaches, and solution options, as well as conversation with the client, is made easier by action-reflecting knowledge (know-how). This knowledge helps to balance all pertinent criteria during the process. Professionals can respond to the question: Why this manner and not in any other way? (know why) at this (highest) level of work process knowledge (Rauner, 2021, p. 47).

Domain-specific knowledge research is made possible by the differentiation of practical knowledge as a component of the work process. This enables more detailed information about work process knowledge and, as a result promises results about the mediation of work process knowledge in or for professional work processes. The professional dimension is essentially moved to a meta-level, where having adequate access to the knowledge that is recorded in practical media, knowledge stores, and knowledge management systems is all that matters. Knowledge management is consequently crucial for the situational growth of the knowledge needed for the work duties. Research on the "objective knowledge" explosion appears to support this theory (Rauner, 2021).

The notion of vocational learning in the context of significant work scenarios, as well as the guiding principle of a curriculum built according to learning fields, are both supported by expertise and qualification research. The design-oriented viewpoint on vocational learning presupposes an autonomy of working activity beyond the one-dimensionality of scientific rationality as is typical for the subject-systematic curriculum. This orientation is towards (vocational) work and business processes (cf. Fischer & Roben, 2004). The term "subject" knowledge, which refers to subject-systematic information whose origins are based on the specialised sciences, is problematic. Professional action and design competency are founded on the knowledge of the actions and work processes incorporated into actual professional work and not on (scientific) specialist knowledge.

Polanyi (1966) introduced the concept of implicit knowledge (also known as tacit knowledge), which drew attention to a type of knowledge to which Neuweg (2000) gave a paradigmatic significance in terms of professional competence. Since that time, the idea of tacit knowledge has come to be seen as a crucial element in the growth of the idea of professional competence. It can also be used to explain the significance of implicit knowledge as the foundation for skilful professional action.

Neuweg (2000) explored the didactic consequences of this knowledge notion and provided a differentiated evolution of it. There is a common misconception in vocational education that subject-systematically arranged information equates to some dubious professional action that, in procedural words, results in professional ability (cf. Fischer, 2002; Neuweg, 2000).

Crawford (2010, p. 215) illustrated the difference between theoretical and practical knowledge and the limited relevance of theoretical knowledge for action (Crawford, 2010, 215 f.). One should, however, not confuse professional skills with the category of Tacit Knowledge. Professional competence is developed during the process of reflective practical experience (reflection-in-action). Professional competence development is based on the expansion of the repertoire of unique cases, i.e., through systematic learning. However, competence development cannot be substantiated by technical systems (Rauner, 2021, p. 49).

Practical knowledge in vocational education and training is directly related to work experience, knowledge and skills. Reckwitz (2003) refers to practical knowledge as implicit logic of practice, for example, the artefacts of the working world and the knowledge, interests and purposes objectified in them are the subjects of interest to vocational education, which is applicable to the current investigation.

The assumption that action within the framework of practices can first and foremost be understood as knowledge-based activity, as an activity in which practical knowledge, ability in the sense of "know-how," and practical understanding are used, is central to the practical understanding of action. Although action also contains an element of intentionality, one can assume that action is a knowledge-based activity in which practical knowledge, ability in the sense of "know-how," and practical understanding are used (Rekwitz, 2003, p. 291).

Reckwitz holds that practical theory encompasses practical knowledge, and the following aspects should be taken into consideration: “(i) Knowledge in line with an interpretative understanding, i.e., a routine assignment of meanings to objects, persons, etc.; (ii) A methodical knowledge of script-like procedure, how to produce a series of actions competently; and (iii) A motivational-emotional knowledge, an implicit sense of what one actually wants, what it is about and what would be unthinkable' (Rekwitz, 2003, p. 291).

Benner (1997) emphasises the fundamental importance of practical knowledge for professional competence in her investigation of the typical work environment and tasks for nurses. Benner (1997) distinguishes between six dimensions of practical knowledge. With reference to the results of qualification research in industrial-technical domains, these dimensions of practical knowledge are outlined in Table 3.1, to further differentiate the category of work process knowledge.

Table 3.1 The Six Dimensions of Practical Knowledge (Benner, 1997; Rauner, 2004)

DIMENSIONS OF PRACTICAL KNOWLEDGE	
Sensitivity	With increasing work experience, the ability to perceive and evaluate. increasingly subtle and the subtlest differences in typical work situations develops
Contextuality	The increasing work experience of the members of the professional practice groups lead to the development of comparable patterns of action and evaluations as well as to intuitive communication possibilities that go far beyond linguistic communication.
Situativity	Work situations can only be adequately understood subjectively if they are also understood in their genesis. Assumptions, attitudes, and expectations guided by experience lead to comprehensive awareness and situational action and constitute an extraordinarily fine differentiation of the action plans
Paradigmatic	Professional work tasks have a paradigmatic quality in the sense of 'development tasks' if they raise new content-related problems in the development process, which force us to question and newly establish existing action concepts and well-coordinated behaviours.
Communicativity	The subjective significance of the communicated facts is highly compliant in a practice community. The degree of professional understanding is far higher than that of external communication; the context-related language and communication can only be fully understood by members of the practice community.
Perspectivity	The management of unforeseeable work tasks based on the fundamentally incomplete knowledge (knowledge gap) is characteristic for practical work process knowledge. This gives rise to a meta-competence that enables us to deal with non-deterministic work situations.

Schoen's (1983) examination of problem-solving behaviour offers similar insights into the cognitive and professional demands of numerous professions. The psychological (cognitive) performance criteria for competent action are the focus of Gardner's analyses (Professional Knowledge Systems). Schoen's accomplishment is to demonstrate the basic significance of practical competence and professional artistry as an independent competence uninformed by theoretical (declarative) knowledge, both of which fall under the category of practical intelligence. This also suggests a critical assessment of academic (disciplinary) knowledge as a cognitive requirement for skilful action.

Schoen (1983, p. VII) summarizes his research on practical competence: as follows:

> I have become convinced that universities are not devoted to the production and distribution of fundamental knowledge in general. There are institutions committed, for the most part, to a particular epistemology, a view of knowledge that fosters selective inattention to practical competence and professional artistry (Schoen, 1983, p. VII).

The systematic knowledge base of a profession has four essential properties, i.e., (i) It is specialized, (ii) firmly bounded, (iii) scientific, and (iv) standardised. Standardisation is particularly important, because of its paradigmatic relationship with a profession's knowledge base and its practice' (Schoen, 1983, p. 23).

Moreover, Schoen (1983) critically examines the didactic reductionist notion that was associated with the phrase "Applied Academics" in the United States of America (USA). At high schools, for instance, the idea of "contextual learning" was not seen as teaching students how to solve problems or to impart practical knowledge, but rather as a way to learn "academic knowledge" (cf. also Grollmann, 2003). Thus, academic knowledge is taught in a way that emphasises practical application. This idea of "application" leads to a hierarchy of professional knowledge, according to Schoen, with "general principles" occupying the top level and "specific problem solutions" at the bottom (Schoen, 1983, p. 24). This training and curriculum practice is in stark contradiction to the results of his analyses of the thoughts and actions of 'professionals' (Schoen, 1983, p. 138).

Didactic research and research in the workplace should establish the initial comprehension and subjective fields of meaning of technical terms for beginners and open the professional fields of meaning of central technical terms for specialists ((Rauner, 2008)). After this has occurred, teaching and learning strategies that assist the gradual transformation of the fields of meaning and structures of common concepts and ideas into fields of meaning that are related to a particular profession, can be produced. The deciding aspect in this case, nevertheless, is that the action-guiding technical terms are not categorically limited but are kept as useful terms that are continually improved (Rauner, 2021, p. 54). Didactic dexterity is characterised using forms of inductive learning such as experimental or action-oriented learning (Patzold, 1995). The action-relevant aspects of meaning and fields of meaning of practical terms are manifold and at the same time highly relevant for competent action (Rauner, 2004).

3.3.4. Measurement Instruments of the COMET Diagnostic Model

The COMET diagnostic model utilises various measuring instruments for data collection as follows:

(i) Domain specific open-ended baseline and main tests are discussed in Sections 3.6.1 and 3.6.2 below. The open-ended baseline and main tests were designed to develop and test students' holistic problem-solving capabilities, amongst other occupational competencies. These tests posed work-related problems for students to solve and were designed to be open-ended to allow students the opportunity to solve complex domain specific problems, holistically.

(ii) Rating sheets (paper and pencil)

(iii) Occupational Identity and Commitment Questionnaire, which explores the participants' attitudes and values towards their profession and training.

(iv) Motivational Questionnaire, which measures the levels of motivation during the completion of the main test, as well as participants' experience of the relevance thereof for TVET.

The construct validity and reliability indices of these measuring instruments are elaborated upon in the methodology chapter that follows.

3.4 Didactic Use of the COMET Diagnostic Model for Teaching, Learning and Assessment

Due to the complex interplay of knowledge, skills, competence and identity in occupational teaching, learning, and assessment, an applicable theoretical framework is critical in providing the necessary conceptual tools to adequately articulate this complexity. The COMET model is based on a three-dimensional notion of competence, which emphasises a structured pedagogy with work integration as the student's development is guided from novice to expert (Rauner, 2007). In contrast with other approaches that attempt to isolate singular attributes or traits of competence, the holistic approach systematically organises the various aspects of competence in a matrix to gain greater insight into the interaction between individuals and their occupational environment (Rauner, 2007). Moreover, TVET as a discipline is constructed on the premise of integrating disciplinary knowledge, occupational application, as well as personal development, of which all are reflected by the COMET model of competence. The holistic approach provides the necessary tools to explore complex factors which might influence competence development both in the workplace as well as in the classroom.

The three-dimensional model of competence was constructed with the intention of being adaptable and relevant across various teaching and learning systems (Rauner, 2007). Research has shown that the COMET diagnostic model is theoretically sound and empirically reliable and valid, as a measurement of occupational competence across vocational education systems and cultural contexts. The COMET model has been successfully tested and utilised in Germany (Lehberger, 2013; Rauner, 2006, 2007, 2013, 2018; Rauner, Frernzel, Piening & Bachmann, 2015; Rauner, Heinemann & Hauschildt, 2013), in China (Zhuang & Li, 2015; Zhuang & Zhao, 2012; Zhou, Rauner & Zhao, 2015), in Norway (Lahn & Nore, 2019; Hellne-Halvorsen, Lahn & Nore, 2021), and in South Africa (Hauschildt, 2016; Jacobs, 2016; Jacobs, 2019), as a didactic tool for occupational competence development and measurement. The South African COMET studies laid the foundation upon which the current study builds.

The Policy on Professional Qualifications for Lecturers in Technical and Occupational Education and Training (Department of Higher Education and Training, 2013: 36), lists a minimum of ten basic competencies for professionally qualified TVET lecturers, of which three are stated as follows:

> “. Professionally qualified lecturers must be able to manage teaching and learning environments effectively to enhance learning. Professionally qualified lecturers must be able to access students in varied and reliable ways, and to use the results of assessment both to improve students’ learning through a variety of types of feedback, and to improve their own practice. Professionally qualified lecturers must be knowledgeable about demands that will be made on their students in the workplace and be able to use the subject that they are teaching to help equip their students to meet these demands” (Department of Higher Education and Training, 2013, p. 36).

The didactical application of the COMET model in TVET Electrical Engineering supports the attainment of these essential skills by professionally qualified TVET lecturers, as mandated by this South African TVET Policy (2013, p. 36).

3.5 Occupational Competence and Commitment Framework

The German-Malaysian Institute (GMI) found that TVET students lacked fundamental abilities including problem-solving, critical thinking, communication, and leadership and suggests switching from traditional instruction to a problem-based learning (PBL) strategy. Using this method, educators actively engage students in the learning process by shifting from imparting knowledge to assisting in acquiring it. Emphasis is placed on the requirement that TVET students obtain technical skills through actual work experience to be able to handle real-world problems at work (Mohamad & De Graaff, 2013). The PBL concept, where curriculum-based knowledge is based on the problem to be addressed, is a distinctive component of the COMET diagnostic model's assessment and development of occupational competence, focused on solving challenging real-world situations holistically.

Jacobs (2016, pp. 103-104) listed the following critical elements of the COMET occupational competence and commitment framework:

- Interactive, scientific, practical, and administrative competence towards change corresponding with negotiated objectives.
- TVET practitioners as promoters of innovative projects.
- Theoretically sound and empirically verified model.
- Establishment of strengths and weaknesses in the system.
- Provision of immediate pedagogical support to educators.
- Large-scale competence diagnostics for comparative studies with use value for governance and support systems in TVET.

- Creating opportunities for constructive dialogue.
- Concept of learning areas.
- A theory-based model empirically analysed.
- A paradigm-shift from a subject based TVET to a design based on developmental logic.
- Quantitative assessment of professional competence and competence development.
- Assessment of vocational identity and commitment.
- Professional acting competence as an indicator of the level of professional aptitude.
- Professional work process knowledge.
- Normative of nature because of learning action guiding rules valid by virtue of social convention.

Processes used in vocational education and training are designed to have an impact on the process of learning action-guiding rules that are valid due to social conventions rather than natural or technology regularities. A model of professional competence therefore, according to Brandstäster (1984), always includes a normative component. Components of the Framework of Vocational Education therefore are:

- "The concept of professional knowledge.
- The learning objective action and shaping competence.
- The objective of professional aptitude as defined in the professional profiles and curricula.
- The theories of professional competence development" (Rauner et al., 2013b, p. 19).

Figure 3.6 (on the next page) shows the Professional Competence Development and Assessment Framework first developed by Rauner et al. (2013, pp. 19-20), and further adapted by Jacobs (2016, p. 104).

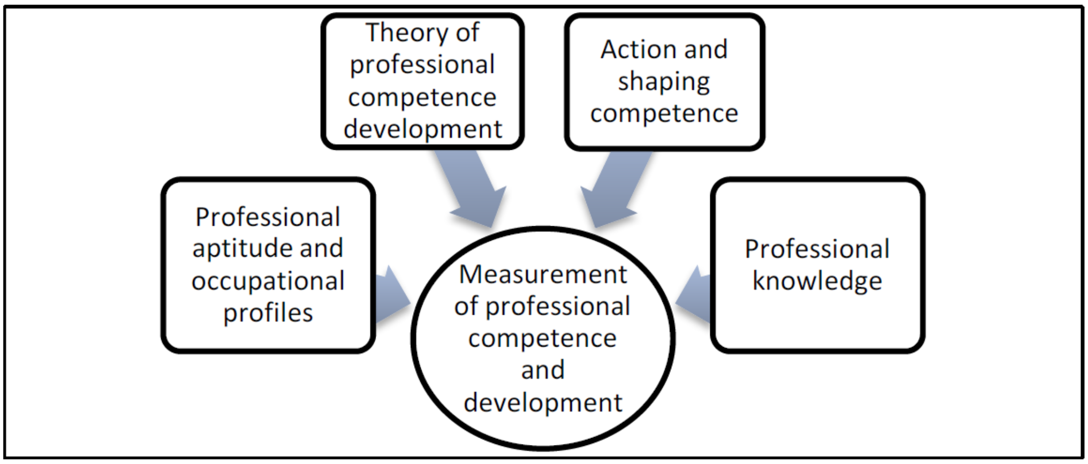


Figure 3.6: Professional Competence Development and Assessment Framework (Jacobs, 2016, p. 104 adapted from Rauner et al., 2013, pp. 19-20).

The conceptual framework of the COMET diagnostic competence model includes a normative component and is founded in normative as well as relevant empirical research. The foundation for developing a competence model is a clear understanding of the expected outcomes of programs and institutions of vocational education. As a result of reflective work experience, it is possible to discern that knowing within the vocation, as defined by Lindberg (2003), involves the following categories of work-related knowledge:

- Tools needed for performing the vocation specific work.
- Materials and their properties – vocational language for the categorisation, identification and description of material.
- Methods and techniques that are vocation specific.
- Planning – sensualised idea of the task and the ability to organise the work.
- Professional Ethics – interaction between the quality aspect of the vocation and being a representative of the vocation.

The relevance of a competence diagnostic model that is based on the concepts of a working process orientation and shaping orientation in TVET is highlighted. The training objective is therefore to develop:

- Professional Competence
- Acting Competence
- Shaping Competence.

To learn a profession is the overarching goal of the aforementioned. The PISA deterministic ideology of applied science is giving way to the design of technology in terms of professional knowledge and as such technology pedagogy needs to start with the work tasks of the professional profile. Based on the following criteria, work process-related dimensions of learning and work are determined:

- The subject matter of professional work is to organise and analyse learning and work from the standpoint of professional work processes. It is embodied in concepts connected to work and how they are expressed in specialised vocabulary.
- The domain-specific and situated context determines the requirement for the tools, methods, and organisational structure of professional work to be a subject of research and development in TVET education.
- Professional work requirements are established by legislative directives, governmental authorities, business, industries, customers, and the employees' subject interests. In order to shape competence, these various needs must result in documents that guide the organisation of work and learning processes (Rauner et al., 2013b, p. 11).

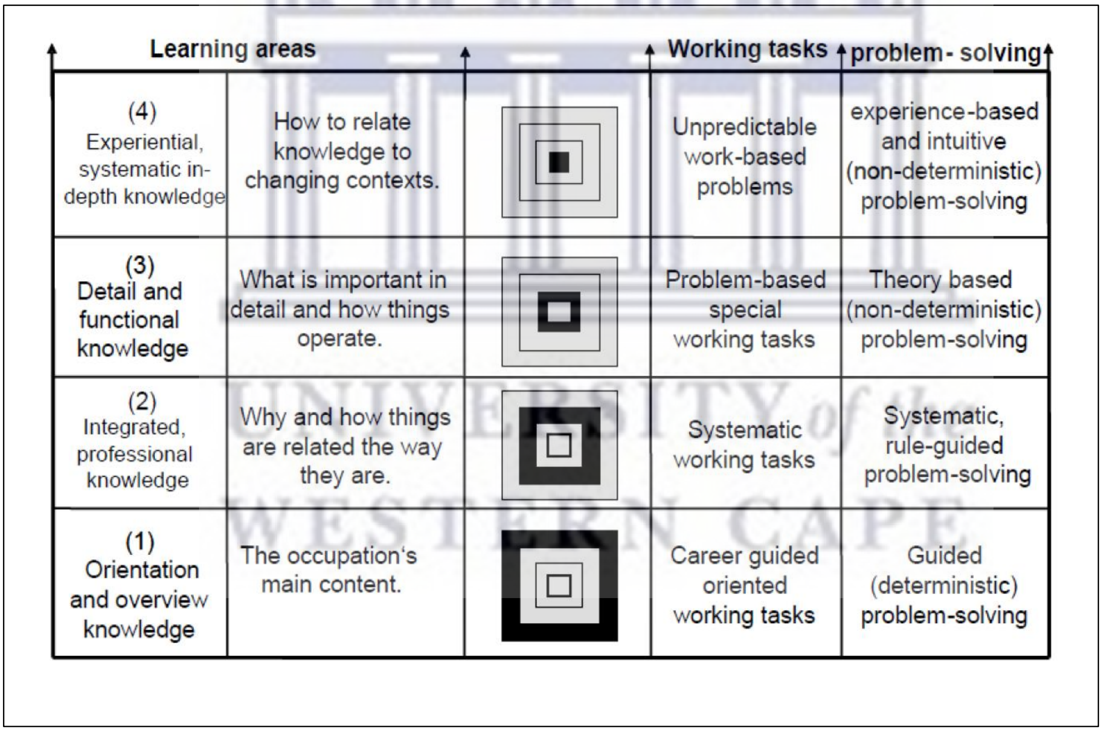


Figure 3.7: The Progressive Stages of Learning According to the Developmental Structure Theory (Rauner, 2021, p. 94)

Jacobs (2016, p. 106) points out that TVET is a process of active development and competence shaping. Professional competence development necessitates that the contents of vocational training programmes be based on subject theory that is developmental in nature. Figure 3.7 depicts the four progressive stages of learning according to the developmental structure theory:

- Knowledge for orientation and overview.
- Integrated knowledge/systemic work tasks.
- Knowledge of details and functions/problem oriented, special tasks.
- Experiential and systemic in-depth work knowledge/unpredictable work task (Rauner et al., 2013b, p. 29).

Figure 3.7 furthermore outlines the four developmental areas according to which TVET programmes can be organised on developmental logic, as:

(1) Orientation work tasks – Novice apprentices work systematically according to rules and regulations and quality standards.

(2) Systemic work tasks – professional knowledge is integrated and may lead to a reflected professional identity.

(3) Problem-orientated special work tasks – major developmental tasks that involve professional responsibility and quality awareness.

(4) Unpredictable work tasks – reflective professionalism is integrated with subject specific competence that may lead to an extended self-concept and higher education towards a career path associated with the relevant occupation (Rauner et al., 2013b, p. 29).

Indicators of how employees view their relationships with their employment include their professional identities and levels of occupational commitment. Professional competence development is an important part of the process that leads to professional identity.

3.6 Applying the COMET Diagnostic Model for the Development and Assessment of Occupational Competence

The COMET diagnostic model utilises various practical tools to develop and assess occupational competence, i.e., (i) Domain specific open-ended baseline and main test assignments, (ii) Occupational Identity and Commitment Questionnaire (exploring the participants' attitudes and values towards their profession and training), as well as (iii) a Motivational Questionnaire that measures the levels of motivation during the completion of the main test assignment, and participants' experience of the relevance thereof for TVET.

3.6.1 Development of COMET Learning Tasks

The open-ended baseline and main COMET test tasks are designed in COMET research to assess and develop students' holistic problem-solving occupational competence and assignments pose work-related problems for students to solve. Open-ended assignments are designed to augment learning programmes which allow students the opportunity to solve complex domain specific problems, holistically (Jacobs, 2016). Learning tasks are integrally part of the COMET didactic process, as they are used as an intervention in preparing students for the main COMET test, irrespective of the curriculum or learning programme. Learning tasks and test tasks are usually developed by industry experts and lecturers. The tasks' main purpose is to help the test takers to familiarise themselves with these kinds of tasks, as well as to enrich the lectures/lessons because such complex and open tasks often address the students' creativity and individual problem-solving capabilities better (Rauner, 2021).

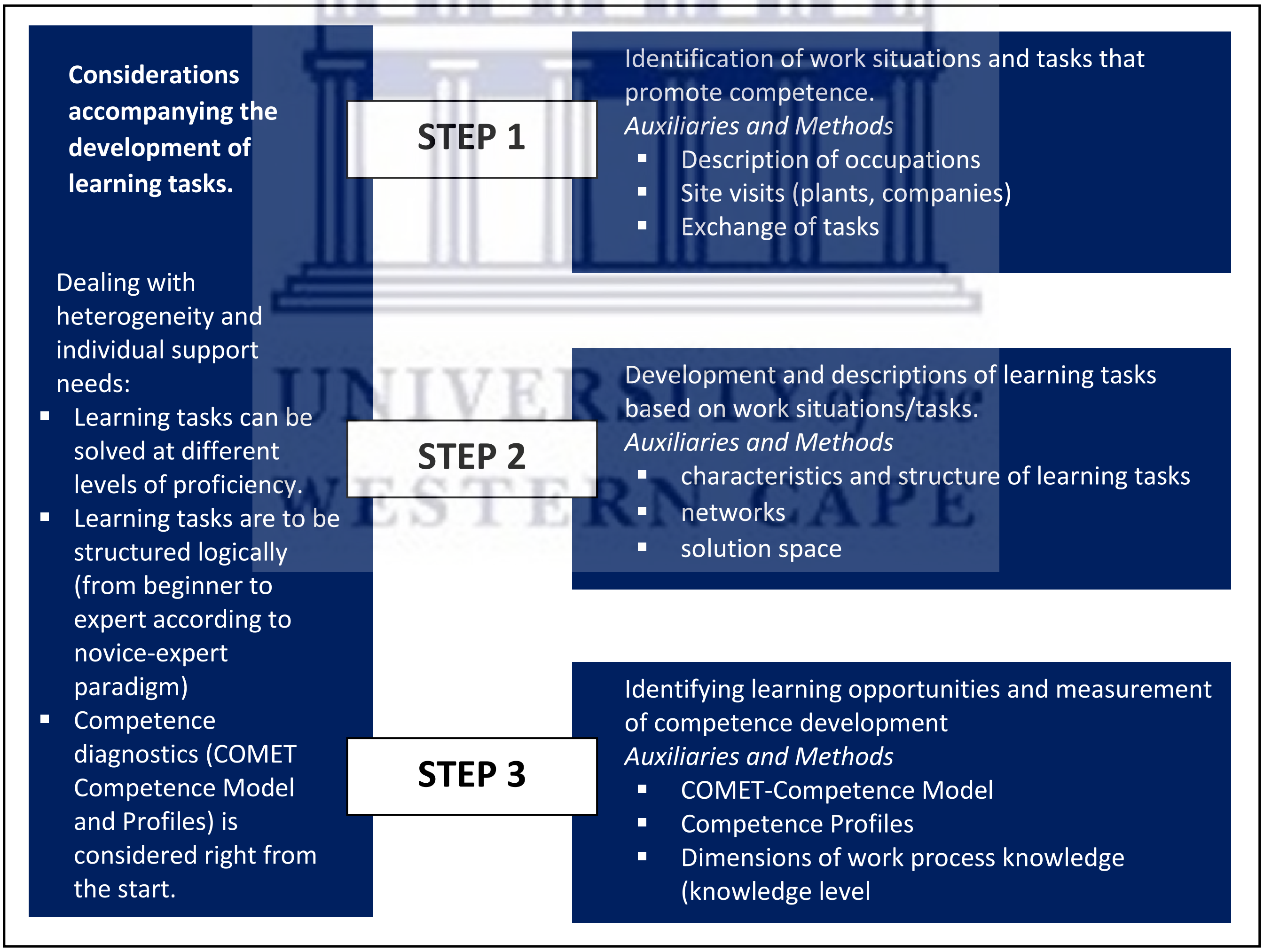


Figure 3.8: Steps to Design Learning Tasks (Rauner, 2021. p. 434)

The following three steps are prescribed by Rauner (2021) for the development of learning tasks (illustrated in Figure 3.8), i.e.,:

Step 1: Identifying Competence-Promoting Work Situations/Tasks

Step 2: Developing and Describing Learning Tasks from Work Situations / Tasks Prospectively

Step 3: Identify Learning Opportunities and Diagnose and Competence Development.

Competence diagnostics track the qualitative and quantitative development of trainees' and students' professional competence as well as the promotion of students' abilities to fully accomplish occupational tasks 'with social and ecological responsibility'. Tests with a focus on learning objectives are used to determine if the teacher's "learning objectives"—measured in the form of scores or marks—have been met. Learning tasks with their possible solutions leave open the level at which they could be solved. For the trainees/students, these have the potential for individual development. The following considerations should guide teachers as they take this initial step:

- The learning task must be selected so that it has an appropriate learning potential for the learning group and all trainees/students on their way to achieving employability (also refer to the job profiles and occupational curricula).
- The learning task should be a challenge for both the weak and the strong students and offer correspondingly challenging solutions.
- The learning task must be described from the customer's perspective. In the case of extensive tasks, the question arises as to a division of labour in groups. This form of learning organisation is very demanding because the coordination of division of labour learning involves cooperation between groups and all participants should benefit from the learning processes and outcomes.
- The combination of sub-solutions and new knowledge must be carefully planned.
- The group should inform each other about what they have learnt (Rauner, 2021, p. 434).

3.6.2 Development of COMET Test Tasks

The development of open-ended COMET test tasks must meet the following criteria:

- The problems to be solved are realistic and domain specific.
- Occupation specific work tasks ranging from Novice to Expert level are included.
- Tasks are set at various levels of ascending complexity to enable the assessment of occupational competence levels to be considered.
- A solution space to allow for a variety of solutions and divergent thinking are incorporated.
- The design of the test task is open and not subject to merely right or wrong answers.
- Tasks extend beyond technical knowledge and expertise but are inclusive of the eight COMET criteria and three dimensions.
- Test tasks must be solved on a conceptual level for the large-scale assessment.
- Test tasks do not directly refer to college/academic curricula but rather the occupational scope of work (Rauner et al., 2013b).

The criterion referenced COMET test tasks are designed to indicate how an individual performs in comparison with a pre-determined criterion (Slavin, 2007). The following core principles should furthermore be applied:

- Test tasks should be developed by subject/occupational specialists to ensure domain specific relevance and content validity.
- A pre-test should be conducted to assess test task validity and suitability.
- The most suitable test tasks, in response to holistic problem solving, should be selected for assessment (Jacobs, 2016, p. 124).

To develop the test tasks, Rauner (2021) proposes that the following Professional Scientific Task Analysis should be conducted:

- The identification of the work contexts and qualification requirements characteristic of a job description-the occupational profile.
- The identification of work tasks covering the job description. A distinction must be made between the core tasks and the industry and application-specific professional areas of responsibility.
- The logical systematisation of developmental tasks according to criteria as suggested by the novice-expert paradigm.
- The differentiation of the work tasks according to the categories:
    - Subject of skilled work,

- Methods, tools, organisation of skilled work,
- Requirements for the subjects and the forms of skilled work.

3.6.3 Administering the COMET Rating Sheets and the COMET Questionnaire

The COMET Rating Sheets and COMET questionnaires are administered in COMET research to evaluate participants' solutions for main test tasks, and to collect data related to participants' occupational competence profiles, as elaborated below:

3.6.3.1 Evaluation of participants' domain specific open-ended baseline and main test assignments using Rating Sheets

COMET Rating Sheets are used in COMET research by trained raters to score students' open-ended baseline and main test assignments. The rating sheet tests students' holistic problem-solving capabilities, amongst other occupational competence. The assignments consist of work-related problems for students to solve. These assignments are designed to be open-ended to allow students the opportunity to solve complex domain specific problems, holistically. The rating sheet comprises of 40 items that are linked to the COMET competence criteria (5 items per criteria). Given that all items are formulated neither in an occupation-specific nor in an assignment-specific way, the rater training function is to establish a link to the context of the specific test task. Each participant's solution to the test tasks is scored independently and anonymously by two raters on a Likert-type scale, consisting of the following scoring options: "3. Fully met", "2. Rather met" "1. Rather not met" or "0. Not met at all".

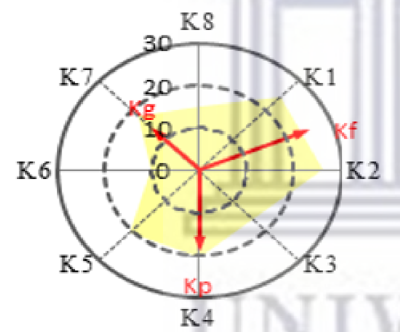
3.6.3.2 COMET Questionnaire

The COMET questionnaire, which item formulation follows the PISA test practice, is administered to participants in COMET studies to briefly give feedback on their personal test experience (Rauner, 2016). Part I of the COMET Questionnaire (Motivational Questionnaire) collects quantitative data, consisting of participants' responses to Likert-type questionnaire items, with regard to the following: their test sites, the test task for which they provided solutions, the time it took participants to complete test tasks, the difficulty level of finding solutions for the tasks, how interesting and useful the test tasks were, how closely test tasks related to participants' occupations, how focussed participants worked on test tasks, as well as the effort that participants made towards working on the test task.

Parts II and III of the COMET Questionnaire comprise the Occupational Commitment and Vocational Identity Questionnaire, developed by Rauner and colleagues (Kalvelage & Zhou, 2017; Rauner, 2016) to explore qualitatively the participants’ identity, commitment, attitudes and values towards their profession and training. Part II also collects general demographic information from participants, as well as participants’ experiences of test sites. Table 4.2 (under Section 4.2.5.1) shows satisfactory Cronbach Alpha reliability indices reported by Rauner (2016) for the Vocational Identity and Commitment Scales of the COMET Questionnaire (Parts II and III), calculated on 3030 datasets involving more than 70 different occupations.

3.6.4 Radar Graphs Used to Visually Represent COMET Competence Profiles

Radar Graph 3.1: An example of a radar graph, showing a competence profile



K1 (Clarity/Presentation) = 24.4
K2 (Functionality) = 26
K3 (Sustainability\utility) = 16.3
K4 (Cost Effectiveness) = 20.3
K5 (Business /Work Process) = 20.6
K6 (Social Responsibility) 10.1
K7 (Environmental Responsibility) = 18.3
K8 (Creativity) = 14.8
KF (Functional Competence) = 25.2
KP (Processual Competence) = 19.1
KG (Holistic Shaping Competence) = 14.4

Radar graphs, of which Graph 3.1 is an example, are generally used in COMET studies to visually represent Competence profiles, mainly for study groups, but also occasionally for individual participants. These radar graphs are drawn from the scores/mean scores obtained from Rating Sheets for the eight COMET competence criteria (K1 to K8), as well as the three COMET levels, i.e., Professional Functional Competence (K_F), Professional Processual Competence (K_P), and Professional Holistic Shaping Competence (K_G).

3.6.5 Possibilities and limitations of using the COMET diagnostic model to measure occupational competence.

Hauschildt (2016, p. 91) explains that “large-scale competence diagnostics reaches some limits as it depends on standardised test procedures that are incompatible with the idea of assessing practical skills in real work situations”. The assessment is standard referenced and not norm referenced, which is better for competence development. Jacobs (2016) applied COMET in a practical setting with great success, where the COMET open-ended Test Tasks counteracted this limitation. For Hauschildt (2016, p. 91), the realisation of a standardised observation procedure for the assessment of professional competence by proven experts would require an amount of human and temporal resources that rules out the feasibility of such a project from the outset. It makes sense to construct a list of the things that can or cannot be measured by its methodology (or only with a greater effort) to better understand the advantages and limitations of competence diagnostics (Hauschildt, 2016, p. 91; Rauner et at, 2013, pp. 13-16).

Rauner (2013, p. 13) maintains that the measurement of occupational competence means to formulate test assignments that allow test persons to explicitly demonstrate their abilities (in the sense of cognitive performance dispositions), which can only be achieved with appropriate effort via situated professional qualifications. Domain specific dispositions are *cognitive,* as competence diagnostics does not look at performance during the work process but looks at the ability of a student to comprehend occupational tasks in its complexity, to weigh up different aims and to develop a viable approach. Knowledge of how to perform tasks (know how) is a crucial component of professional competence. When engaging in professional activities, particularly based on work output, implicit knowledge and abilities can be observed and assessed. Nonetheless, these are unable to be explicitly stated and articulated in technical terms. While often necessary for professional competence and hence covered by exams, skills that cannot be explained in this way are inaccessible to the conventional methods of competence diagnostics (Rauner, 2013, p. 13).

The strengths and peculiarities of large-scale competence diagnostics are grounded in the standardisation of tasks based on a competence model. This is not restricted to measuring individual occupational competence but holds for comparing different groups in different forms and systems of occupational education. ‘Good’ and ‘very good’ results express a good or very good TVET practice (Rauner, 2021; Hauschildt, 2016, p. 91). Furthermore, occupational, and cross-occupational competence levels, that are independent of the forms and structures of educational programmes of test groups based on individual test results, can successfully be measured in the form of implicit professional knowledge (tacit knowledge), as well as individual situated professional ability (professional competence). Competence dimensions (in the form of competence profiles) can also be measured through craftsmanship. Occupational competence can also be measured in combination with the data from context surveys to provide insights into many control and design relevant interrelationships, amongst others the education systems and programmes, contents and forms of professional learning, cooperation between learning locations and educational plans, work organisation, school organisation, and to perform international comparisons. However, this can only be achieved by recognising social competence with its' limitations, as well as by recognising the abilities that are expressed in the interactive form of work, and competence expressed in creative action, for example in arts and crafts (Rauner, 2021, p. 11).

3.7 The Use of a Solution Space in Assessments

A test task's solution scope defines the options for a task solution, under the basic conditions specified in the situation description. A solution space allows for a variety of solutions and incorporates divergent thinking. The client's (customer's) wishes and requirements limit the (theoretical) scope for design. It is therefore more likely to assume that there is room for manoeuvre within the context of a (higher) school learning scenario and a solution space in a test format related to the context of company work orders. The scope for solutions and design can only exemplify possible solutions in their structures. In this regard, the scope for solutions and design is also open to unexpected solutions (Rauner, 2021, p. 104).

The test task author has an idea of the range of possible solutions to the test tasks. A nearly limitless design scope is formed by theoretically feasible solutions. When describing the solution space, it is critical to describe and illustrate the dimensions of possible solutions. The solution spaces for the test tasks are required for rater training and familiarization with task solution rating. The solution space facilitates task-specific interpretation of the rating items, which must be formulated at an abstraction level that allows these to be applied in a broader range of professions (Rauner, 2021, p. 104).

The criteria for holistic task solving serve as a framework for describing solution scopes. The solution scope alerts raters to the range of possible solutions. The solution space can indicate the potential competence contained in the respective test task in the form of its possible solutions. Solution spaces are never complete. They are, however, an essential foundation for rater training when it comes to developing common standards for evaluating various test task solutions and achieving a high level of interrater reliability (Rauner, 2021, p. 105).

When dealing with solution spaces within the framework of rating and rating training, it is critical to avoid misinterpreting solution spaces as ideal-typical solutions. Within the framework of rater training, the use of the solution space when evaluating task solutions is practiced. After rater training, practice shows that raters only occasionally (at first) use the solution spaces to evaluate the solutions. They can use the rating items in a task-specific manner and can think of the solution space almost automatically. This phenomenon manifests itself in a correspondingly high inter-rater reliability (Rauner, 2021, p. 105).

3.8 Chapter Synopsis

In Chapter 3, the COMET diagnostic model of occupational competence development and assessment was presented as the conceptual research framework used in the current investigation. In this chapter, the rationale for using the COMET diagnostic model for didactical purposes was discussed. Detailed descriptions were then provided of the COMET diagnostic model, comprising of three dimensions and eight professional competence criteria, and the development of learning tasks and test tasks were explained. The possibilities and limitations of using the COMET diagnostic model to develop and assess occupational competence were also outlined. The chapter ends with a discussion of the use of solution space in assessment.

Chapter 4

Research Design and Methodology

4.1 Introduction

The mixed-methods sequential explanatory study design that was utilised for my investigation is thoroughly described in this chapter, which is devoted to research design and methodology. This chapter includes details regarding the many measuring instruments, methods, and procedures that were used to collect both quantitative and qualitative data. The chapter provides full descriptions of the sampling techniques that were used, outlines the development of COMET learning and test tasks and the training of raters, and furthermore explains the rating of participating TVET students' solutions for the COMET tests. A summary of the various statistical techniques that were applied to perform both descriptive statistics (means, frequencies, and frequency percentages), as well as inferential statistics (inter-rater reliability**,** Cronbach Alpha reliability coefficients, strengths of associations measured by effect sizes, rank order correlation, and cross-tabulation) is given. The categorical and thematic data analyses performed on the qualitative data, are also explained. The chapter also outlines the measures that were taken to ensure and statistically test the reliability (internal consistency of measurements), inter-rater reliability, trustworthiness, and credibility of the study's findings. The chapter concludes by conveying the ethical considerations of this study.

4.2 Research Design and Methodology

Research design can be described as a method and structure for an investigation that includes strategy, conceptual framework, who or what are to be studied and the tools and procedures to be used for collecting and analysing data (Punch, 2009; Salkind, 2009). A mixed-methods sequential explanatory research design was followed for the purpose of this investigation, and data were purposefully collected from an availability sample comprising of TVET Electrical Engineering students and lecturers at five TVET Colleges across four South African Provinces, using mixed-methods of data collection. Data from the COMET tests tasks were collected at two points in time to examine the change in holistic problem-solving competence of the sampled students before and after learning tasks were implemented. This method in which assessment occurs at more than one point is referred to as a longitudinal method (Salkind, 2009, p. 248). Students and staff were trained on the COMET Test Task (CTT) structure using COMET Learning Tasks (CLT) and subsequently, COMET Baseline Tests (CBT) were conducted followed by more exposure to COMET methodology. After this point, the main COMET tests were done.

In the section that follows, the research design is elaborated upon, followed by an outline of the various methods that were used for data collection.

4.2.1 Mixed-Methods Sequential Explanatory Research Design

To the current investigation, a mixed-methods sequential explanatory research design was followed. In accordance with the basic sequence prescribed for this type of research design, quantitative data were first collected and analysed, whereafter qualitative data were collected for the purpose of reaching in-depth explanatory understanding of the findings obtained from the quantitative data analysis (Nicolau, et al., 2017, p. 2). The mixed-methods sequential explanatory research design used in this investigation afforded the possibility of successfully meeting the criteria of professional competence development within the domain of Electrical Engineering. The learning assignments were interventions aimed to introduce students to the learning methodology supported by COMET, while a baseline test and a main test assignment followed the COMET rating sheet and measurement procedures. Personal characteristics of participants, for example their demographic information, prior knowledge, and test motivation while undertaking the assessments, are reported in the chapter that follows.

4.2.2 Mixed Methods of Data Collection

This large-scale longitudinal study was conducted across four South African Provinces and made use of mixed methods utilising both quantitative and qualitative methods to collect data (Creswell, 2003). Creswell (2003) explains that research designs which incorporate both quantitative and qualitative methods in a single project should do so with thoughtful planning and recognition of the potential contribution of each approach. As already stated in Section 4.2, the current investigation comprised two research components, i.e., a main empirical quantitative research component, as well as a qualitative research component to explain the findings obtained through the quantitative research component.

Quantitative methods applied in this study were based on the COMET diagnostic model for holistic problem-solving occupational competence development and assessment (Rauner et al., 2013). However, from a broader perspective, quantitative research can be defined as a type of empirical investigation into a social phenomenon or human problem, testing a theory consisting of variables that are measured with numbers and analysed with statistics, to determine if the theory explains or predicts phenomena of interest (Creswell, 2014). Quantitative research methods allow for efficiency, modelling of real-world phenomena and the use of a powerful, familiar language (Tredoux, 2009). The quantitative methods of data collection in this study were influenced by the need for explanation, description and evaluation (Check & Schutt, 2012) of occupational competence in TVET. A quantitative approach for data gathering and analysis, including the measuring of competence in relation to COMET competence diagnostics criteria, was conducted.

As previously indicated, context-sensitive qualitative findings resulting from the in-depth qualitative data acquired are used to further examine and explain the findings received from the empirical data that were collected using quantitative methods of data collection.

4.2.3 Sampling Technique and Sample

A purposively selected, availability sampling technique was applied based on a target group, rather than a randomly selected sample (Teddlie & Yu, 2007). For the quantitative component, an availability sample of n=238 Electrical Engineering TVET students from five TVET colleges situated across four South African provinces agreed to participate in this study. The inclusion of the five TVET colleges was based upon the following:

- Three TVET colleges that had previously participated in COMET research made themselves available for participation in this study. Although the three TVET colleges had previously participated in COMET research, none of the Electrical Engineering lecturers nor any of the participating students had had prior knowledge or exposure to the model.
- Two TVET colleges, with no prior exposure to the COMET diagnostic model, were purposefully selected according to their geographical proximity and availability, to introduce more colleges to the didactic application of the model.
- The overall availability and willingness of TVET colleges to participate, and
- Logistical considerations.

The COMET diagnostic model does not cater for COMET professional competence scores below 5 as measured in COMET test tasks (Rauner, 2021), and as a result, the quantitative data of n=39 students who scored below 5 in the baseline test had to be excluded from my data analysis. Consequently, the final research sample comprised of the remaining N=199 students who all obtained total professional competence scores > 5.

To further support and explain the findings obtained from TVET students during the quantitative research component, additional in-depth, context-sensitive, focus-group interview data were collected from an availability sample of N=9 TVET Electrical Engineering lecturers, representative of four of the five participating TVET Colleges. TVET College B was the only TVET College whose lecturers were not available to participate in the focus-group interview. In the section that follows (Section 4.2.3.1), information is provided pertaining to the five test sites (participating TVET colleges).

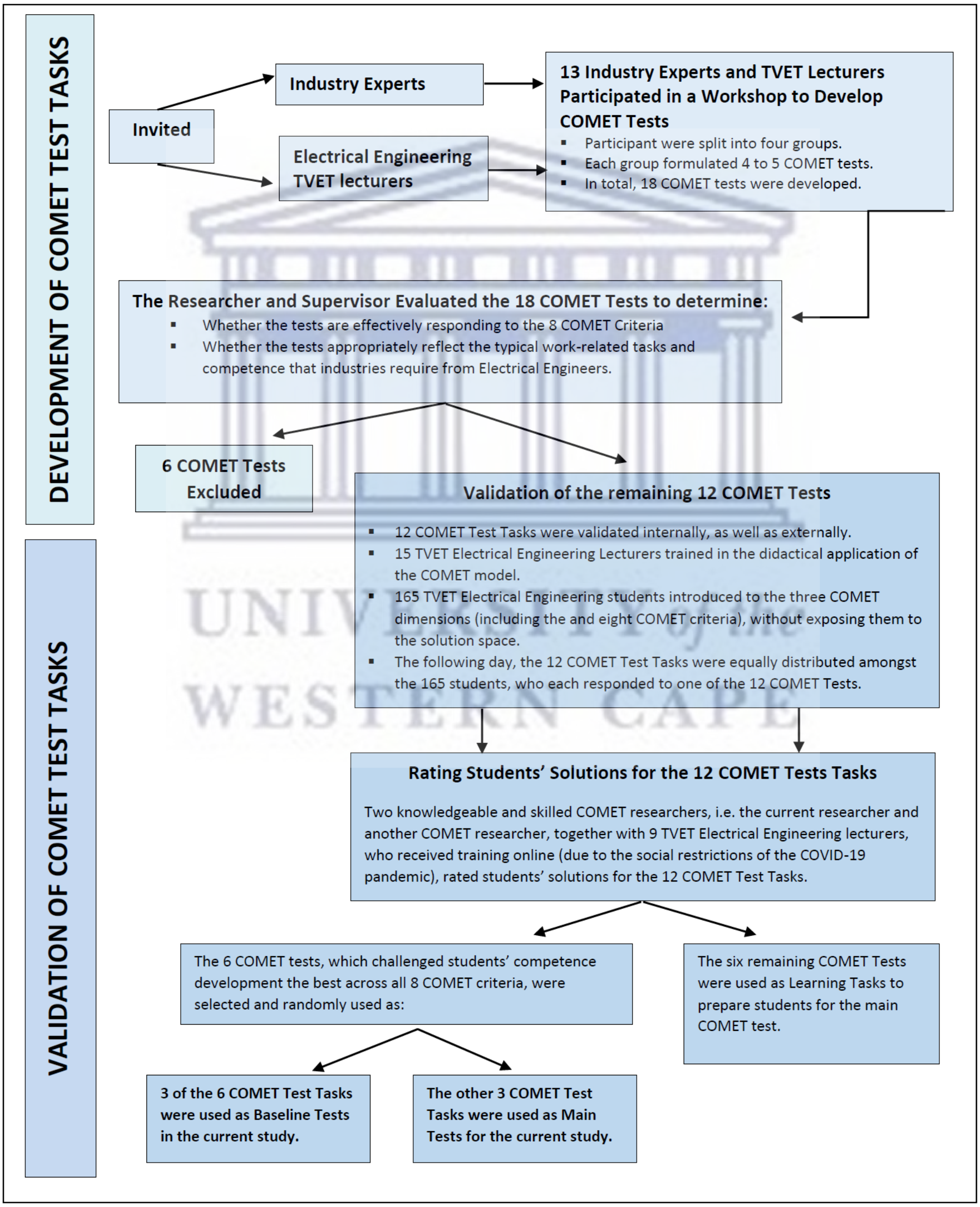


Figure 4.1: Research Procedures Used for the Development and Validation of COMET Test Tasks

4.2.4 Research Procedures

Figure 4.1, presented on the previous page, provides a visual overview of the various research procedures used for the development and validation of COMET Test Tasks. Rauner's (2021) framework and guidelines for the development of test tasks, the training of raters, as well as measuring instruments for data collection, were used as a general framework within which the COMET processes were contextualised for the current South African study.

4.2.4.1 Development of COMET Test Tasks

The development of open-ended test assignments with a broad range of potential solutions was crucial to the COMET large-scale occupational competency assessment, as shown in Figure 4.1. The COMET learning and test tasks were developed by TVET college lecturers and Electrical Engineering industry experts, guided by the three dimensions and eight COMET criteria explained as part of the COMET model presented in Chapter 3. The industry experts were invited to participate based-upon their previous involvement in the COMET-SA research project. Lecturers from participating colleges were invited as these colleges had already given permission for lecturers to participate. For the development of COMET test and learning tasks, a four-day workshop was organised by the co-supervisor at a neutral geographic location (conference facilities at a hotel). A total of 18 COMET Test Tasks were developed.

4.2.4.2 Selection and Validation of COMET Test Tasks

The researcher and co-supervisor evaluated the 18 COMET Test Tasks to ensure that they were aligned with the typical work tasks that industries require from Electrical Engineers daily. The COMET Test Tasks were validated online, due to the restrictions imposed by the ongoing COVID-19 pandemic. After the validation process, 6 of the 18 COMET Test Tasks were excluded from this study, based-upon the fact that they did not adequately reflect the everyday duties required by industries, nor did these tests adequately respond to the eight COMET Competence Criteria. The remaining 12 COMET Test Tasks were then validated internally, as well as externally.

Internal validation was conducted by the participants of the COMET Electrical Engineering expert group. The test tasks were then internally validated, as part of the workshop, using the COMET Validation Sheet for Professional Test Tasks (Table 4.1), as recommended by Rauner (2021, p. 92).

Table 4.1: COMET Validation Sheet for Professional Test Tasks (Adapted from Rauner (2021, p. 92))

Professional Work Task	**Frequencies: How often is the Professional Task Performed**		**Significance of Task for the Profession**		**Difficulty Level of Task**	**Significance for one's own professional development**
	Evaluation (1-10)	Future Increase or Decrease of Task's Importance (↑ or ↓)	Evaluation (1-10)	Future Increase or Decrease of Task's Importance (↑ or ↓)	Evaluation (1-4)	Evaluation (1-10)
Test Task 1						
Test Task 2						
Test Task 3						
Test Task 4						
Test Task 5						
Test Task 6						
Test Task 7						
Test Task 8						
Test Task 9						
Test Task 10						
Test Task 11						
Test Task 12						

The following validation questions guided the completion of the COMET Validation Sheets for Professional Test Tasks:

- Frequency: *How often is the professional task performed?*
- Significance: *What is the significance of the professional task for the profession?*
- Difficulty: *What level of difficulty does the task have?*
- Significance for one's own professional development: *What significance does the professional task have for one's own professional development?*

The frequency and significance of each test task was evaluated on a scale of 1 to 10. The validators also indicated the future importance (increase or decrease) of each test task for the domain Electrical Engineering.

The 12 test tasks were also objectively and externally validated, to ensure an unbiased validation that is not company or industry specific. Experts from the Department of Electrical

Engineering at the Tshwane University of Technology (TUT) conducted the external validation of the 12 COMET test tasks after being trained in COMET methodology, using Table 4.1 and COMET rating sheets. Both the internal and external validation results confirmed that the 12 test tasks were indeed valid work tasks that catered for future developments in the domain Electrical Engineering. The validation results of these 12 test tasks also affirmed their alignment with future industry expectations and demands.

4.2.4.3 COMET Training of TVET Lecturers and Introducing COMET to TVET Students

Fifteen TVET Electrical Engineering Lecturers were thoroughly trained in the didactical application of the COMET model during subject expert workshops. The validation of the COMET test tasks encompassed a total of 165 TVET Electrical Engineering students who were introduced to the three COMET dimensions and eight COMET criteria, without exposing them to the solution space. The following day, the 18 COMET Test Tasks were equally distributed amongst the 165 TVET students, who each provided a solution to the 18 COMET Test Tasks. Of the 18 COMET Test Tasks, six were used as learning tasks to prepare students for the COMET Test Task. The other 12 COMET test tasks which challenged TVET students' competence development with the best coverage across all eight COMET criteria, were selected for the COMET Baseline and the Main Test in this longitudinal investigation.

4.2.4.4 Training of Raters and Rating of Students Solutions for COMET Baseline and Main Test Tasks

Raters were trained TVET college lecturers who assisted with the COMET assessment of students' baseline and main COMET test responses, by manually completing the COMET rating sheet (Addendum F) for individual students. These raters received training to effectively prepare them for this task, and to familiarise them with the COMET measuring instruments. All raters were qualified Electrical Engineering lecturers who were recruited at the five participating TVET Colleges. They were requested to submit their Curriculum Vitaes to the researcher and supervisors who verified their suitability to act as raters for this investigation. All the raters attended orientation and training sessions at a geographic location accessible to all (conference facilities of a hotel) over a four-day period. The rater training was facilitated by the researcher and co-supervisor with a focus on the training of sufficiently equipped lecturer-raters with both theoretical knowledge and practical skills in the rating process that would be required for them to effectively conduct the rating of students' occupational competence according to the COMET diagnostic model. There were open discussions where potential errors and misinterpretations were clarified. Exemplar responses were issued to the raters for practice and evaluation purposes. After they had rated the exemplar responses, open forum discussions were held for further clarification purposes. During the raters' training, lecturers were requested to start with individual task ratings, then to perform task ratings in groups consisting of four members, and finally to perform individual task ratings again. Lecturers' knowledge concerning the didactic application of the COMET diagnostic model as well as their rating of test tasks were observed and evaluated by means of verbal discussions in which they were requested to motivate their rating scores, and to reach consensus about possible discrepancies in their rating scores. Their rating of the COMET test tasks of participating students only commenced after the group had successfully achieved satisfactory inter-rater reliability and the researcher was satisfied with their acquired rating competence.

In addition to the COMET diagnostic model and the rating scale, the raters were also equipped with a solution space for each test assignment. Rauner, Heinemann, Maurer, Haasler, Erdwien and Martens (2013, p. 78) maintain that the solution space "describes what possible solutions and variants are associated with the open test assignments". Professional problems typically do not include algorithmic answers and problem-solving methods, but rather allow for solutions whose variety comprises a vast solution space. During the rating process, solution spaces acted as guides, and were therefore not considered as a memorandum, as they cater for a holistic problem-solving of complex problems using diverse thinking skills.

The rater training and rater tasks involve familiarity with the broad range of the problem as well as a user-oriented interpretation of the job environment, in terms of subject-matter and social situatedness (Rauner et al., 2013, p. 12). Two common misinterpretations of the solution space are to view it as an exhaustive description of solutions, or to view it as an ideal description of a complete solution. This misunderstanding was subsequently clarified during the rater training.

Implementation of the Data Collection Instruments

The researcher, assisted by co-researchers and TVET College lecturers, administered three baseline tests to participating TVET students (N=238). After the baseline tests were administered, college lecturers implemented learning task within two weeks intervals. The tasks were used to introduce students to COMET ways of thinking. Lecturers were trained prior to this on how to implement learning tasks as didactic tools. The training took place before the task validation process and before the students took the baseline test. The training of students and lecturers took place on separate occasions. The two COMET baseline tests were implemented for the purpose of improving students' competence levels and also to be able to compare students' competence profiles before and after their exposure to the learning tasks. COMET learning tasks were used in two intervals within two weeks as didactical tools to develop and prepare students for the main COMET Test Task (see chapter 3, section 3.6). Each student then participated in a sequence of two learning tasks that were administered approximately two weeks apart. Two months after the baseline test, the Main COMET Test was administered to student participants to measure students' development of occupational competence by comparing the baseline and main COMET Test Task results.

4.2.5 Data Collection

This section provides information with regards to the various instruments and methods used to collect data for both the quantitative and qualitative research components of this study, the procedures that were followed during data collection, as well as the various data analyses that were performed on both the quantitative and qualitative datasets.

4.2.5.1 Measuring Instruments Used to Collect Quantitative Data

As explained in Section 3.3.3, the COMET diagnostic model utilises various measuring instruments to collect quantitative data primarily from student participants that are empirically analysed. The following COMET measuring instruments were used to collect empirical data from participating TVET students:

(i) **Domain specific open-ended baseline and main COMET test assignments** The open-ended baseline and main test assignments were designed to develop and test students' holistic problem-solving capabilities, amongst other occupational competencies. The assignments posed work-related problems for students to solve. These assignments were designed to be open-ended to allow students the opportunity to solve complex domain specific problems holistically. The solutions that TVET students provided in response to the COMET test assignments were quantitatively rated on corresponding COMET rating sheets by TVET lecturers, as explained in the section that follows.

(ii) **Rating sheets (Addendum F)**: Students' solutions for the COMET test assignments were rated (evaluated) by TVET lecturers, who completed the rater training, using the COMET rating sheet (Addendum, F). The rating sheet comprises 40 items that are linked to the COMET competence criteria (5 items per criteria).

Given that all items are formulated neither in an occupation-specific nor in an assignment-specific way, the rater training aimed, above all, to establish a link to the context of the specific test task. Since the instrument was applied to the Electrical Engineering domain, the way each of the items could be interpreted within the context of the underlying occupational profile, as well as the expectations associated with the test assignments, were clarified. The solution of each student in response to the COMET tests were rated independently and anonymously by two raters (TVET Electrical Engineering lecturers) on a Likert-type scale, consisting of the following rating options: "3. Fully met", "2. Rather met" "1. Rather not met" or "0. Not met at all". Each completed rating sheet received a unique code, to protect the identity of the student. No personal information was entered on the rating sheets. After the "rating" process was completed, the researcher calculated group competence profiles for the total sample (N=199), as well as the group competence profiles per test site, for the top 5 best students, as well as for the n=39 students who initially scored less than 5 in the baseline test.

(iii) **COMET Motivational Questionnaire (Part I of Addendum E):** After completion of the COMET test, participating TVET students were requested to complete the COMET questionnaire, which item formulation followed the PISA test practice, to briefly give feedback on their personal test experience. Part I of the COMET Questionnaire collected quantitative data, consisting of student participants' responses to Likert-type of questionnaire items, with regard to the following: the test site (TVET College), the COMET test task that the student worked on, the difficulty level of finding a solution for the task, the time spent on completing the assignment, how interesting and useful the test task was, how closely the test task relates to the student's occupation, how diligently the student worked on the test task, as well as the effort that the student made in working on the test task. Part I of the South African questionnaire also included a question on whether the student agreed that similar tasks become part of his/her vocational training, as well as the reason for the student's approval or disapproval thereof, which was qualitatively answered by students in the form of narrative answers (Rauner, 2016).

(iv) **Vocational Identity and Commitment Questionnaire (Parts II and III of Addendum E)**: These sections of the COMET Questionnaire were developed by Rauner and colleagues (Kalvelage & Zhou, 2017) to quantitatively explored participants' identity, commitment, attitudes and values towards their profession and training. Part II also collected general demographic information of participating students, as well as the experiences of their respective TVET Colleges. Table 4.2 shows satisfactory Cronbach Alpha reliability indices reported by Rauner (2016) for the Identity and Commitment Scales of the COMET Questionnaire (Parts II and III of Addendum E), calculated on 3030 datasets involving more than 70 different occupations.

Table 4.2: Satisfactory Cronbach Alpha Reliability Indices (internal consistency) Reported for the Identity and Commitment Scales of the Occupational Identity and Commitment Questionnaire (Parts II and III of Addendum E) (Rauner, 2016, p. 85)

Scale	Items	Cronbach's Alpha[13]
Occupational Identity	I like to tell others which profession I am learning now	α= .87
	I „fit" to my profession/I work well with my profession	
	I would like to continue working in my profession after training, it could as well be in another company	
	I am proud of my profession	
	I feel kind of home in my profession	
	I am not that interested in my profession (-)	
Occupational Commitment	I am interested in how my work contributes to the overall company's workflow	α= .82
	„Profession" means to submit quality	
	I am taken up in my profession / I am merged in my profession	
	I know what the tasks I carry out have to do with my profession.	
	I sometimes think about ways how to improve my work or its quality.	
	I want to have a say on my work content	

With regards to the construct validity of the above two COMET scales, both confirmatory and exploratory factor analyses were performed by Kalvelage and Zhou (2017) on the datasets of two large German studies (N=1121 and N=3030 respectively). The factor loadings of the factor analyses, however, do not clearly support Rauner's differentiation between two sources of commitment (i.e., organisational vs occupational) because it seems that, on average, apprentices in these two studies did not clearly distinguish between organisational commitment and occupational commitment as two separate constructs (factors).

4.2.5.2 The Collection of Quantitative Data

Ethical clearance was obtained prior to data collection. Communication with College Principals was done through each participating college's central office. Eight TVET college lecturers including two PhD students, four industry academy staff and two COMET experts actively participated in the development and quality assurance of COMET Test Tasks during a three-day workshop in October 2019, in Cape Town.   Initially the study targeted six colleges in four

Provinces and in all instances, permission was granted, however this had to be reduced to five participating colleges across four Provinces, due to logistical constraints, such as time and large geographical traveling distances, as well as Covid-19 pandemic restrictions at the time of the research. As a result, two Gauteng Province TVET colleges were dropped from participation due to travelling pressure for the researcher and large distances between colleges. After permission was obtained from TVET college principals, the campus managers of the various TVET college campuses were contacted. Appointments were made to brief campus managers, Head of departments and staff about the nature and purpose of the study. In these briefings, the dates for training lecturers were decided and the training mostly took place during those dates. The training consisted of an introduction to the COMET methodology and learning task orientation and the duration was 8 hours. There were separate training occasions for lecturers and students. Most of the communication with participating students was handled by college lecturers, but the researcher briefed the students on the project. One campus from Mpumalanga had to drop out of the study due to the combination of curriculum pressure and being severely affected by frequent campus closures due to Covid-19 pandemic. Campus managers reserved two days of the week, including Saturdays, to accommodate the study and to minimise interference with their normal teaching schedule and activities.

The COMET diagnostic model and questionnaires utilises various data collection instruments, i.e., (i) domain specific open-ended baseline and main test assignments, (ii) Occupational Identity and Commitment Questionnaire (exploring the participants' attitudes and values towards their profession and training), as well as (iii) a Motivational Questionnaire that measures the levels of motivation during the completion of the main test assignment, as well as participants' experience of the relevance thereof for TVET. The open-ended baseline and main test assignments were designed to develop and test students' holistic problem-solving capabilities, amongst other occupational competence. The assignments posed work-related problems for students to solve. These assignments were designed to be open-ended to allow students the opportunity to solve complex domain specific problems, holistically within the solution space.

The COMET tests were administered at the various TVET colleges. Students responded to the COMET test task by writing solutions on an answer sheet using a pen/pencil. The maximum time available to students to complete a test task was 120 minutes. Students exceeding the 120 minutes were not given additional time to complete the task. The researcher collected both the test task and answer sheets from participating students. Ideally, students at the five TVET Colleges were supposed to write the COMET tests on the same date and time. Due to limited human resources, geographical distances between colleges, and different time slots that the colleges made available for the completion of the COMET tests, this was not viable. To safeguard the credibility and integrity of the COMET test tasks, students were not allowed to take photos or make notes, and all COMET related material was collected at the end of the sessions.

4.2.5.3 Methods Used to Collect Qualitative Data

Qualitative data were collected using two qualitative methods of data collection. The first method was a qualitative open-ended question included at the end of Part I of the COMET questionnaire, which requested students to qualitatively explain (in the form of narrative answers) the reason why they approve or disapprove of similar tasks becoming part of their vocational training. Students' narrative answers were qualitatively analysed to determine the strengths and weaknesses of the COMET model's didactic application, as experienced by participating TVET students. The second method used to collect qualitative data were by means of a focus-group interview that collected the qualitative responses of Electrical Engineering TVET lecturers who participated in the study. A focus-group interview schedule, comprising of the following open-ended questions was drafted by the researcher and verified by the research supervisor, to act as a guide for the focus-group discussion: (a) Whether or not lecturers' current didactic practice sufficiently prepared students for the requirements of modern-day work; (b) The manner in which lecturers implemented the two learning tasks in classes; (c) Lecturers' experiences of the COMET learning task solution space in comparison with the test memorandum; (d) The strengths of using the COMET diagnostic model; and (e) The weaknesses of using the COMET diagnostic model.

4.2.5.4 Procedures Used to Collect Qualitative Data

The collection of qualitative data were conducted after the quantitative data analysis was completed. Qualitative data comprised of N=9 TVET Electrical Engineering lecturers who participated in a focus group interview. These were the same lecturers who were involved in the rating of COMET test tasks; therefore, they were already trained in the application of the COMET diagnostic model. As stated in the previous section, a focus-group interview schedule was developed by the researcher and verified by the supervisors, to guide the discussion through five open-ended questions. The researcher invited all TVET lecturers who had already acted as raters for this study's quantitative component, to participate in the focus-group discussion. Nine of the lecturers indicated their willingness to participate voluntarily. A date and time were scheduled, and an hour-long focus-group discussion was conducted online via Google Meet, as the participants were located in various geographic locations, and were familiar with online meetings due to COVID-19 restrictions. The focus group interview was conducted in the afternoon during the week, since participating lecturers were working full time. Lecturers' responses were audio-recorded during the focus-group interview, and afterwards transcribed into digital text. Students' narrative answers to the open-ended COMET questionnaire item ("*Why would you approve this kind of task becoming part of your vocational training?"*) were also captured from the completed questionnaires in the form of digital text. TVET lecturers' focus-group interview data, as well as the qualitative data collected from TVET students via the open-ended questions that were included as part of the COMET Questionnaire, were integrated into a single hermeneutic unit for qualitative data analysis, as recommended by Merriam and Tisdell (2016).

4.2.6 Data Analysis

According to Hakansson (2013) data analysis is the process of inspecting, cleaning, transforming, and modelling data, which supports decision-making and draws conclusions from findings. Both quantitative empirical data, as well as qualitative narrative responses (i.e., TVET lecturers' interview data and TVET students' responses to the open-ended questionnaire item: "*Why would you approve this kind of task becoming part of your vocational training?"*) were analysed as follows.

4.2.6.1 Quantitative Data Analysis

The statistical analysis software, IBM SPSS version 25, was used to perform analyses on the combined quantitative dataset obtained from N=199 Electrical Engineering TVET students, by calculating both descriptive statistics (means, frequencies and percentage frequencies), as well as inferential statistics (Cronbach Alpha reliability indices, cross-tabulations, and the strengths (effect sizes) of associations and differences between variables), in order to investigate empirically, the didactic effect that the COMET diagnostic model had on the development of occupational competence amongst participants. The data were organised according to the occupational competence levels measured by the three-dimensional COMET diagnostic model, with its eight competence criteria scales (Rauner et al., 2013). The empirical findings gained from these statistical analyses are reported and discussed in the next chapter.

Table 4.3: Various Statistical Analyses Performed on the Quantitative Data of TVET Electrical Engineering Students (N=199)

Sources of Quantitative Data	Description of Quantitative Data	Statistical Analyses	Purpose of Statistical Analyses
COMET test tasks Rating Sheets	Rated scores (on a Likert scale) of 40 items completed for individual student's solution of the COMET test task, conducted by two independent raters	Inferential Statistics Finn Coefficient calculated	To determine the inter-rater reliability of TVET lecturers' selection and rating of students COMET tests solutions
Rating Sheets	Likert-scale values of 40 items on the Rating Sheet used to evaluate the solutions provided by N=199 TVET Electrical Engineering students for both the based-line and main COMET tests	Inferential Statistics Cronbach Alpha (α) reliability coefficients (Cronbach, 1951; Cronbach & Shavelson, 2004)	Cronbach Alpha (α) reliability coefficients were calculated to determine the internal consistency of the measuring scales pertaining to the three competence levels, the eight-competence criterion, as well as the combined professional occupational competence score.
Rating Sheets COMET Questionnaire	TVET Students' Likert-type responses to items on the COMET Questionnaire	Descriptive Statistics (Means, frequencies, and frequency percentages)	The means, frequencies, and frequency percentages were calculated for all Rating Sheet and COMET questionnaire items, for the purpose of describing the empirical findings. The descriptive findings are reported in the following chapter in Sections 5.2.1.
	Likert-scale values of 40 items on the Rating Sheet used to evaluate the solutions provided by N=199 TVET Electrical Engineering students for both the based-line and main COMET tests	Inferential Statistics Cohen's effect sizes (d-values) were calculated	Cohen's effect sizes (d-values) were calculated between the Likert-scale values rated for the baseline and main COMET tests, to determine the strength of the effect that the COMET diagnostic model had on the enhancement of N=199 TVET Electrical Engineering students' occupational competence profiles. These findings are reported in Chapter 5, Section 5.2.2.1, and Table 5.16.
		Inferential Statistics Spearman's rank order correlation coefficients / effect sizes (R-values) were calculated	Spearman's rank order correlation coefficients (R-values) were calculated to determine to what extent were students' competence levels (measured in the

Sources of Quantitative Data	Description of Quantitative Data	Statistical Analyses	Purpose of Statistical Analyses
			baseline and main tests) being influenced by their age and years of training. Findings are reported in Section 5.2.2, Table 5.17.
	Likert-scale values of 40 items on the Rating Sheet used to evaluate the solutions provided by N=199 TVET Electrical Engineering students for both the based-line and main COMET tests, as well as TVET students' Likert-type responses to items on the COMET Questionnaire	Inferential Statistics Cross-tabulation of variables measured by Spearman's effect sizes (r-values)	Cross-tabulation was conducted in order to measure the strengths of associations between the various variables in the quantitative dataset, for both the baseline and main tests. These findings are reported in Section 5.2.2.3, Table 5.18

Table 4.3 provides a summary of the various statistical techniques (analyses) that were performed on the quantitative data collected from N=199 TVET Electrical Engineering students. Both Descriptive Statistics (Means, frequencies, and frequency percentages), as well as inferential statistics (inter-rater reliability**,** Cronbach Alpha reliability coefficients, strengths of associations measured by effect sizes, rank order correlation, and Cross-tabulation) were calculated.

According to Ellis and Steyn (2003), data obtained through purposefully selected convenience sampling, is in many cases erroneously analysed as if it were obtained by random sampling. Such data should be considered as small populations for which statistical inference and p-values are not relevant. Instead of only reporting descriptive statistics in convenience sampling, the effect size is calculated to measure practically significant differences in means. Practical significance can be understood as a large enough difference or correlation to have an effect in practice.

Cohen's effect sizes (d-values) were calculated between the rated scale values for the base-line COMET test, and the rated scale values of the main COMET test, to determine the effect of the COMET diagnostic model on enhancing the occupational competence profile of TVET Electrical Engineering students who participated in the current study, which not only make the differences independent of units and sample size, but relate them to the spread of the data (Ellis & Steyn, 2003; Steyn, 2000,2002). For differences in mean scores, the effect size:

$$d = \frac{|\bar{x}_1 - \bar{x}_2|}{s_{max}},$$

where $|\bar{x}_1 - \bar{x}_2|$ is the difference between $\bar{x}_1$ and $\bar{x}_2$, and S_{max} = maximum of S_1 and S_2, i.e., the sample standard deviations.

An effect size $0.3 \le d < 0.5$ was considered as a small effect size, with none or a statistically small significant effect. An effect size $0.5 \le d < 0.8$ was regarded as indicative of a medium effect size, with an effect that tends towards a practically significant difference. While an effect size $d \ge 0.8$ was a large effect size that is indicative of a practically significant difference between the rated scores of the base-line COMET test, and the rated scores of the main COMET test. These effect sizes were empirically calculated to determine the strength of practically significant effects that the COMET diagnostic model had on the development of participating TVET students' total professional occupational competence development.

The various COMET rating scales were also correlated with each other, using cross-tabulation. Spearman's Rho is a non-parametric test used to measure the strength of association between two variables, where the value r = 1 means a perfect positive correlation and the value r = -1 means a perfect negative correlation. Spearman's rank-order correlations (r) were determined between the various COMET rating scales, as these items exhibit rank-order. Spearman's rank-order correlations (r) were interpreted as follows:

$r \leq 0.1$ indicative of a small or no practical significant correlation

$0.2 \leq r \leq 0.4$ indicative of a medium effect that tends to practical significant correlation.

$r \geq 0.5$ indicative of practically significant correlation.

4.2.6.2 Qualitative Thematic and Categorical Data Analyses

Qualitative data analysis is described as an eclectic process, as it depends on the creativity and intellectual ingenuity of the researcher who analyses the data to build on theory (McMillan & Schumacher, 2001). The researcher should engage him/herself fully in the qualitative data, in order to gain in-depth, context-sensitive and rich insights into the phenomenon under investigation (Leech & Onwuegbuzie, 2009). I followed the six interactive steps of qualitative data analysis recommended by Jesson, Matheson, and Lacey (2011) as set out below:

1. Create a Hermeneutic Unit for analysis.
2. Integrate and combine all sources (qualitative datasets) into the hermeneutic unit. Qualitative data obtained from the focus-group interviews, as well as student participants narrative responses to the open-ended question that was added to the COMET Questionnaire, were combined into a single integrated hermeneutic unit on which qualitative data analysis was performed.
3. Discovery relevant passages: The researcher read through the qualitative dataset and tentatively identified potential themes and categories in the dataset.
4. Data coding: The information in the qualitative dataset was coded, tagged and related information was grouped into clusters of data (categories and themes of data), as recommended by (Jesson, Matheson, & Lacey, 2011).
5. Building theory: The researcher identified regularities and patterns between the various themes and categories of data, and labelled out a dynamic network of meaningful relationships that exist between them, underpinned by previous COMET research. These category, themes and patterns materialised from the data without depending on any pre-determined analysis structure (McMillan & Schumacher, 2001). Throughout the qualitative data analysis, the researcher systematically tried to make sense of the collected data

through a process of data selection, categorisation, comparison, synthetisation and interpretation (McMillan & Schumacher, 2001; Neuman, 2011).

6. Visualising and reporting of findings: the researcher charted up network visualisations of the various clusters of interrelated themes and categories of data that are presented and discussed in Chapter 5, Section 5.3.

4.2.7 Reliability, Trustworthiness and Credibility

4.2.7.1 Reliability of the Quantitative Measurements

Internal Consistency of Measuring Scales (Cronbach Alpha (α) Reliability Coefficients)

As part of the inferential statistical analysis, the *Cronbach Alpha (α)* reliability coefficients were calculated to determine the internal consistency of the measuring scales pertaining to the three competence levels, the eight-competence criteria, as well as the combined professional occupational competence score. On the next page, Table 4.4 reports the coefficient Cronbach **α** values calculated within the current study and compares these reliability indices with those previously reported by Martens, Heinemann, Maurer, Rauner, Ji and Zhao (2011, p. 109), Rauner, Heinemann, Maurer, Haasler, Erdwien and Martens (2013, p. 162), Martens (2015, p. 195), as well as Rauner (2021, p.191-192). Satisfactory coefficient Cronbach **α** values were reported for the current study, indicative of good internal consistency of the various measurements of the COMET diagnostic model. A large Cronbach **α** = 0.97 coefficient was calculated for the total professional occupational competence score of participating students, which affirmed the good reliability (internal consistency) of the COMET diagnostic model and its measuring instruments for the current investigation. Reliability is relative to a specific situation or situations. A reliability coefficient value of 0.5 is typical for ordinary classroom assessments. The good reliability coefficient values reported for the COMET model's didactical application, could: (i) Be indicative of the fact that the TVET Electrical Engineering students who participated in the current study, experienced the COMET tasks as practical and relevant for their future occupations in Electrical Engineering (Downie, 1967, p. 92), and (ii) could be indicative that the learning tasks, as practice items, positively affected the test task scores of participating students (Downie, 1967, p. 89).

Table 4.4: Satisfactory Reliability (Internal Consistency) Reported for the COMET Diagnostic Model's Quantitative Measurements

	COMET Measuring Items and Scales	Cronbach Alpha (α) Reliability Coefficients Reported by Martens et al. (2011, p. 109) and Rauner et al. (2013, p.162)	Rasch-Model Identification Reliability Coefficients Reported by Martens (2015, p. 195)	Cronbach Alpha (α) Reliability Coefficients Reported by Rauner (2021, p.191-192)	Cronbach Alpha (α) Reliability Coefficients Reported for the Current Investigation
EIGHT COMPETENCE CRITERION					
Clearness / Presentation	Items 1 to 5	0.88	0.88	0.91	0.90
Functionality	Items 6 to 10	0.86	0.85	0.90	0.90
Utility/sustainability	Items 11 to 15	0.84	0.84	0.90	0.92
Economy / efficiency	Items 16 to 20	0.82	0.80	0.82	0.90
Work and Business Process Orientation	Items 21 to 25	0.87	0.87	0.92	0.88
Social Compatibility	Items 26 to 30	0.84	0.77	0.84	0.91
Environmental Compatibility	Items 31 to 35	0.85	0.73	0.83	0.84
Creativity	Items 36 to 40	0.90	0.86	0.91	0.86
THREE COMPETENCE LEVELS					
Functional Competence	Clearness / Presentation Functionality	0.93	Not reported	0.95	0.95
Processual Competence	Utility Economy Work and Business Process Orientation	0.92		0.91	0.96
Shaping Competence	Social Compatibility Environmental Compatibility Creativity	0.93		0.92	0.93
Professional Occupational Competence	All 40 Items	0.97		0.96	0.97

Table 4.5: Example of Satisfactory Inter-Rater Reliability *(Finn Coefficients)* Reported for the Test Task Factory Renovations in the Current Study

Task - Factory renovations
Task Number - S 019

0 not met at all
1 rather not met
2 rather met
3 fully met
Item not assessed

Rater A
Rater B
Rater C
Rater D
Rater E
Rater F
Rater G
Rater H
Rater I
Rater J
Rater K

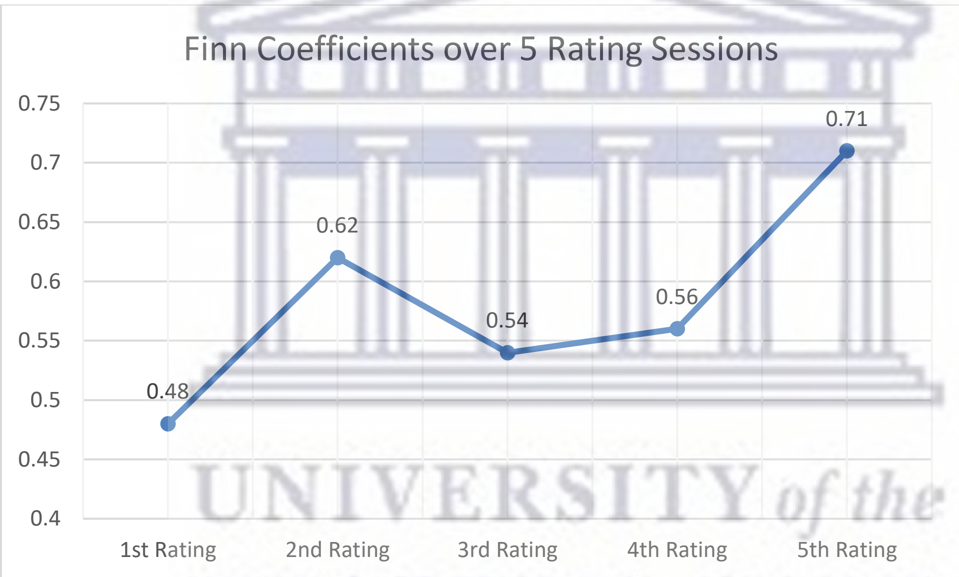
	Clearness/Presentation					Functionality					Use Value/Sustainability					Efficiency/effectiveness				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
[redacted]	2.0	2.0	2.0	2.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	0.0	0.0	2.0	1.0	2.0	0.0	0.0	0.0	2.0
[redacted]	1.0	0.0	1.0	1.0	1.0	1.0	0.0	2.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0
[redacted]	1.0	0.0	0.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[redacted]	0.0	0.0	1.0	1.0	1.0	0.0	1.0	2.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0
[redacted]	3.0	2.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	3.0	2.0	3.0	2.0	3.0	3.0	2.0	1.0	0.0	2.0
[redacted]	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0
[redacted]	2.0	1.0	2.0	1.0	2.0	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0
Quintin	0.0	0.0	2.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	3.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0
Babs	1.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Nishen	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0
Adhir	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	2.0	0.0	0.0	2.0	1.0	2.0	0.0	0.0	0.0	1.0
Mean	1.36	0.91	1.36	1.27	1.27	1.45	0.73	1.55	1.09	1.18	1.55	0.73	0.73	1.27	1.09	1.36	0.55	0.27	0.36	1.00
Standard	0.92	0.83	0.81	0.79	0.65	0.82	0.65	0.82	0.70	0.98	0.93	0.90	1.10	0.79	0.94	0.81	0.69	0.47	0.50	0.63
Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Group Evaluation																				

	Work and business Proce					Social Responsibility					Environmental Responsibi					Creativity						
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Mean	Std. Dev.
[redacted]	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.0	1.0	0.0	0.93	0.93
[redacted]	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	0.48	0.59
[redacted]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.38	0.58
[redacted]	1.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	0.53	0.59
[redacted]	3.0	3.0	2.0	2.0	2.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	2.0	2.0	3.0	1.0	1.0	2.0	2.0	2.0	2.13	0.74
[redacted]	0.0	0.0	1.0	1.0	0.0	1.0	1.0	2.0	2.0	2.0	1.0	1.0	1.0	0.0	2.0	1.0	1.0	1.0	1.0	1.0	0.93	0.53
[redacted]	1.0	1.0	2.0	1.0	1.0	1.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	1.0	0.0	0.0	2.0	1.23	0.79
Quintin	3.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.43	0.63
Babs	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.25	0.42
Nishen	0.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0	0.0	0.73	0.56
Adhir	0.0	2.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	2.0	0.0	0.0	1.0	1.0	0.0	0.95	0.83
Mean	0.73	1.09	0.55	0.82	0.45	0.64	0.82	0.64	1.18	0.64	0.73	0.64	0.73	0.36	1.73	0.45	0.45	0.73	0.91	0.73	0.90	0.37
Standard	1.19	0.94	0.82	0.75	0.69	0.81	0.98	0.81	0.75	0.92	1.01	0.81	0.79	0.67	0.79	0.52	0.52	0.65	0.54	0.79	0.79	
Item	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Mean	
Group Evaluation																						

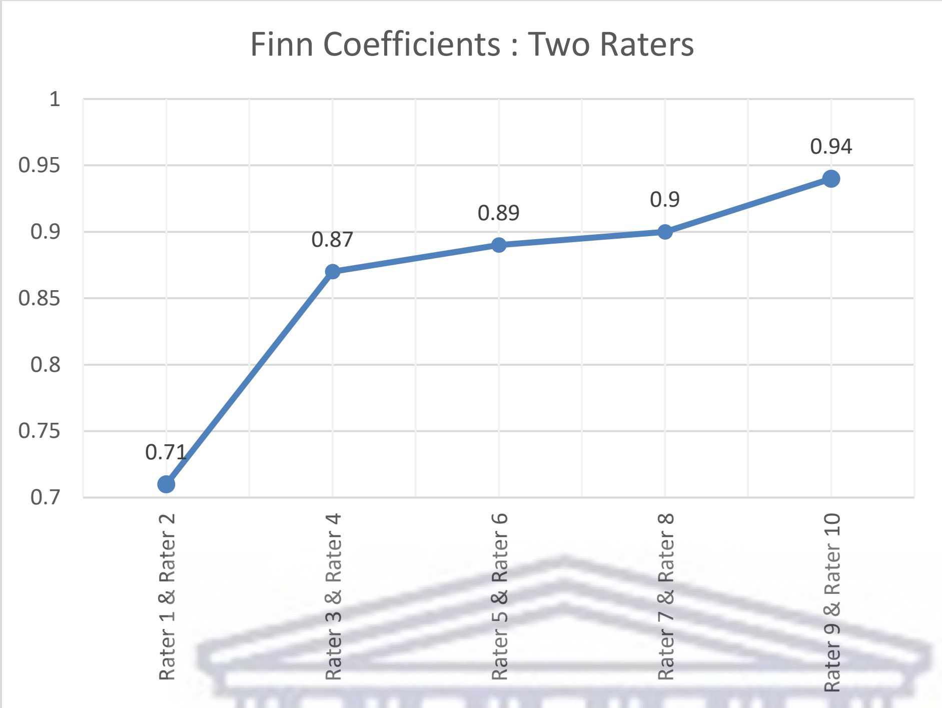
Inter-Rater Reliability (Finn Coefficients) for the Selection of Test Tasks

Table 4.5 shows the rating results of the first trial rating conducted by 11 raters (TVET Electrical Engineering lecturers). The degree of agreement was very low for the first trial rating with a Finn coefficient of 0.48. A Finn coefficient score from 0.5 onwards is considered as satisfactory and scores above 0.7 as good (Rauner et al., 2013, pp. 149-154).

During the course of the rater training, the degree of agreement was below a satisfactory value for the first rating session. The second session however, showed a remarkable improvement but the level of agreement declined for the third session. Thereafter the level of agreement increased steadily and converged to a good Finn coefficient value > 0.70, as can be seen in Graph 4.1 below.



Graph 4.1: Convergence of a good Finn coefficient value = 0.71 was achieved after five sessions



Graph 4.2: Good inter-rater reliability Finn coefficients values > 0.7 achieved for the five test tasks.

In addition to the above ratings, five test tasks were rated by two different raters for each task. Good inter-rater reliability Finn coefficient values > 0.7 were consistently achieved for the various test tasks, as shown in Graph 4.2 above. .

Internal Reliability and Construct Validity

According to Macmillan and Schumacher (2010) validity refers to the degree to which scientific explanation of the phenomena matches reality. It refers to truthfulness of findings and conclusions. This study ensured design validity by taking into consideration the following validity issues: design validity, internal validity, construct validity and external validity. Inter-rater reliability is a key element in COMET assessment. In this study two or more raters of the same COMET open-ended test task completed by a TVET student were assigned to evaluate test task assignment of students. Inter-rater reliability refers to the degree to which raters agree on how students' work is rated and observed. To assure quality, the assessment or rating of respondents' individual solutions, a common understanding of the expectation of the solutions of test tasks or work assignments must be established among raters (Rauner, 2013). To get raters comfortable with the 40-item rating assessment sheet and achieving convergence of individual ratings, rating practice based on empirical data was carried out. Finn coefficient values ≥ 0.5 are deemed satisfactory, while values ≥ 0.7 are regarded as excellent (Rauner et al., 2013).

The measurement of occupational competence and holistic problem solving is the focus of the COMET methodology. The use of domain/subject-specific test tasks ensures content validity. Inter-rater reliability was used, in which raters agreed on a rating based on what had been observed. As COMET tasks are open-ended, scoring them can be more difficult. Thus, proper training is crucial for the standardisation process.

4.2.7.2 Trustworthiness, Credibility, and Inter-rater Reliability of the Qualitative Data

The collection of qualitative data were guided by the following three standards, as recommended by Eisenhart and Juirow (2013), which contributed towards ensuring the general trustworthiness and credibility of the qualitative data and findings: Standard 1: Ensuring a good fit between the research questions, data collection procedures and data analysis techniques; Standard 2: Providing good context for the study, in order to ensure that the reader of the dissertation will have a good understanding of who the participants were, how the data were collected, and what the features were that characterized the activity system; and Standard 3: The researcher's assumptions and biases were minimized by means of triangulations and member checking.

Following the advice of Merriam and Tisdell (2016) and Creswell (2003), the trustworthiness and credibility of the qualitative findings were furthermore ensured through the following measures: (i) Only actual TVET Electrical Engineering students and lecturers were invited to participate in the study. (ii) The researcher has 3 years of teaching experience in TVET Electrical Engineering subjects, which contributed to the data's trustworthiness, based on the researcher's expertise and experience in Electrical Engineering. Furthermore, qualitative data were collected until data saturation was reached (Merriam & Tisdell, 2016), and during the data analysis, a triangulation technique was employed to verify the accuracy of the data analysis and interpretation (Merriam & Tisdell, 2016). As part of this triangulation, the researcher asked a colleague, who has proficient knowledge and skills in Electrical Engineering and the application of the COMET diagnostic model, to also analyse and group the data thematically. We then compared the findings of our respective qualitative thematic data analyses with each other, and where the findings significantly differed between the two, we discussed, clarified, and resolved such issues through collaborative efforts. Two Smart-phones were used to make voice recordings during the focus-group interview, which enabled the researcher to readily make word-for-word verbatim transcriptions of the voice recordings and capture the focus-group interview narratives as electronic text. The researcher also handled the data in an unprejudiced manner and regularly conducted follow-up discussions with student-participants, as well as with a peer researcher who is also an Electrical Engineering expert, in order to clarify and correctly interpret the findings (Merriam & Tisdell, 2016). Finally, the researcher also triangulated and calculated the interrater reliability for the findings derived from the focus-group interview, which is fully explained in the section that follows:

Inter-rater reliability calculated for the findings derived from the focus-group interview

Cohen's kappa coefficient (*κ*), proposed by Cohen (1960), is a statistical calculation used in qualitative research to measure the agreement (interrater reliability) between two raters who each classify *N* items (themes) into *k* mutually exclusive data categories (McHugh, 2012). In qualitative research Cohen's kappa coefficient (*κ*) is much more than just a percentage of agreement between two raters in a study, as *κ* also considers the possibility of agreement occurring by mere chance. Following Cohen (1960), the kappa coefficient (*κ*) is calculated by the following equation:

$$k = \frac{p_o - p_e}{1 - p_e}$$

Where p_o is the relative degree of agreement observed between the choices made by two (or more) independent raters, and p_e is the hypothetical probability of this agreement occurring by mere chance. Like correlation coefficients, Cohen's Kappa (κ) can range from -1 to +1, where 0 represents the amount of agreement that can be expected from random chance, and 1 represents perfect agreement between two raters. While kappa values below 0 are possible, Cohen (1960), however, found this to be unlikely in practice. Table 4.6 shows the interpretation criteria for Kappa (κ) values, as originally suggested by Cohen (1960).

Table 4.6: Interpretation of Kappa (*K*) values as suggested by Cohen (1960)

Cohen's Kappa Coefficient (κ) Values	Level of Agreement
K < 0	No Agreement
0.00 ≤ K ≤ 0.20	None to Slight Agreement
0.21 ≤ K ≤ 0.40	Fair Agreement
0.41 ≤ K ≤ 0.60	Moderate Agreement
0.61 ≤ K ≤ 0.80	Substantial Agreement
0.81 ≤ K ≤ 1.00	Almost to Perfect Agreement

Table 4.7: Satisfactory reliability (perfect inter-rater agreement), measured by Cohen's Kappa Coefficient (κ), calculated for the qualitative categorical and thematic focus-group and questionnaire data pertaining to the strengths and weaknesses of the didactic use of the COMET Diagnostic Model

		TWO DATA CATEGORIES	
		Strengths of COMET	**Weaknesses of COMET**
21 DATA THEMES	Based upon real-life	Rater A Rater B	
	Circumscribed by Limited Time Due to Fixed Curriculum		Rater A Rater B
	Develops Students' Competence Needed to Enter Industries	Rater A Rater B	
	Not easily implementable in TVET		Rater A Rater B
	Industry-based	Rater A Rater B	
	Hand-on (pragmatic)	Rater A Rater B	
	Increases Workload		Rater A Rater B
	Students gain skills for personal and domestic use	Rater A Rater B	
	"Not practical"		Rater A Rater B
	Develops Problem Solving Skills	Rater A Rater B	
	Enhances Higher Order Critical Thinking	Rater A Rater B	
	Pragmatic: Assists Students to Apply Gained Knowledge	Rater A Rater B	
	Enhances Occupational Competence	Rater A Rater B	
	Repetition of what is already known		Rater A Rater B
	Enhances Academic Competence	Rater A Rater B	
	Promotes Teamwork	Rater A Rater B	
	Creates Confusion and Uncertainty		Rater A Rater B
	Subject/Field Relevance	Rater A Rater B	
	Promotes Entrepreneurship	Rater A Rater B	
	Stimulates Creativity and Offers Flexibility to Students to Think Outside the Box	Rater A Rater B	
	Models Students' Work Experience	Rater A Rater B	

Number of observed agreements: 21 (100% of the observations)
Number of agreements expected by chance: 12.4 (59.18% of the observations)

Cohen's Kappa Coefficient (κ) = 1.000 – almost perfect interrater agreement (reliability)‡

‡ A Cohen's Kappa Coefficient (κ) value below 0.6 is regarded as inadequate agreement amongst raters and little confidence should be placed in the results. The minimum acceptable interrater agreement value is Kappa value of 0.8 (80% agreement between raters). This means that 20% of the data collected is erroneous misrepresented data because only one of the raters can be correct when there is disagreement. The Cohen Kappa coefficient value should directly be interpreted as the percent of data that are correct. The Cohen's Kappa Coefficient (κ) = 1.000 calculated in this study, is an almost perfect interrater agreement (reliability), with a 100% confidence in the results.

The categorical and thematic nature of the qualitative focus-group interview and questionnaire data allowed for the triangulation of these findings by calculating interrater reliability by means of Cohen's Kappa (***κ***). Accordingly, the researcher calculated and measured the level of agreement (interrater reliability) between two raters who independently classified n=21 themes of data into *k=2* mutually exclusive data categories, as suggested by Landis and Koch (1977), and McHugh (2012), representing the strengths and weaknesses of didactically using the COMET diagnostic model for the South African Electrical Engineering TVET context.

The satisfactory Cohen's Kappa Coefficient (*κ*) = 1.000 reported in Table 4.7 (on the previous page), is an almost perfect interrater agreement (reliability), with a 100% confidence in results. The *κ* value of 1.000 confirmed that the qualitative data were categorically and thematically analysed, classified, and interpreted in a reliable and consistent manner.

4.2.8 Ethical Considerations

Research should be conducted in accordance with high ethical standards and values, with the researcher's professional integrity and ethical research methods serving as guides (Miles, Huberman & Saldanha, 2014; Sotuku & Duku, 2015). Ethical considerations also include the worthiness of the project, implications of the data analysis and findings, the competence of researcher (or people involved) to carry out a study of good quality, obtaining formal permissions and informed consent, participation being fully voluntary, etc. Potential risks to participants, confidentiality, anonymity, intervention and advocacy, research integrity and quality, ownership of data and conclusions, use and misuse of results, dilemmas and conflict of interest were all considered in this study. Any study conducted at institutions of higher learning, where students must respond to a written task or questions, tends to expose performance and practices. To ensure that the abovementioned principles and guidelines were followed, the following measures were taken:

4.2.8.1 Ethical Clearance

An Ethical clearance certificate (Addendum A) was obtained from the Research Ethics Committee of the University of the Western Cape.

4.2.8.2 Formal Permission and Informed Consent

Before commencement of data collection, formal permission was obtained from the respective managements of the purposefully selected TVET colleges (Addendum C). Informed consent (Addendum D) was obtained from participating students and lecturers. Participation was voluntary and anonymous, and participants were informed about the nature and purpose of the study, as well as their right to withdraw from the study at any time or stage of the research process. All participants were treated with respect and dignity, and the combined findings of the study were shared with participating colleges, and the occupational competence profiles of individual students were made available to them.

4.2.8.3 Covid-19 Protocols

This investigation was conducted during the Worldwide Covid-19 pandemic. It was therefore very important to make sure that all participants were protected from potentially being infected by the virus or transmitting it.

All Covid-19 Health and Safety protocol and lockdown regulations were adhered to during data collection, including providing participants with face masks, sanitizers, keeping social distancing in the venues. The colleges assisted us in taking daily temperatures upon arrival.

4.3 Chapter Synopsis

Chapter 4 has provided a comprehensive discussion of the mixed-methods sequential explanatory research design that was followed, as well as the various methods that were used for data collection. The chapter furthermore explained the sampling technique that was utilised and provided the demographical profiles of both the TVET Electrical Engineering students (N=199) and lecturers (N=9) who participated in the study. General information was also provided concerning the TVET colleges (test-sites) where the COMET diagnostic model was didactically applied and tested. The development of COMET learning and test tasks and the training of raters were also fully discussed, as well as the rating of students' solutions for the COMET tests. The various measuring instruments, methods and procedures that were used to collect both quantitative and qualitative data, are fully elaborated upon. The various statistical techniques that were applied to perform both descriptive statistics (means, frequencies and frequency percentages), as well as inferential statistics (inter-rater reliability, Cronbach Alpha reliability coefficients, strengths of associations measured by effect sizes, rank order correlation, and cross-tabulation), were also discussed in detail. The categorical and thematic data analysis that was performed on the qualitative data, was also explained. Chapter 4 also outlined the measures that were taken to ensure and statistically test reliability (internal consistency of measurements), inter-rater reliability, trustworthiness, and credibility, as well as ethical considerations.

Chapter 5

Presentation of Findings

5.1 Introduction

The quantitative findings of the descriptive and inferential statistical analyses, as well as the findings derived from the qualitative thematic data analysis findings, are reported in this chapter. The findings are presented in the form of frequency tables, inferential statistical tables, and qualitative network visualisations of data themes, visually supported by competence profile radar graphs, and other graphs. The chapter opens with the descriptive findings (frequencies and frequency percentages) pertaining to the demographical profile of participating TVET Colleges as test sites, as well as the demographical profiles of participating Electrical Engineering TVET students and lecturers. The empirical findings of both descriptive and inferential statistical analyses are then presented to effectively respond to the first two research sub-questions:

Sub-question 1: What was the occupational competence level of electrical engineering TVET students prior to the application of the COMET diagnostic model?

Sub-question 2: To what extent was the occupational competence of electrical engineering TVET students enhanced through the application of the COMET diagnostic model?

Qualitative findings are then presented to effectively respond to the third research sub-question:

Sub-question 3: How did TVET lecturers implement and apply the COMET diagnostic model in their classrooms?

Next, quantitative findings derived from TVET students' questionnaire responses are then applied to effectively respond to the fourth research sub-question:

Sub-question 4: What were the vocational identity, attitudes, and occupational commitment of TVET students in the study?

Findings of the qualitative thematic data analyses of TVET lecturers focus group interviews data, as well as of TVET students' narrative responses, are then reported to effectively respond to the last two research sub-questions:

Sub-question 5: What were the strengths of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

Sub-question 6: What were the weaknesses of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

These findings ultimately contribute towards answering the main research question of this study: ***How can the COMET diagnostic model be didactically applied in teaching and learning to enhance the occupational competence of National Certificate Vocational Electrical Engineering students at TVET colleges?***

5.2 Demographical Profiles of Participating TVET Colleges and Students

Table 5.1: General Demographical Information of the Five Participating TVET Colleges

	TVET College A	TVET College B	TVET College C	TVET College D	TVET College E
Province	Western Cape	Kwa-Zulu Natal	Mpumalanga	North-West	Western Cape
Total number of enrolled students (College size)	10,998 (Ministerial and Occupational) 1565 students at Participating TVET College Campus	14,231 (Ministerial and Occupational) 1565 students at Participating TVET College Campus	9,100 (Ministerial and Occupational) 1,300 students Participating TVET College Campus	2,827 (Ministerial and Occupational) 1565 students at Participating TVET College Campus	9,887 (Ministerial and Occupational) 1565 students at Participating TVET College Campus
Throughput Rate - Year 2021	13.7% for NC(V) level 4	30% for NC(V) level 4	85% for NC(V) level 4	65% for NC(V) level 4	29.6% for NC(V) level 4
Number of Study Programmes	TVET College 88 Participating Campus - 11	TVET College 29 Participating Campus - 5	TVET College 9 Participating Campus - 6	TVET College 13 Participating Campus – 6	TVET College 21 Participating Campus -6
Number of Students enrolled for Electrical Engineering	TVET College 647 Participating Campus - 60	TVET College 582 Participating Campus - 390	TVET College 816 Participating Campus - 204	TVET College 460 Participating Campus - 110	TVET College 150 Participating Campus - 61
Number of Electrical Engineering TVET lecturers	TVET College 9 Participating TVET College Campus - 3	TVET College 25 Participating TVET College Campus- 9	TVET College 20 Participating TVET College Campus - 5	TVET College 17 Participating TVET College Campus - 6	TVET College 20 Participating TVET College Campus - 6

5.2.1 Demographic Profile of TVET colleges used as Test Sites

The general demographic data for the five participating TVET Colleges that was easily accessible is shown in Table 5.1 on the previous page. The information provided in Table 5.1 sketches the background and educational context of the five participating TVET Colleges, across four South African Provinces that were used as test sites to apply the COMET diagnostic model didactically, for the teaching, learning and assessment of competence development among electrical engineering students. As information provided in Table 5.1 is self-explanatory, no further discussion is given here.

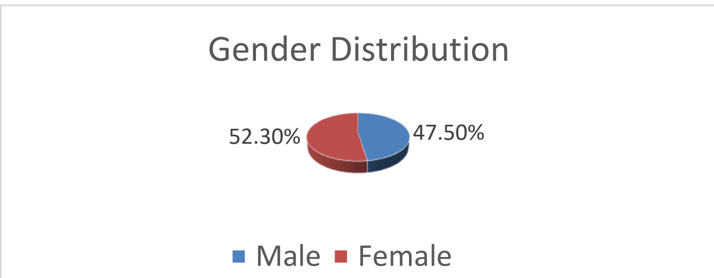
5.2.2 Demographic Profile of Participating TVET Students

This section provides information regarding the demographic profile of the total sample of TVET Electrical Engineering students (N=199) who participated in the quantitative research component of this mixed-methods investigation. Originally, N=238 TVET students participated, however, the quantitative data of n=39 students had to be excluded from my data analysis, as the COMET diagnostic model does not cater for students who obtain a total professional competence score < 5, as measured in the baseline or main COMET tests (Rauner, 2021). The demographic profile of the remaining N=199 TVET students are reported in this section regarding gender and age group distributions, cultural-language groups distribution, test-site distribution, entry-level qualifications, and practical training of the sample of participants.

Gender Distribution

Frequency Table 5.2 (with graph) shows the gender distribution of the total sample (N=199) of participating TVET Electrical Engineering students.

Table 5.2 (with Graph): Gender Distribution of the Total Sample of Electrical Engineering students

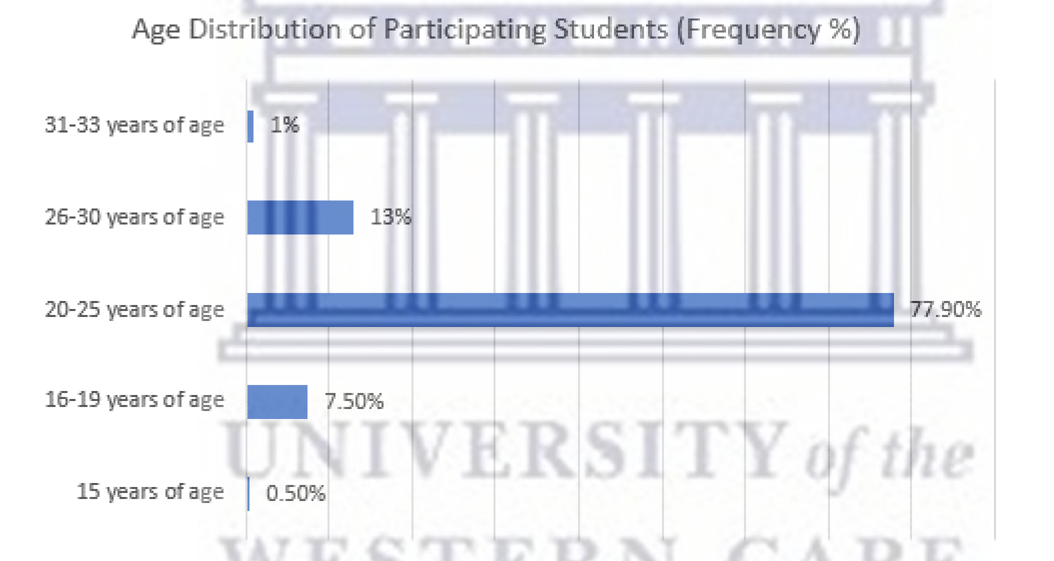


	Frequencies (n)	**Frequency %**
Females	104	52.3
Males	95	47.7
Total	**199**	**100.0**

In the total sample of participating TVET students (N=199), n=104 (52.3%) were females, and n=95 (47.7%) were males. Amongst the N=386 Electrical Engineering students who participated in the 2016 merSETA study, Hauschildt (2016, p. 153) reported a gender distribution of 42.7% (n=165) females and 57.3% (n=221) males. In the period stretching between the earlier 2016 merSETA study and 2021 (the year in which data were collected for the current investigation), the gender distribution of male and female Electrical Engineering students, has been reversed, and this is reflected by female students now outnumbering male students by 4.6% in the current study.

Age Distribution

Table 5.3 (with Graph): Age Distribution of the Total Sample of Electrical Engineering Students



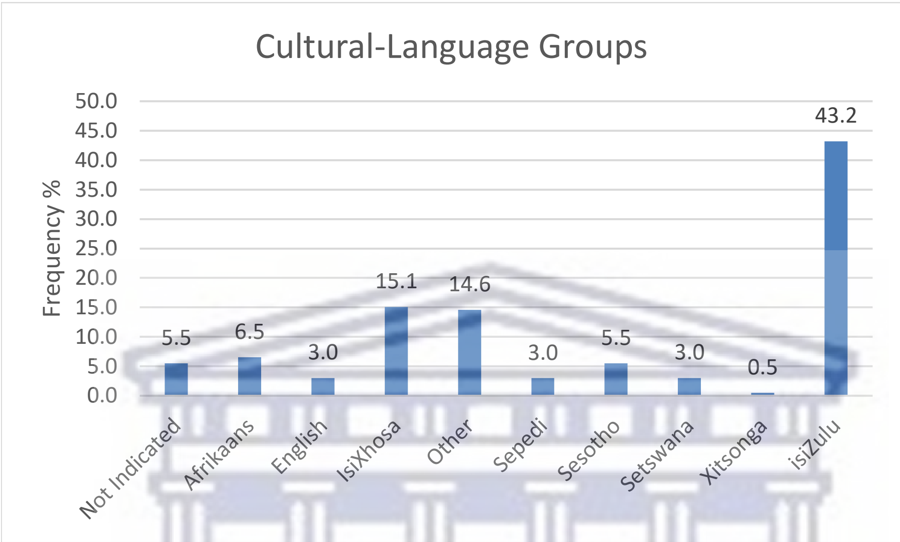
Age Groups	Frequencies (n)	Frequency %
15 years of age	1	0.5
16-19 years of age	15	7.5
20-25 years of age	155	77.9
26-30 years of age	26	13.0
31-33 years of age	2	1.0
Totals	**199**	**100.0**

Table 5.3 shows the age distribution of the total sample of N=199 Electrical Engineering TVET students who participated. Most participants were between the ages of 20 and 25 years of age (n=155; 77.9%). The age groups least represented in the study sample, were students of 15, 16 and 33 years of age (each n=1; 0.5%).

Cultural-Language Groups

Frequency Table 5.4 (on the page that follows) shows the cultural-language group distribution of the total sample (N=199) of participating TVET Electrical Engineering students.

Table 5.4 (with Graph): Cultural-Language Group Distribution of Participating TVET students



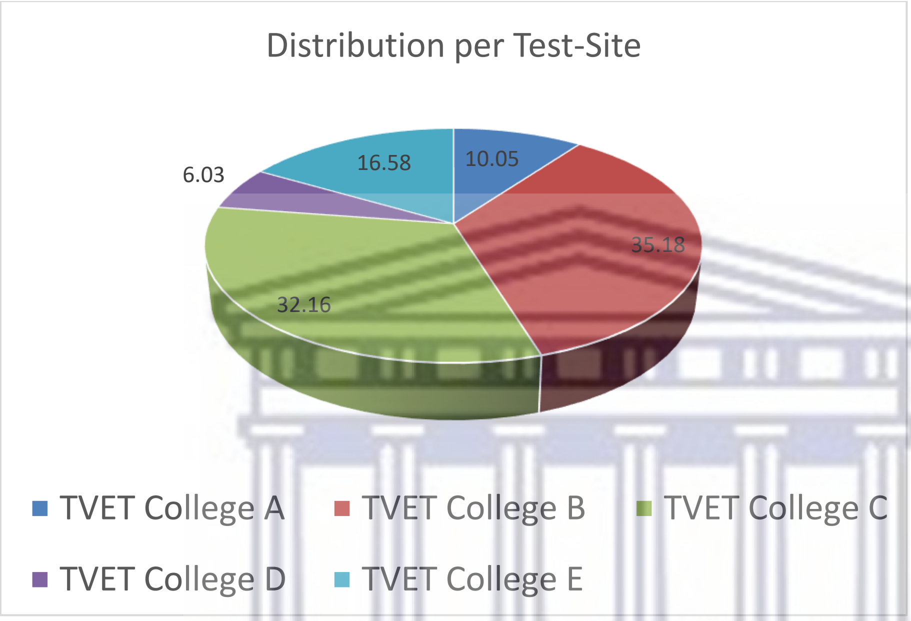
Cultural-Language Groups	Frequencies (n)	Frequency %
Not Indicated	11	5.5
Afrikaans	13	6.5
English	6	3.0
IsiXhosa	30	15.1
Other	29	14.6
Sepedi	6	3.0
Sesotho	11	5.5
Setswana	6	3.0
Xitsonga	1	0.5
isiZulu	86	43.2
Totals	**199**	**100.0**

The participating students represented eight of South Africa's twelve official languages. Eleven participants (n=11) choose not to indicate their home language, while n=29 of the students indicated that they belong to other cultural-language groups not listed in the table. isiZulu was the cultural-language group most represented by students in the sample (n=86; 43.2.%), while Xitsonga was least represented (n=1; 0.5%).

TVET College Distribution of Participating TVET Electrical Engineering students

Frequency Table 5.5 (on the following page) shows the TVET College site distribution of participating students, who took both the baseline and main COMET tests.

Table 5.5 (with Graph): TVET College Site Distribution of Participating Students



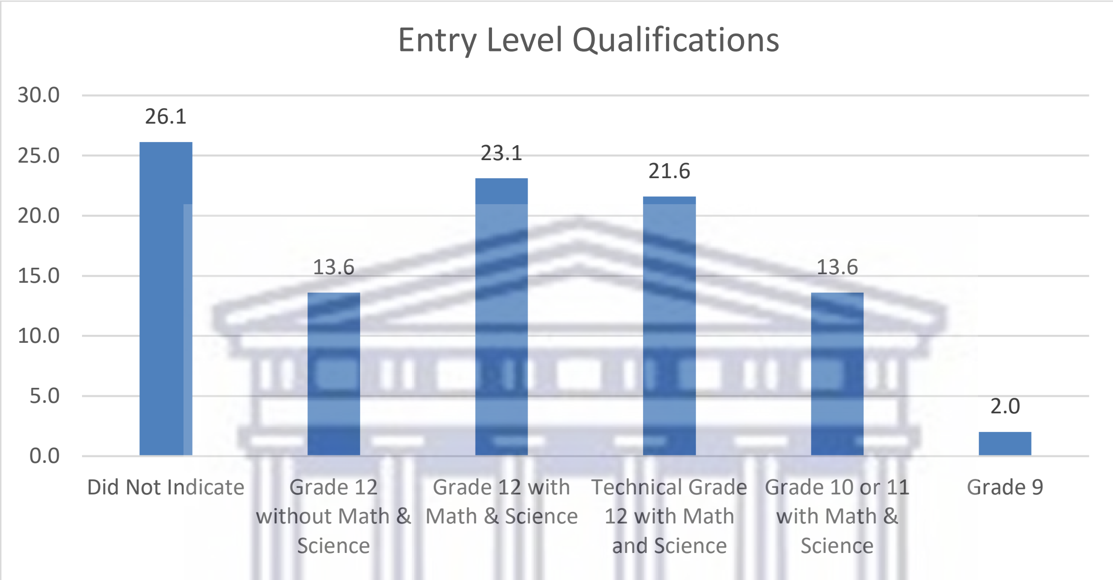
	Frequencies (n)	Frequency %
TVET College A	20	10.1
TVET College B	70	35.2
TVET College C	64	32.7
TVET College D	12	6.0
TVET College E	33	16.6
Totals	**199**	**100.0**

TVET College B was most represented in the total sample (n=70; 35.2%), while TVET College D was least represented (n=12; 6%). Initially, more students indicated their willingness (Addendum D) to participate, however, some of these students opted out and did not participate.

TVET Students' Entry Level Qualifications

Table 5.6 shows the entry level qualifications that participating TVET students obtained prior to their TVET enrolment.

Table 5.6 (with Graph): Students Entry Level Qualifications Obtained Prior to TVET Enrolment



	Frequencies (n)	Frequency %
Did Not Indicate	52	26.1
Grade 12 without Math & Science	27	13.6
Grade 12 with Math & Science	46	23.1
Technical Grade 12 with Math & Science	43	21.6
Grade 10 or 11 with Math & Science	27	13.6
Grade 9	4	2.0
Totals	**199**	**100.0**

The participants had the minimum entry qualifications of Grade 9 and the highest entry qualification of Grade 12. The category of Grade 9 as an entry qualification had fewer participants, only 2.1%. Participants who did not indicate their entry qualifications were 29 %.

5.2.3 Demographical Profile of Participating TVET Lecturers

Table 5.7 (on the next page) shows the demographic information of the N=9 TVET Electrical Engineering lecturers who participated in the qualitative focus-group interview. As the information in Table 5.7 is self-explanatory, no further discussion is required.

Table 5.7: Demographic Profile of TVET Electrical Engineering Lecturers (N=9) who Participated in the Qualitative Focus-Group Interview

	Frequencies (n)	Frequency %
Gender		
Male	8	88.9
Female	1	11.1
Years of Industry Experience		
1 to 5 years	3	33.3
6 to 10 years	1	11.1
11 to 15 years	0	0.0
16 to 20 years	1	11.1
Did not indicate	4	44.4
Years of Teaching Experience		
1 to 5 years	2	22.2
6 to 10 years	3	33.3
11 to 15 years	1	11.1
16 to 20 years	2	22.2
21 to 25 years	1	11.1
Cultural Groups		
African	5	55.6
Indian	3	33.3
Coloured	1	11.1
Participating TVET Colleges		
TVET College A	3	33.3
TVET College B	0	0.0
TVET College C	3	33.3
TVET College D	1	11.1
TVET College E	2	22.2
NCV Levels Teaching		
Level 2	9	100
Level 3	9	100
Level 4	9	100

5.3 Quantitative Research Findings Responding to Sub-question 1: What was the occupational competence level of electrical engineering TVET students prior to the application of the COMET diagnostic model?

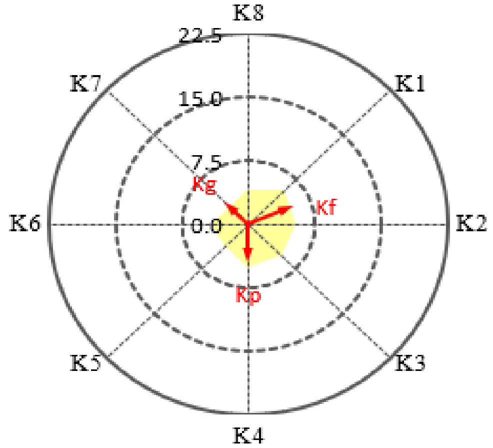
This section reports the combined occupational competence profile of participating TVET Electrical Engineering students prior to the COMET intervention, as measured against the eight COMET criteria and holistic problem-solving competence levels, and also deals with identifying areas for development. It must be noted that the COMET diagnostic model is standard referenced, and not criterion referenced. These tasks were designed to develop and to assess competence of individuals and groups. The increase or decrease in competence levels, COMET criteria, and WPK is indicated as percentage points and must therefore be read and interpreted as such.

Competence results reported in this section are interpreted and categorised according to the following descriptions provided by Rauner (2013, p.44) for the various levels of occupational competence:

I Nominal competence:	Superficial -conceptual knowledge that does not guide activity, the meaning of the professional terms remains at the level of colloquial language.
II Functional competence:	Basic technical knowledge leads to technical-instrumental skills. "Professionalism" is displayed as decontextualized technical knowledge and corresponding skills ("know that").
III Processual competence:	Professional tasks are interpreted in the context of company work processes and situations. Work process knowledge leads to professional action competence ("know how").
IV Holistic shaping competence:	The complexity of professional work tasks is fully realized, and tasks are solved with a view to diverging demands and in the form of intelligent compromises.

Table 5.8 (with Graph): Competence Profile of the Total Sample of Participating TVET Electrical Engineering Students in the Baseline Test (mean scores)

	Min	Max	Mean	Standard Deviation
K1 (Clarity/Presentation)	0.5	13.5	5.71	2.45
K2 (Functionality)	0.0	12.0	5.26	2.14
K3 (Use value)	0.0	13.5	5.18	2.44
K4 (Cost Effectiveness)	0.0	13.5	3.85	2.40
K5 (Business /Work Process)	0.0	13.5	4.24	2.16
K6 (Social Responsibility)	0.0	13.0	3.76	2.28
K7 (Environmental Responsibility)	0.0	12.5	2.97	2.03
K8 (Creativity)	0.0	13.0	4.01	2.05
Total Professional Competence Score	1.25	37.25	13.56	5.71
K_F (Functional Competence)	0.25	12.75	5.48	2.19
K_P (Processual Competence)	0.00	13.50	4.42	2.08
K_G (Holistic Shaping Competence)	0.33	11.83	3.66	1.93

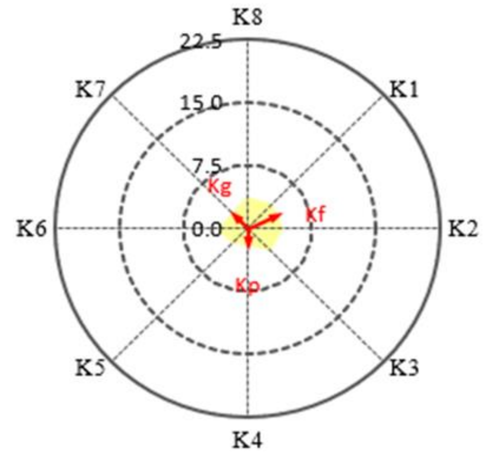


Total Professional Competence Mean = 13.56; n = 199

Table 5.8 (with Graph) illustrates the combined competence profile means scores of Electrical Engineering TVET Students in the Baseline Test (mean scores). The table reflects the mean scores for the eight COMET criteria, as well as the Functional, Processual and Holistic Shaping competence performance for the occupation Electrical Engineering. As illustrated in the above competence profile radar graph, the baseline test results show a weak competence profile for participants that leans heavily towards functionality (K1and K2). The table also illustrates that K1 which at the “know that” level scored the highest with the mean value of 5.71. K7-Environmental Responsibility competence is the lowest, with a mean value of 2.97. The worst performance is reported for K7 –Environmental compatibility. K8 – creativity has mean value is at 4.01 this is a rather surprising finding considering that it is ranking a little bit higher than K4-cost effectiveness and K6 – social responsibility. All TVET students performed at a low,’ know that’ work process knowledge level in the baseline COMET Test Tasks. They therefore only have knowledge to guide their responses but lacks understanding, and reflection required for solving complex problems holistically.

Table 5.9 (with Graph): Competence Profile of Electrical Engineering TVET Students of TVET College A in the Baseline Test (mean scores)

	Mean	Standard Deviation
K1 (Clarity/Presentation)	4.05	1.82
K2 (Functionality)	4.28	2.27
K3 (Use value)	3.65	2.48
K4 (Cost Effectiveness)	2.13	2.25
K5 (Business /Work Process)	2.55	2.19
K6 (Social Responsibility)	3.55	2.03
K7 (Environmental Responsibility)	2.50	2.33
K8 (Creativity)	3.80	1.81
Total Professional Competence Score	9.80	5.03
KF (Functional Competence)	4.16	1.97
KP (Processual Competence)	2.78	2.05
KG (Holistic Shaping Competence)	2.87	1.81

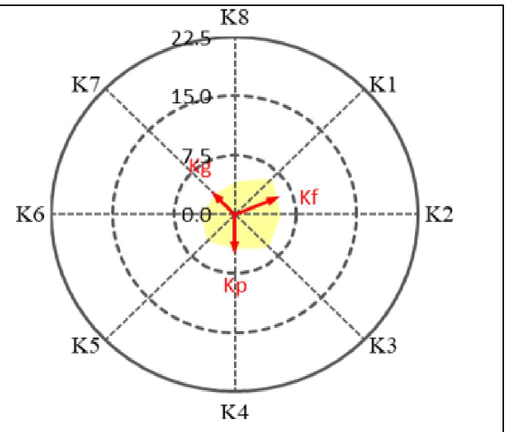


Total Professional Competence
Mean = 9.80; n = 20

Table 5.9 (with Graph) reports the combined competence profile mean scores of Electrical Engineering TVET Students at TVET College A for the Baseline Test (mean scores). The average profile of the participants at site A leans heavily towards functionality (K1 and K2), which is consistent with the overall results of the baseline assessment. The average score of site A is 9.8 which shows a very weak profile compared to the average profile of all participating sites, as it is 3.76 lower than the mean score reported for the total sample. It should, however, be noted that the COMET model is standard referenced, and not criterion referenced. Table 5.9 shows that K2 which at the ‘know that’ level scored the highest with the mean value of 4.28. This implies that students responded to the task, while relying only on basic technical knowledge, which leads to technical-instrumental skills. The total group of students at TVET College A scored lowest for the K4- Cost Effectiveness COMET criteria, with a mean value of 2.13. This means that students at TVET College A are still on the lowest “know that” level of competence in work process knowledge.

Table 5.10 (with Graph): Competence Profile of Electrical Engineering TVET Students of TVET College B in the Baseline Test (mean scores)

	Mean	Standard Deviation
K1 (Clarity/Presentation)	6.36	2.49
K2 (Functionality)	5.61	2.20
K3 (Use value)	5.91	2.08
K4 (Cost Effectiveness)	4.41	2.23
K5 (Business /Work Process)	4.91	1.79
K6 (Social Responsibility)	4.11	1.92
K7 (Environmental Responsibility)	3.44	1.73
K8 (Creativity)	4.13	1.98
Total Professional Competence Score	15.22	5.38
KF (Functional Competence)	5.99	2.28
KP (Processual Competence)	5.08	1.87
KG (Holistic Shaping Competence)	4.15	1.60

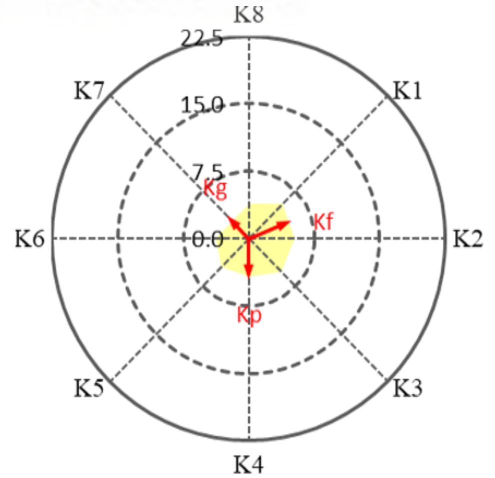


Total Professional Competence
Mean = 15.22; n = 70

Table 5.10 (with Graph) shows the competence profile mean scores of Electrical Engineering TVET Students at TVET College B for the Baseline Test (mean scores). The overall competence profile of site B is not balanced due to the fact that it is leaning more in favour of functionality (K1 and K2), which is consistent with the overall results of the baseline assessment. However, it can be noted that Site B's result is a bit stronger than the overall profile for the study. The average score of site B is 15.22 which is above the overall results reported for all participating sites. Table 5.3 shows that K1 scored the highest with the mean value of 6.36; while students scored lowest for Environmental Responsibility K7, with a mean value of 3.44. The overall competence profile of the students at this test site is leaning closer towards Processual Competence, but work process knowledge remains at "know that" level.

Table 5.11 (with Graph): Competence Profile of Electrical Engineering TVET Students of TVET College C in the Baseline Test (mean scores)

	Mean	Standard Deviation
K1 (Clarity/Presentation)	5.55	2.58
K2 (Functionality)	5.19	2.10
K3 (Use value)	5.23	2.33
K4 (Cost Effectiveness)	4.17	2.56
K5 (Business /Work Process)	4.37	2.42
K6 (Social Responsibility)	3.75	2.25
K7 (Environmental Responsibility)	2.73	1.99
K8 (Creativity)	3.80	2.36
Total Professional Competence Score	13.57	6.16
KF (Functional Competence)	5.37	2.26
KP (Processual Competence)	4.59	2.26
KG (Holistic Shaping Competence)	3.61	2.02

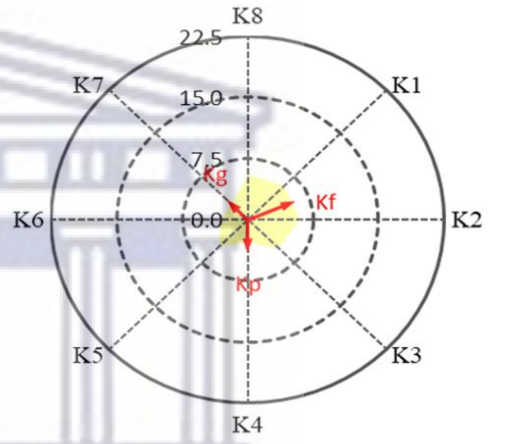


Total Professional Competence
Mean = 13.57; n = 64

Table 5.11 (with Graph) reports the competence profile means scores of Electrical Engineering TVET Students at TVET College C for the Baseline Test (mean scores). The overall competence profile of TVET College C is also not balanced; it is leaning towards functionality (K1 and K2), which is consistent with the overall results of the baseline assessment. The average score of TVET College C is 13.57 which is identical to the overall score of all participating sites. Table 5.11 shows that K1 scored the highest with the mean value of 5.55, while K7- is the lowest with the mean values of 2.73.

Table 5.12 (with Graph): Competence Profile of Electrical Engineering TVET Students of TVET College D in the Baseline Test (mean scores)

	Mean	Standard Deviation
K1 (Clarity/Presentation)	5.83	1.35
K2 (Functionality)	5.88	1.81
K3 (Use value)	4.96	1.03
K4 (Cost Effectiveness)	2.75	1.79
K5 (Business /Work Process)	4.54	0.96
K6 (Social Responsibility)	3.17	2.00
K7 (Environmental Responsibility)	2.63	1.87
K8 (Creativity)	5.46	1.29
Total Professional Competence Score	13.38	1.97
KF (Functional Competence)	5.85	1.54
KP (Processual Competence)	4.08	0.94
KG (Holistic Shaping Competence)	3.44	1.35

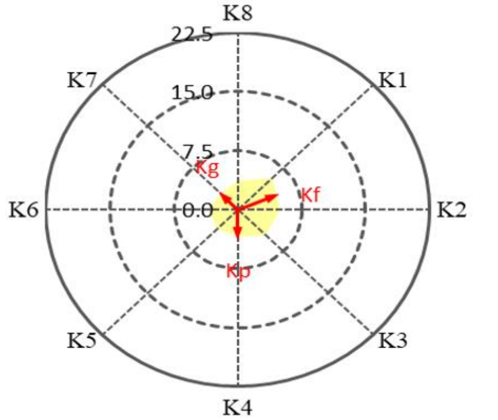


Total Professional Competence
Mean = 13.38; n = 12

Table 5.12 (with Graph) shows the competence profile means scores of Electrical Engineering TVET students at TVET College D for the Baseline Test (mean scores). The overall competence profile of site D is leaning towards functionality (K1 and K2) which is consistent with the overall results of the baseline assessment. It can also be noted that the profile for TVET College B is identical to that of the overall results. The average score of site D is 13.38 which is also identical to that of the overall results of all participating sites. Table 5.12 shows that K2 scored the highest with the mean value of 5.88, while K7- is the lowest with the mean score of 2.63. K8 also scored the third highest in for this site with the score of 5.46.

Table 5.13 (with Graph): Combined Competence Profile of Electrical Engineering TVET Students of TVET College E in the Baseline Test (mean scores)

	Mean	Standard Deviation
K1 (Clarity/Presentation)	5.59	2.30
K2 (Functionality)	5.02	1.95
K3 (Use value)	4.58	1.96
K4 (Cost Effectiveness)	3.47	2.18
K5 (Business /Work Process)	3.47	1.94
K6 (Social Responsibility)	3.38	3.14
K7 (Environmental Responsibility)	2.89	2.46
K8 (Creativity)	3.74	1.75
Total Professional Competence Score	12.39	5.67
K_F (Functional Competence)	5.30	1.90
K_P (Processual Competence)	3.84	1.84
K_G (Holistic Shaping Competence)	3.25	2.40



Total Professional Competence
Mean = 12.39; n = 33

Table 5.13 (with Graph) shows the competence profile means scores of Electrical Engineering TVET Students at TVET College E for the Baseline Test (mean scores). The overall competence profile of site E is leaning towards functionality (K1 and K2) which is consistent with the overall results of the baseline assessment. It can also be noted that the profile for site E is identical to that of the overall results. The average score of site D is 12.39 which is below that of the overall score reported for all participating sites. Table 5.13 shows that K1 scored the highest with the mean value of 5.59, while K7- scored the lowest with a mean value of 2.89.

Summary of Baseline Test Results

TVET students' baseline test results show that the overall competence profile of participating TVET Electrical Engineering students was weak prior to the COMET didactical intervention. It is clear from the evidence above, that TVET College B obtained the highest total professional competence score of 15.22, while TVET College A scored the lowest with a total professional competence score of 9.80.

Table 5.14 (with Graph): Student competence levels in the Baseline Test

Competence Levels	Baseline Test Number of students attaining the competence levels	Percentage of students attaining the competence levels
Nominal competence	134 / 199	67.37%
Functional competence	42 / 199	21.10%
Processual competence	17 / 199	8.42%
Holistic shaping competence	6 / 199	3.01%

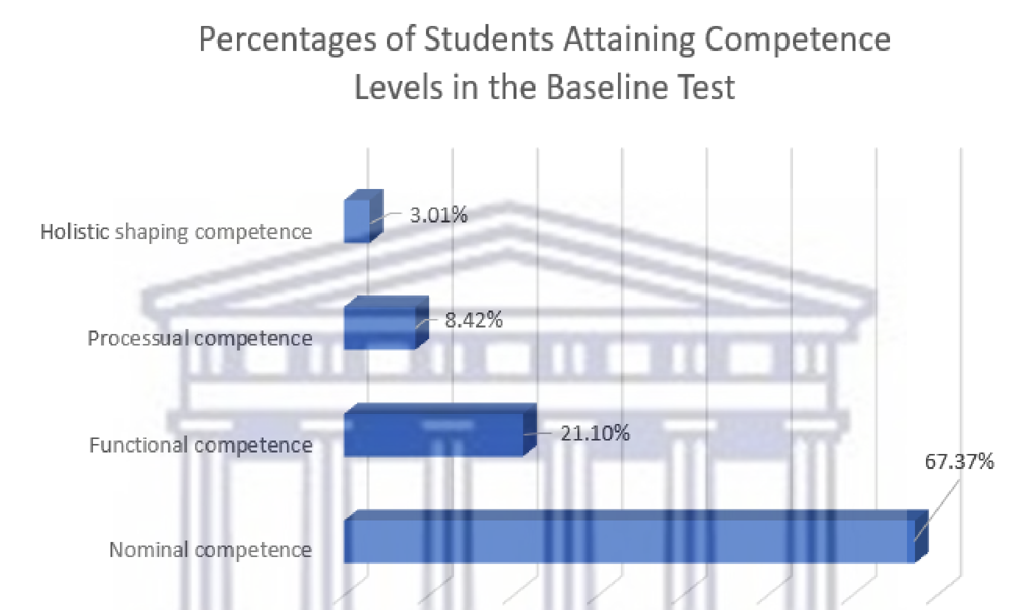
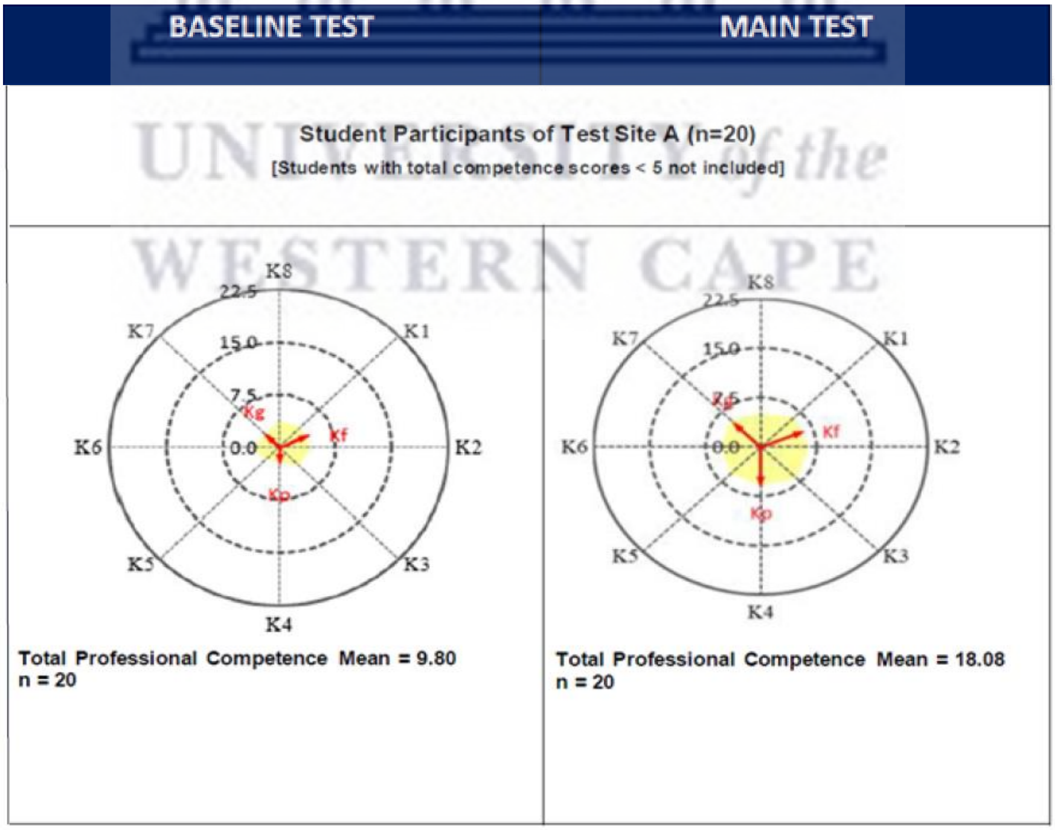


Table 5.14 (with Graph) shows the percentages of students who attained nominal (67.37%), functional (21.1%), processual (8.42%), and holistic shaping (3.01%) competence levels. The competence profile of all the test sites were leaning more towards Functionality, which reflects a level of competence that is characterised by basic technical knowledge that leads to technical-instrumental skills. "Professionalism" is displayed as decontextualized technical knowledge and corresponding skills ("know that").

5.4 Quantitative Research Findings Responding to Sub-question 2: To what extent was the occupational competence of electrical engineering TVET students enhanced through the application of the COMET diagnostic model?

Table 5.15 (with Graph): Comparing the Baseline and Main Test Task Results of The Main Test \ Occupational Competence Profiles of Students at TVET College A (n=20)

	Baseline Mean	Main test Mean
K1 (Clarity/Presentation)	4.05	6.45
K2 (Functionality)	4.28	6.45
K3 (Sustainability\Utility)	3.65	6.83
K4 (Cost Effectiveness)	2.13	5.85
K5 (Business /Work Process)	2.55	5.85
K6 (Social Responsibility)	3.55	5.38
K7 (Environmental Responsibility)	2.50	5.85
K8 (Creativity)	3.80	5.15
Total Professional Competence Score	9.80	18.08
KF (Functional Competence)	4.16	6.45
KP (Processual Competence)	2.78	6.18
KG (Holistic Shaping Competence)	2.87	5.46



This section presents the total professional competence mean scores of the COMET test (post the COMET intervention) and compares it with the mean scores of the baseline test. A breakdown of the results with regards to different test sites, is also included and discussed.

Table 5.15 (on the previous page) shows the competence profile of students in TVET College A. It can be seen from the graph that there was a remarkable improvement in the occupational competence profile at this test site. The occupational competence profile of the students is balanced as illustrated by the radar graph. There was a significant increase is in all eight COMET competence criteria as indicated by the radar graph. Criteria K3 scored the highest with the value of 6.83. The lowest score was 5.15. K3 scored higher than K1 and K2 which falls under functional competence. These findings are interesting since K3 is the second highest level of competence which is processual competence. The Total Professional Competence Score for TVET College A was 18.08, KF (Functional Competence) scored 6.45, KP (Processual Competence) scored 6.18 and KG (Holistic Shaping Competence) scored 5.46. The overall occupational score of TVET College A is 18.08 which is lower than that of the group. It must be noted though that in as much as the students in test site A showed a remarkable improvement, their competence profile remains predominantly at a Nominal Competence level (60%). 30% of respondents functioned at Functional competence with 25% at Processual competence and 5% at Holistic competence. This means that they were still at risk or solving the professional task, by relying only on technical knowledge without tapping into other competence knowledge. This means that even though evidence suggests that there was an improvement after they were exposed to the COMET learning task, their occupational competence did not transfer to other competence levels adequately. One may only speculate that perhaps these students required more learning tasks to become more familiar with the COMET didactics.

Table 5.16 (with Graph): Comparing Competence Levels of Electrical Engineering Students at Test Site A in the Baseline and Main COMET Tests

Competence Levels	BASELINE TEST		MAIN TEST		Overall Increase in the % of Students Attaining the Competence Levels
	Number of students attaining the competence levels (n)	Percentage (Freq %)	Number of students attaining the competence levels (n)	Percentage (Freq %)	
Nominal competence	16 / 20	80%	12 / 20	60%	**Reduced from 80% to 60% = 20%**
Functional competence	2 / 20	10%	6 / 20	30%	**Increased 10% to 30% = 20%**
Processual competence	1 / 20	5%	5 / 20	25%	**Increased from 5% to 25% = 20%**
Holistic shaping competence	0 / 20	0%	1 / 20	5%	**Increased from 0% to 5% = 5%**

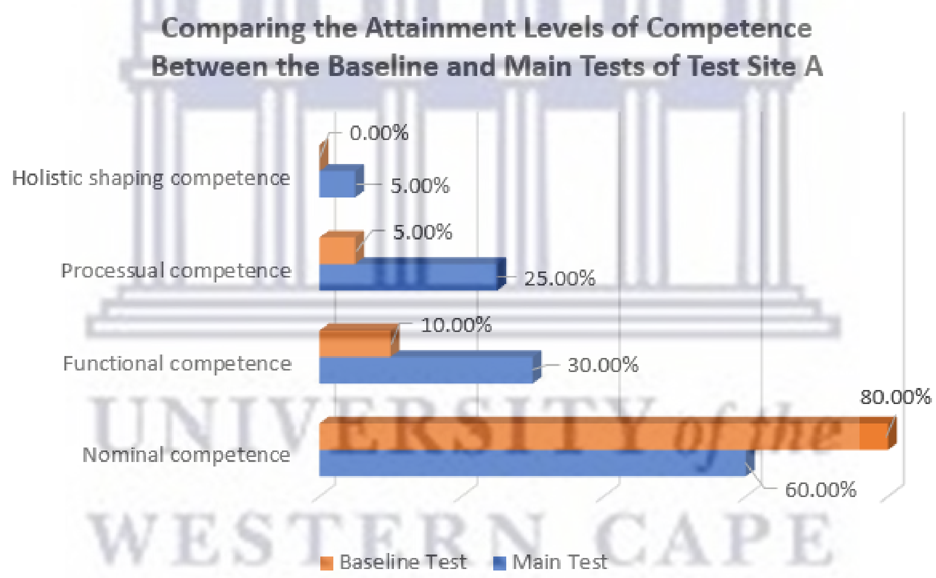


Table 5.16 compares the baseline and main test competence levels of TVET Electrical Engineering students at test site A. On average, there was a 20% reduction from the baseline to the main tests with regard to students who scored on a nominal competence level. The COMET model's didactical application enhanced the occupational competence levels of students at test site A, with a 20% increase in functional competence, 20% increase in processual competence, and 5% increase in holistic shaping competence. Inferential statistics, however, found no practically significant difference between the competence development of students at the five test sites.

Table 5.17 (with Graphs): Occupational Competence Profiles of TVET College B (n=70)

	Baseline Mean	Main test Mean
K1 (Clarity/Presentation)	6.36	6.78
K2 (Functionality)	5.61	6.28
K3 (Sustainability\Utility)	5.91	6.25
K4 (Cost Effectiveness)	4.41	4.75
K5 (Business /Work Process)	4.91	5.37
K6 (Social Responsibility)	4.11	5.02
K7 (Environmental Responsibility)	3.44	5.06
K8 (Creativity)	4.13	5.29
Total Professional Competence Score	15.22	17.11
KF (Functional Competence)	5.99	6.53
KP (Processual Competence)	5.08	5.46
KG (Holistic Shaping Competence)	4.15	5.12

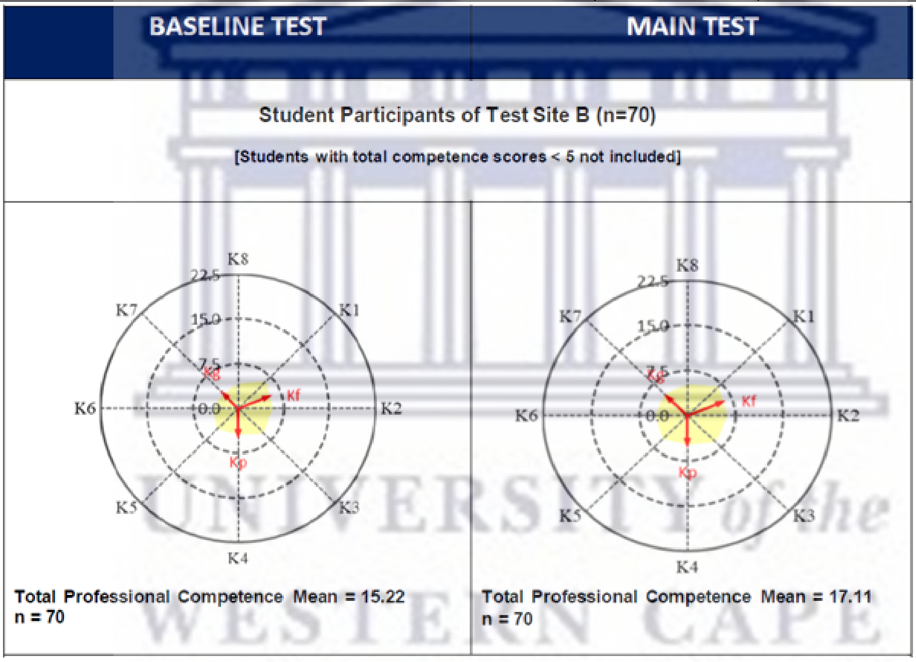


Table 5.17 shows the occupational competence profile of TVET College B. The occupational profile of TVET College B in the main COMET test did not change much, compared to that of the baseline except for Holistic competence levels. It must also be noted that TVET College B had a much stronger profile in the baseline test compared to other test sites. In contrast to other test sites, TVET College B was the least improved site in terms of overall test scores. However, there was no significant change after the intervention as can be noted by the radar graph. In TVET College A criteria K3 score the highest with the value of 6.83. The lowest score was 5.17. K3 score higher than K1 and K2 which falls under functional competence. These findings are interesting due to the fact that K3 is situated at the second highest level

of competence which is processual competence. The Total Professional Competence Score for TVET College A was 18.08, KF (Functional Competence) scored 40%, KP (Processual Competence) scored 17.14% and KG (Holistic Shaping Competence) scored 10%. 71.14% remained at risk (Nominal competence level).

Table 5.18 (with Graph): Comparing Competence Levels of Electrical Engineering Students at Test Site B in the Baseline and Main COMET Tests

	BASELINE TEST		MAIN TEST		
Competence Levels	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Overall Increase in the % of Students Attaining the Competence Levels**
Nominal competence	59 / 70	84.59%	54 / 70	71.14%	**Reduced from 84.59% to 71.14% = 13.45%**
Functional competence	22 / 70	31.43%	28 / 70	40%	**Increased 31.43% to 40% = 8.53%**
Processual competence	10 / 70	14.23%	12 / 70	17.14%	**Increased from 14.23% to 17.14% = 2.91%**
Holistic shaping competence	1 / 70	1.43%	7 / 70	10%	**Increased from 1.43% to 10% = 8.57%**

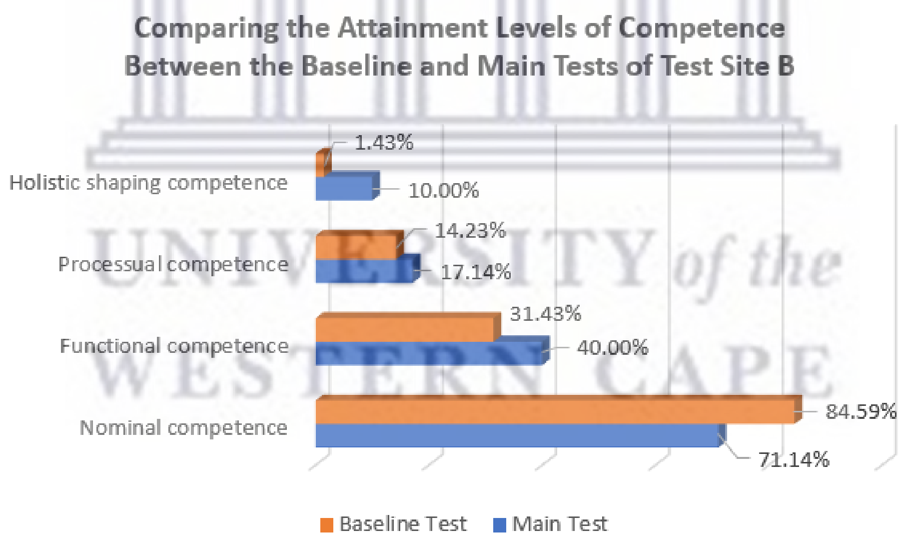


Table 5.18 compares the baseline and main test competence levels of TVET Electrical Engineering students at test site B. On average, there was a 13.45% reduction from the baseline to the main tests with regard to students who scored on a nominal competence level. The COMET model's didactical application enhanced the occupational competence levels of students at test site B with 8.53% increase in functional competence, 2.91% increase in processual competence, and 8.57% increase in holistic shaping competence. Inferential

statistics, however, found no practically significant difference between the competence development of students at the five test sites. Because no practically significant differences were found between the competence scores of the various test sites these inferential statistical results were omitted from this report. Scientific evidence for the COMET model's didactical enhancement of TVET Electrical Engineering students' occupational competence was calculated by means of inferential statistics (effect sizes), which findings are reported in Table 5.29.

Table 5.19 (with Graphs): Occupational Competence Profiles of TVET College C (n=64)

	Baseline Mean	Main Test Mean
K1 (Clarity/Presentation)	5.55	9.28
K2 (Functionality)	5.19	8.55
K3 (Sustainability\Utility)	5.23	8.01
K4 (Cost Effectiveness)	4.17	7.04
K5 (Business /Work Process)	4.37	6.91
K6 (Social Responsibility)	3.75	5.98
K7 (Environmental Responsibility)	2.73	5.79
K8 (Creativity)	3.80	6.72
Total Professional Competence Score	13.57	22.40
KF (Functional Competence)	5.37	8.92
KP (Processual Competence)	4.59	7.32
KG (Holistic Shaping Competence)	3.61	6.16

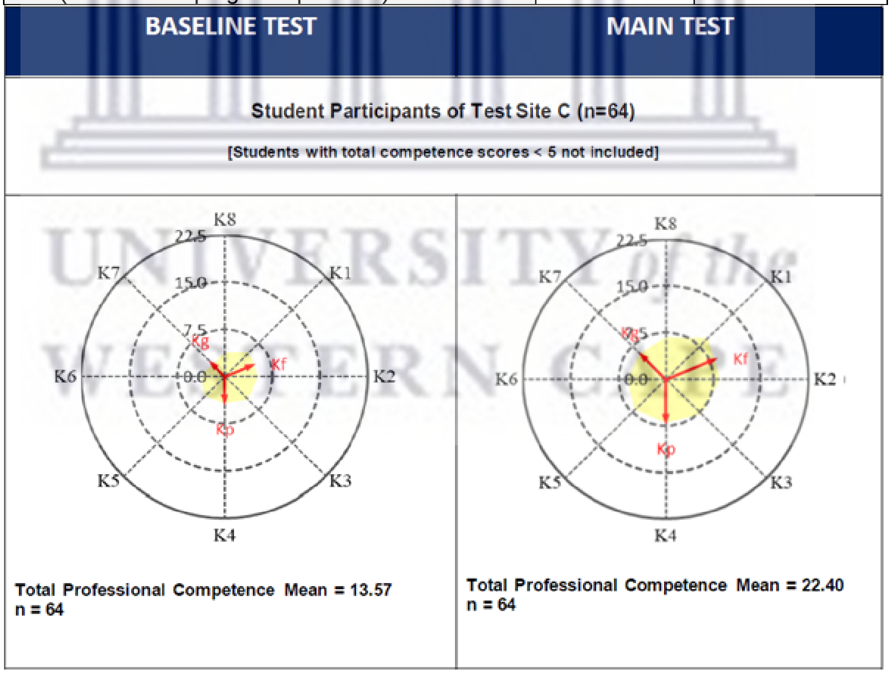


Table 5.19 shows the occupational competence profile of TVET College C. The occupational competence profile of students at TVET College C, as measured in the main COMET test, shows the strongest improvement compared to all the test sites. Students at this test site showed good progress but still mostly in the "know that" level of Work Process Knowledge. The overall student competence profiles lean slightly toward the "know how" level as illustrated

by the radar graphs above. All-other test sites did not reach this level of competence. The table above also illustrates that there was improvement in all eight COMET criteria. In TVET College C criteria K1 score the highest with the value of 9.28, the lowest score was recorded for K7 at 5.79. The overall occupational score increased significantly, almost doubling from 13.5 to 22.40. These findings reflect that the students at test site C's occupational competence developed to the next competence level in the main COMET test. This improvement happened after their exposure to the COMET learning task. These findings are interesting because K3 is situated at the second highest level of competence which is processual competence. The Total Professional Competence Score for TVET College B was 18.08, KF (Functional Competence) scored 6.45, KP (Processual Competence) scored 6.18 and KG (Holistic Shaping Competence) scored 5.46. TVET College B was the site that least improved, in terms of overall test scores. However, a notable improvement in scores at all competence levels were shown after the students were exposed to the COMET baseline tasks.

Table 5.20 (on the next page) compares the baseline and main test competence levels of TVET Electrical Engineering students at test site C. On average, there was a 42.48% reduction from the baseline to the main tests with regard to students who scored on a nominal competence level. The COMET model's didactical application enhanced the occupational competence levels of students at test site C with 64.05% increase in functional competence, 34.37% increase in processual competence, and 29.69% increase in holistic shaping competence. Inferential statistics, however, found no practically significant difference between the competence development of students at the five test sites. Accordingly, no further comparison or deductions was required with regard to the competence development of students at the five TVET colleges, as no practically significant differences existed in the results obtained from these colleges. Scientific evidence for the COMET model's didactical enhancement of TVET Electrical Engineering students' occupational competence was calculated by means of inferential statistics (effect sizes), which findings are reported in Table 5.29.

Table 5.20 (with Graph): Comparing Competence Levels of Electrical Engineering Students at Test Site C in the Baseline and Main COMET Tests

	BASELINE TEST		MAIN TEST		
Competence Levels	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Overall Increase in the % of Students Attaining the Competence Levels**
Nominal competence	58 / 64	90.62%	31 / 64	48.44%	**Reduced from 90.62% to 48.44% = 42.48%**
Functional competence	10 / 64	15.63%	51 / 64	79.68%	**Increased from 15.63% to 79.68% = 64.05%**
Processual competence	5 / 64	7.81%	27 / 64	42.18%	**Increased from 7.81% to 42.18% = 34.37%**
Holistic shaping competence	3 / 64	4.69%	22 / 64	34.38%	**Increased from 4.69% to 34.38% = 29.69%**

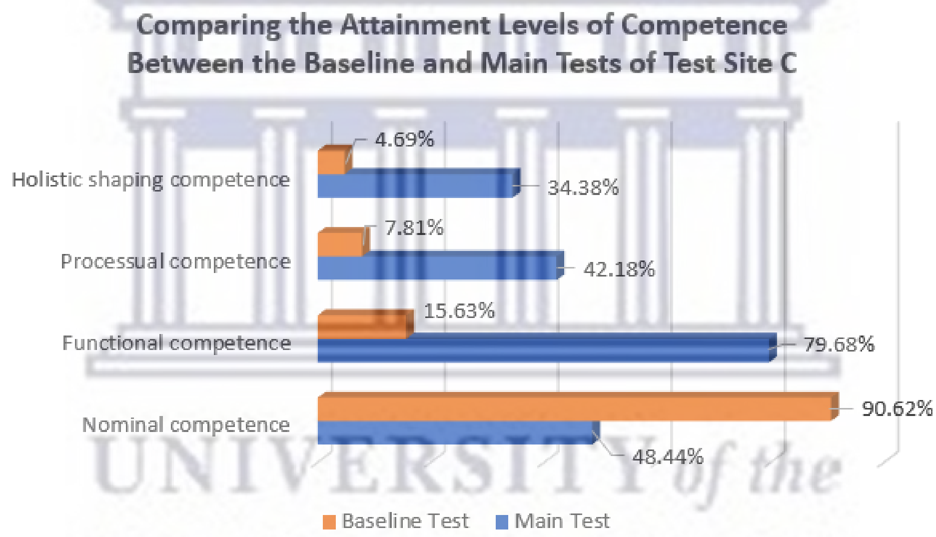


Table 5.21 (with Graphs): Occupational Competence Profiles of TVET College D (n=12)

	Baseline mean	Main test Mean
K1 (Clarity/Presentation)	5.83	7.17
K2 (Functionality)	5.88	7.29
K3 (Sustainability\Utility)	4.96	7.50
K4 (Cost Effectiveness)	2.75	6.67
K5 (Business /Work Process)	4.54	7.50
K6 (Social Responsibility)	3.17	7.50
K7 (Environmental Responsibility)	2.63	6.29
K8 (Creativity)	5.46	6.21
Total Professional Competence Score	13.38	21.12
KF (Functional Competence)	5.85	7.23
KP (Processual Competence)	4.08	7.22
KG (Holistic Shaping Competence)	3.44	6.67

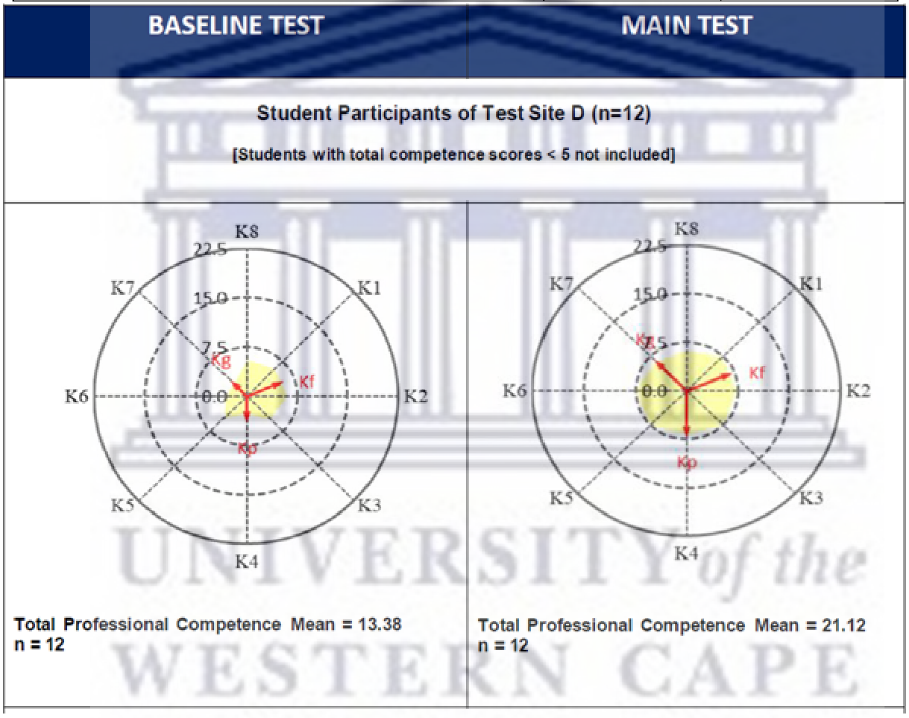


Table 5.21 shows the occupational competence profile of TVET College D. The occupational competence profile of TVET College D is also strong and balanced in the main COMET test. It can be seen from the profile that the students at this TVET College responded to the test task by reaching processual occupational competence and moving closer to holistic shaping competence. There was also a significant improvement in the profile of the students at this test site. In TVET College A, criteria K3 scored the highest with the value of 7.50. The lowest score was K8 6.21. The total occupational score improved from 13.38 to 21.12 which is a significant improvement. However, it must be noted that they were responding to the task at the “know that” level. This suggests that these students answered to the main COMET test

task with fundamental technical knowledge, even after the didactic application of the COMET learning tasks, without necessarily demonstrating how the problem might be solved.

Table 5.22 (with Graph): Comparing Competence Levels of Electrical Engineering Students at Test Site D in the Baseline and Main COMET Tests

	BASELINE TEST		MAIN TEST		
Competence Levels	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Overall Increase in the % of Students Attaining the Competence Levels**
Nominal competence	10 / 12	83.33%	8 / 12	66.67%	**Reduced from 83.33% to 66.67% = 16.66%**
Functional competence	2 / 12	16.67%	3 / 12	25%	**Increased 16.67% to 25% = 8.3%**
Processual competence	0 / 12	0%	5 / 12	41.67%	**Increased from 0% to 41.67% = 41.67%**
Holistic shaping competence	0 / 12	0%	5 / 12	41.67%	**Increased from 0% to 41.67% = 41.67%**

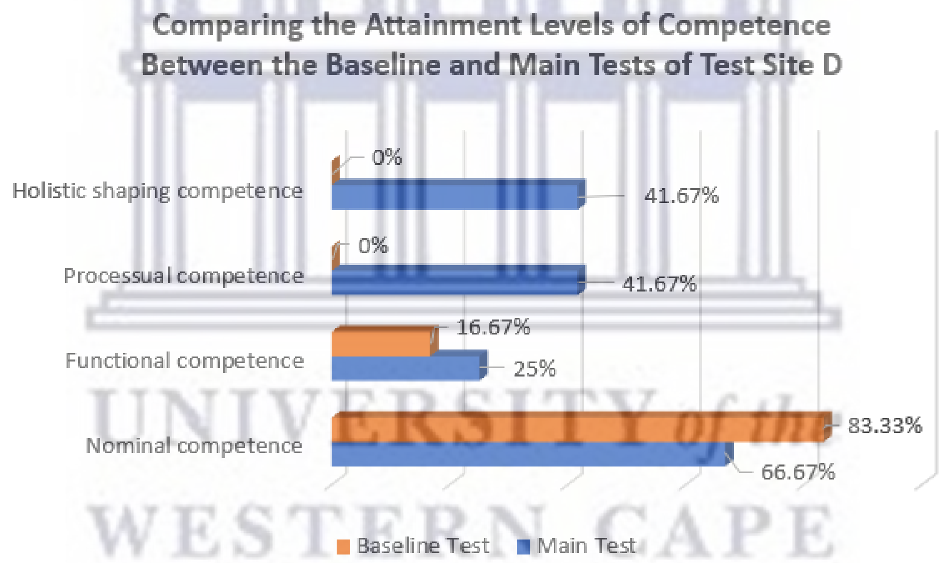


Table 5.22 compares the baseline and main test competence levels of TVET Electrical Engineering students at test site D. On average, there was a 16.66% reduction from the baseline to the main tests with regard to students who scored on a nominal competence level. The COMET model's didactical application enhanced the occupational competence levels of students at test site D with 8.3% increase in functional competence, 41.67% increase in processual competence, and 41.67% increase in holistic shaping competence. Inferential statistics, however, found no practically significant difference between the competence development of students at the five test sites. Accordingly, no further comparison or deductions were required with regard to the competence development of students at the five

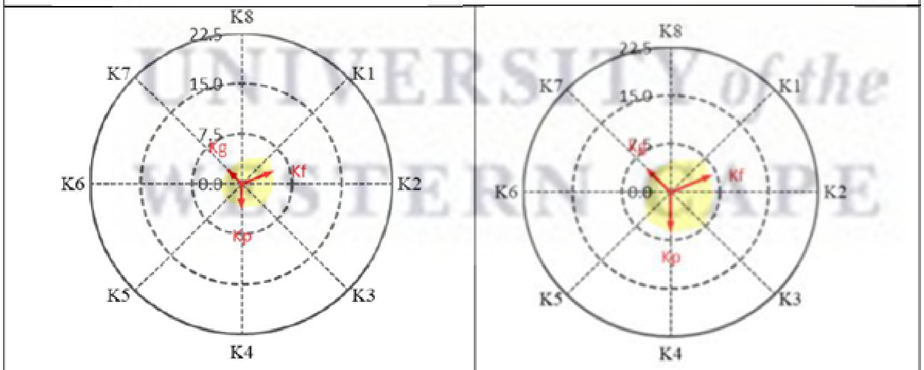
TVET colleges, as no practically significant differences existed between the results obtained from these colleges.   Scientific evidence for the COMET model's didactical enhancement of TVET Electrical Engineering students' occupational competence was calculated by means of inferential statistics (effect sizes), which findings are reported in Table 5.29.

Table 5.23 (with Graphs): Occupational Competence Profiles of TVET College E (n=33)

	Baseline test mean	Main test Mean
K1 (Clarity/Presentation)	5.59	7.29
K2 (Functionality)	5.02	6.64
K3 (Sustainability\Utility)	4.58	6.45
K4 (Cost Effectiveness)	3.47	6.33
K5 (Business /Work Process)	3.47	5.74
K6 (Social Responsibility)	3.38	3.79
K7 (Environmental Responsibility)	2.89	4.18
K8 (Creativity)	3.74	4.89
Total Professional Competence Score	12.39	17.43
KF (Functional Competence)	5.30	6.96
KP (Processual Competence)	3.84	6.18
KG (Holistic Shaping Competence)	3.25	5.45

BASELINE TEST	MAIN TEST

Student Participants of Test Site E (n=33)
[Students with total competence scores < 5 not included]



Total Professional Competence Mean = 12.39 n = 33	Total Professional Competence Mean = 17.43 n = 33

Table 5.23 shows the occupational competence profile of TVET College E. The occupational competence profile of TVET College E was the weakest in the main COMET test. The students' profile was still leaning towards the functional competence even after the students were exposed to the two COMET learning tasks. In TVET College E criteria K1 scored the highest with the value of 7.59. The lowest score was K6 3.79. The total occupational score improved from 12.39 to 17.43

which is a significant improvement. It can be seen from the competence profile that students in this TVET College responded to the test task at functional competence even though their profile was approaching processual competence. However, it should be noted that after the didactic application of the COMET learning activities, this test site showed the least improvement. It was deduced that the two learning tasks students completed for this test were insufficient for them to advance to the next competence levels.

Table 5.24 (with Graph): Comparing Competence Levels of Electrical Engineering Students at Test Site E in the Baseline and Main COMET Tests

	BASELINE TEST		MAIN TEST		
Competence Levels	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Number of students attaining the competence levels (n)**	**Percentage (Freq %)**	**Overall Increase in the % of Students Attaining the Competence Levels**
Nominal competence	31 / 33	93.94%	25 / 33	75.76%	**Reduced from 93.94% to 75.76% = 18.18%**
Functional competence	4 / 33	12.12%	15 / 33	45.45%	**Increased 12.12% to 45.45% = 33.33%**
Processual competence	2 / 33	6.06%	6 / 33	18.18%	**Increased from 6.06% to 18.18% = 12.12%**
Holistic shaping competence	1 / 33	3.03%	3 / 33	9.09%	**Increased from 3.03% to 9.09% = 6.06%**

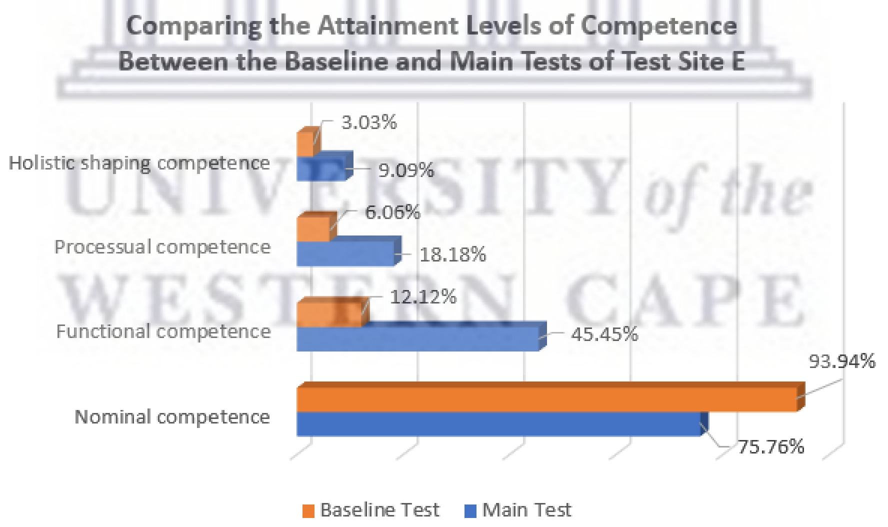
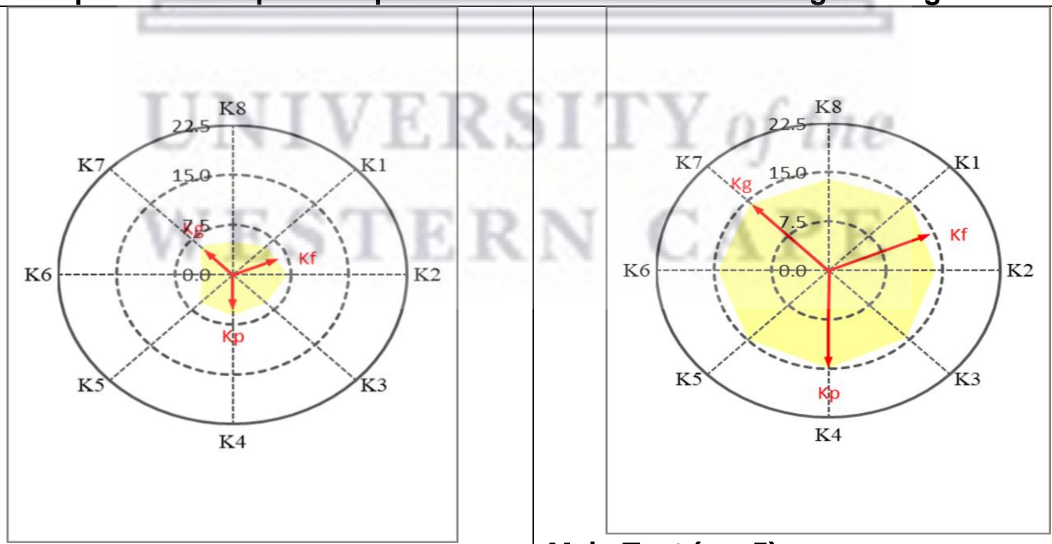


Table 24 compares the baseline and main test competence levels of TVET Electrical Engineering students at test site E. On average, there was a 18.18% reduction from the baseline to the main tests with regard to students who scored on a nominal competence level. The COMET model's didactical application enhanced the occupational competence levels of students at test site E with 33.33% increase in functional competence, 12.12% increase in processual competence, and 6.06% increase in holistic shaping competence. Inferential statistics, however, found no practically significant difference between the competence development of students at the five test sites. Accordingly, no further comparison or deductions were required with regard to the competence development of students at the five TVET colleges, as no practically significant differences existed between the results obtained from these colleges. Scientific evidence for the COMET model's didactical enhancement of TVET Electrical Engineering students' occupational competence was calculated by means of inferential statistics (effect sizes), which findings are reported in Table 5.29.

Table 5.25: Comparing average baseline scores and main test for the top 5 students who showed improvement

	Baseline Mean	Mean Main test	Mean increasement
K1 (Clarity/Presentation)	5.8	14.8	9
K2 (Functionality)	5.5	14.5	9
K3 (Sustainability\Utility)	5	13.9	9.4
K4 (Cost Effectiveness)	4	13.4	9.4
K5 (Business /Work Process)	4	12.8	8.8
K6 (Social Responsibility)	4	11.8	7.2
K7 (Environmental Responsibility)	2.3	11.2	8.9
K8 (Creativity)	2.3	12.7	10.4
Total Professional Competence Score	13.2	40.0	26.8
KF (Functional Competence)	4.6	14.7	10.1
KP (Processual Competence)	5	13.4	8.4
KG (Holistic Shaping Competence)	3.6	11.9	8.3

Occupational competence profile "of Best" 5 Electrical Engineering students



Baseline test (n = 5)
Average total score = 13.148

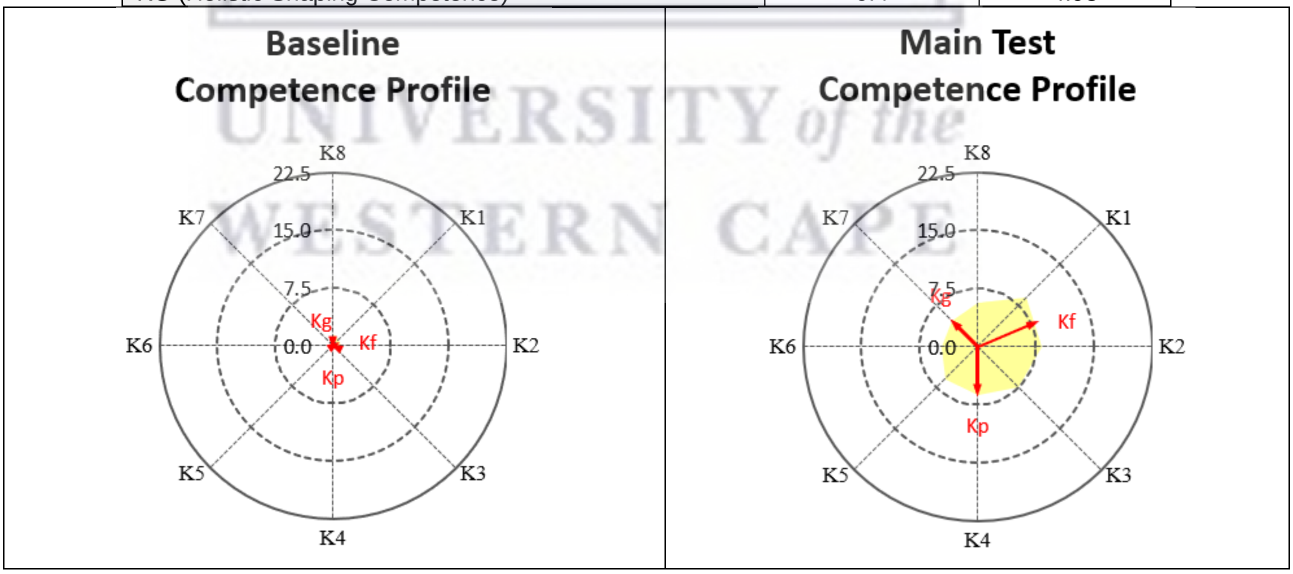
Main Test (n = 5)
Average total score = 39.918

When one compares the baseline and main test mean scores for the top 5 students who showed improvement (Table 5.25 above), their total professional competence mean scores increased by 26.8 from 13.2 for baseline test to 40.0 for the main COMET test , while the K8 (creativity) was the

COMET criteria with the biggest increase of 10.4, and K1 (clarity/presentation) had the lowest increase of 9 mean score .Their baseline profile was initially weak, leaning towards functionality, however, after the COMET intervention, their competence profile increased, and holistically responded to all levels of competence. It can be suggested that these students benefited from the two COMET learning tasks, given the magnitude of development in their competence profile. For these students, one could speculate that the COMET learning tasks were sufficient to improve their competence development, and perhaps with the completion of more learning tasks, they could have easily reached the holistic shaping competence level.

Table 5.26 (with Graph): Total Professional Competence Profiles of the n = 39 Students, who scored < 5 in the baseline test, and whose scores were excluded from the main sample

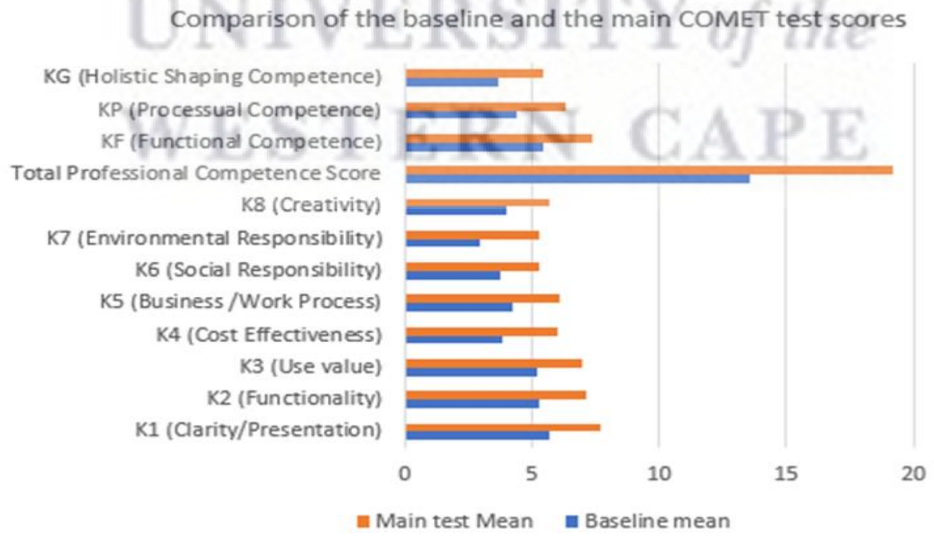
	Baseline (Means)	Main test (Means)
K1 (Clarity/Presentation)	1.05	8.93
K2 (Functionality)	1.04	8.22
K3 (Sustainability\Utility)	0.54	7.41
K4 (Cost Effectiveness)	0.31	6.32
K5 (Business /Work Process)	0.57	5.88
K6 (Social Responsibility)	0.39	4.66
K7 (Environmental Responsibility)	0.26	4.57
K8 (Creativity)	1.42	5.72
Total Professional Competence Score	1.93	20.1
KF (Functional Competence)	1.05	8.6
KP (Processual Competence)	0.49	6.5
KG (Holistic Shaping Competence)	0.4	4.98



The COMET diagnostic model typically discards the data obtained from students whose baseline scores are on a nominal non-competence level (< 5), from being analysed and reported. The findings of the current investigation, however, clearly show that the mean total professional competence score (1.93) of the 39 students, who all scored < 5 in the baseline test, increased with 18.17 to a mean total competence score of 20.1 for the main test. This increase in competence development is larger than the increase in competence development of the main study sample (N=199). The radar graphs in Table 5.26 (on the previous page) clearly show a significant increase in the competence profile of this group of n=39 students whose competence developed from nominal competence (i.e., Superficial conceptual knowledge that does not guide activity; the meaning of the professional terms remains at the level of colloquial language) to a Functional Competence level (i.e., Basic technical knowledge leads to technical-instrumental skills. "Professionalism" is displayed as decontextualised technical knowledge and corresponding skills ("know that").

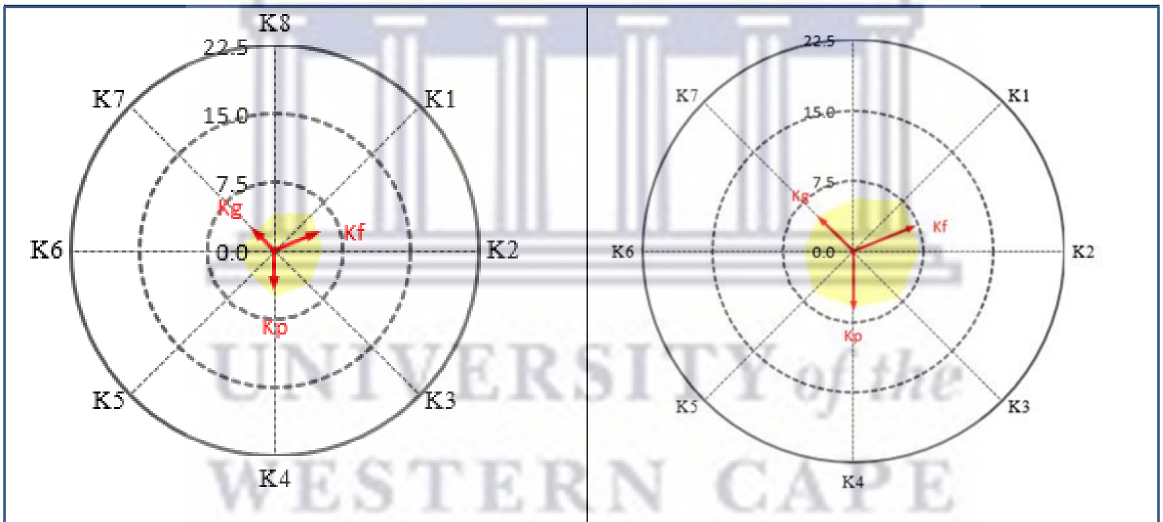
Table 5.27 (with Graph): Comparing the total professional occupational competence baseline and main test mean scores of participating Electrical Engineering TVET students

	Min	Max	Baseline mean	Main test Mean	Standard Deviation
K1 (Clarity/Presentation)	1.0	15.0	5.71	7.66	2.54
K2 (Functionality)	0.5	15.0	5.26	7.15	2.50
K3 (Sustainability\Utility)	0.5	15.0	5.18	6.98	2.42
K4 (Cost Effectiveness)	0.0	15.0	3.85	5.98	2.64
K5 (Business /Work Process)	0.0	15.0	4.24	6.10	2.53
K6 (Social Responsibility)	0.0	15.0	3.76	5.31	2.80
K7 (Environmental Responsibility)	0.0	14.5	2.97	5.30	2.67
K8 (Creativity)	0.0	14.5	4.01	5.72	2.54
Total Professional Competence Score	3.08	43.66	13.56	19.2	6.68
KF (Functional Competence)	1.75	15.00	5.48	7.40	2.42
KP (Processual Competence)	0.66	14.83	4.42	6.35	2.33
KG (Holistic Shaping Competence)	0.50	14.33	3.66	5.45	2.45



In Table 5.27 (with Graph), the total sample's (N=199) professional occupational competence baseline and main test mean scores are compared. As reflected in Table 5.27, there was an overall improvement in all the competence criteria of participating students, between the baseline and main COMET tests. It can be seen from the graph that even though the spread of this is a little better, the profile is still leaning heavily towards functional competence. However, it must be noted that there is a remarkable improvement in the profile scores obtained for processual competence (K3 and K4). An average improvement of 5.64 was found between the total professional occupational scores that participants obtained for the baseline test (mean score = 13.56) and the main COMET test (mean score = 19.2). Considering the brief interval of one day to two weeks between the assessments of participants' baseline and main test solutions, it was inferred that the COMET intervention was responsible for the observed increase in participants' competence profiles. Besides the reported descriptive statistical findings above, inferential statistical analyses were also conducted to determine the didactical enhancement of Electrical Engineering TVET students' occupational competence and were measured through effect sizes (see Table 5.29).

Radar Graphs 5.1: Comparing the COMET Competence Profiles of Participating TVET students in the Baseline and Main COMET tests



Baseline Test (n=199)
Total Professional Competence Mean Score = 13.56

Main Test (n=199)
Total Professional Competence Mean Score = 19.2

Radar Graph 5.1 visually compares the competence profiles of participating TVET students (N=199) in the COMET Baseline test (pre) and Main test (post). The general occupational competence profile of participating TVET students clearly improved from a competence profile that was initially weak, to a strong competence profile, due to the COMET learning tasks intervention. The total professional competence profile mean scores increased from an initial baseline test score of 13.56 to 19.2 measured for the main COMET test, which represents an overall improvement of 5.64 (41.59%) in participants' occupational competence mean score.

The empirical findings reported here indicate improvements in all eight COMET criteria, which will be further discussed in Chapter 6 to effectively contribute towards answering the main research question.

Table 5.28 (with Graph): Comparing Competence Levels of Electrical Engineering Students in the Baseline and Main COMET Tests (Total Sample N=199)

	BASELINE TEST		**MAIN TEST**		
Competence Levels	**Number of students attaining the competence levels**	**Percentage of students attaining the competence levels**	**Number of students attaining the competence levels**	**Percentage of students attaining the competence levels**	**Overall Increase in the % of Students Attaining the Competence Levels**
Nominal competence	134 / 199	67.37%	4 / 199	2.01%	**Reduced from 67.37% to 2.01% = 65.36%**
Functional competence	42 / 199	21.10%	102 / 199	51.56%	**Increased 21.1% to 51.56% = 30.46%**
Processual competence	17 / 199	8.42%	55 / 199	27.64%	**Increased from 8.42% to 27.64% = 19.24%**
Holistic shaping competence	6 / 199	3.01%	38 / 199	19.10%	**3.01% to 19.1% = 16.09%**

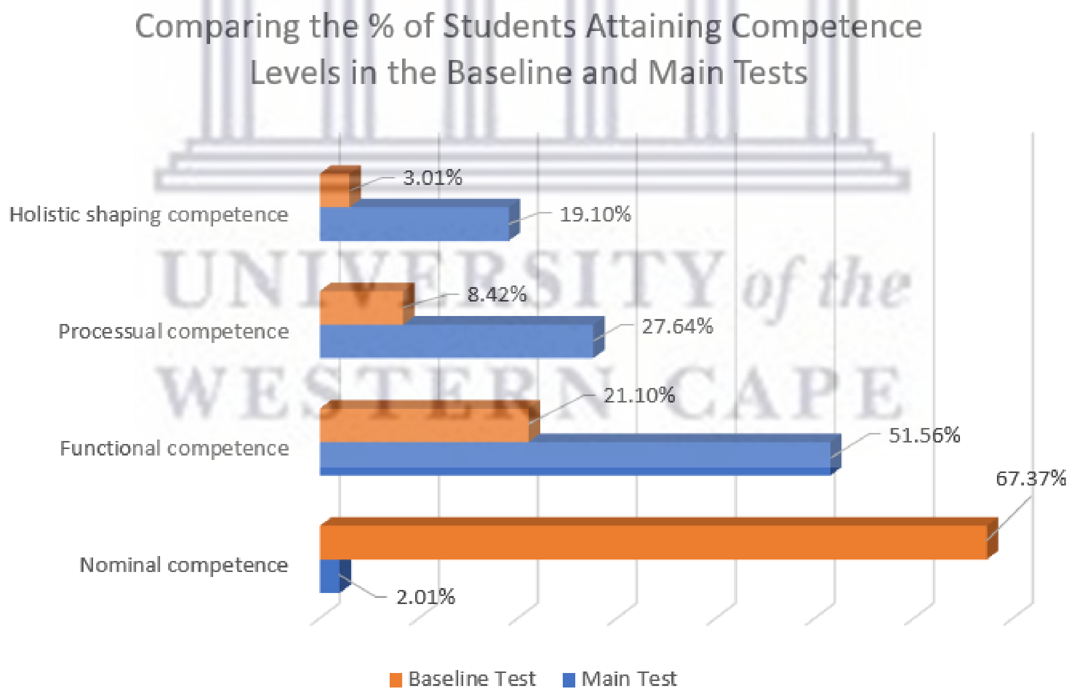


Table 5.28 (with Graph) compares the percentages of students who attained the various competence levels in the Baseline and Main COMET tests. The percentages of students who scored competence on a nominal level reduced from 67.37% in the Baseline to 2.01% in the Main tests (65.36% improvement in competence). In the baseline test, 21.1% of students

attained a Functional Competence level, which increased with 51.56% in the main test (30.46% improvement in competence). This means that in the main test, 51.56% of the students at all test sites attained a Functional Competence level, having basic technical knowledge and technical-instrumental skills. Their professionalism is reflected by their decontextualised technical knowledge and corresponding skills (“know that”). In the baseline test, 8.42% of students attained a Processual Competence level, which increased with 19.24% to 27.64% in the main test. This means that in the main test 27.64% of the students at all test sites attained the Processual Competence level to perform professional tasks that are interpreted in the context of company work processes and situations. These students were also able to apply their knowledge (“Know how”) to solve work-related tasks. Furthermore, 3.01% of students in the baseline test attained Holistic Shaping Competence, which then increased by 16.09% to 19.1% in the main test. This means that 19.1% of students in the main test attained a Holistic Shaping Competence level, in which they fully realised the complexity of professional work tasks, and were able to solve the test tasks, while focusing on the divergent demands in the form of intelligent compromises.

Cohen’s effect sizes (d-values) were calculated between the rated scale values for the base-line COMET test, and the rated scale values of the main COMET test, to determine the effect of the COMET Model on enhancing the occupational competence profile of TVET Electrical Engineering students who participated in the current study, which not only makes the difference independent of units and sample size, but also relates it to the spread of the data (Ellis & Steyn, 2003; Steyn, 2000,2002). An effect size $0.3 \leq d < 0.5$ is considered as a small effect size, with none or a small statistically significant effect. An effect size $0.5 \leq d < 0.8$ is considered as a medium effect size, with an effect that tends towards a practically significant difference. An effect size $d \geq 0.8$ is considered as a large effect size that is indicative of a practically significant difference between the rated scores of the base-line COMET test, and the rated scores of the main COMET test, to determine what effects the COMET Model had on the eight COMET criteria, as well as the total professional occupational competence of the participating students.

Table 5.29 (on the page that follows) reports the effect sizes (Cohen’s d values) of the differences calculated between the base-line test scores and the main test scores, for determining the COMET Model’s effective didactic enhancement of Electrical Engineering TVET students’ occupation competence.

Table 5.29: Inferential Statistical Results Pertaining to the COMET Model's Didactic Enhancement (measures by effect sizes) of Electrical Engineering TVET Students' Occupation Competence Scores from the Baseline to the Main COMET Test

Differences Between Base-Line Test Scores & Main Test Scores for the following COMET Scales:	Effect Sizes (d)	Standardizer*	Point Estimate	95% Confidence Interval	
				Lower	Upper
K1 (Clarity/Presentation)	Cohen's d	3.48219	0.7	0.578	0.863
	Hedges' correction	3.48771	0.7	0.577	0.862
K2 (Functionality)	Cohen's d	3.23469	0.7	0.599	0.886
	Hedges' correction	3.23982	0.7	0.598	0.885
K3 (Sustainability\Utility)	Cohen's d	3.32842	0.7	0.580	0.866
	Hedges' correction	3.33370	0.7	0.579	0.864
K4 (Cost Effectiveness)	Cohen's d	3.49507	0.8	0.602	0.889
	Hedges' correction	3.50061	0.7	0.601	0.888
K5 (Business /Work Process)	Cohen's d	3.26822	0.7	0.582	0.867
	Hedges' correction	3.27340	0.7	0.581	0.866
K6 (Social Responsibility)	Cohen's d	3.66066	0.6	0.415	0.688
	Hedges' correction	3.66646	0.6	0.415	0.687
K7 (Environmental Responsibility)	Cohen's d	3.33077	0.8	0.672	0.966
	Hedges' correction	3.33606	0.8	0.671	0.965
K8 (Creativity)	Cohen's d	3.22400	0.6	0.464	0.740
	Hedges' correction	3.22911	0.6	0.463	0.739
KF (Functional Competence)	Cohen's d	3.22071	0.8	0.618	0.907
	Hedges' correction	3.22582	0.8	0.617	0.905
KP (Processual Competence)	Cohen's d	3.17630	0.8	0.630	0.919
	Hedges' correction	3.18133	0.8	0.629	0.918
KG (Holistic Shaping Competence)	Cohen's d	3.08467	0.7	0.580	0.866
	Hedges' correction	3.08956	0.7	0.579	0.864
Total Professional Occupational Competence	Cohen's d	8.74526	0.8	0.670	0.964
	Hedges' correction	8.75913	0.8	0.669	0.962

Notes:
*The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

As indicated in Table 5.29, Cohen effect size values within the range 0.6 ≤ d ≤ 0.7, represent medium effect sizes tending towards practically significant enhancements in competence, are reported for the following COMET criteria: K1 - Clarity/Presentation (d=0.7), K2 – Functionality (d=0.7), K3 - Sustainability\utility (d=0.7), K5 - Business/Work Process (d=0.7), K6 - Social Responsibility (d=0.6), K8 – Creativity (d=0.6), and KG - Holistic Shaping Competence (d=0.7). The 0.7 d-values of five of these COMET scales, are so strongly tending towards practically significant competence enhancement, that these effects could also be regarded as such.

Table 5.30: Relationships between the various Age Groups and Years of Training, and the Eight COMET Criteria, for both Baseline and Main COMET Tests

		BASE-LINE TEST		MAIN TEST	
		Age n=199	Year of Training n=196	Age n=199	Year of Training n=196
K1 (Clarity/Presentation)	Spearman Rank Correlation Coefficient	0.139	**.194****	-0.082	0.105
	Sig. (2-tailed)	0.050	0.006	0.250	0.142
K2 (Functionality)	Spearman Rank Correlation Coefficient	0.089	0.095	-0.061	0.120
	Sig. (2-tailed)	0.213	0.187	0.393	0.095
K3 (Sustainability\Utility)	Spearman Rank Correlation Coefficient	0.125	**.177***	-0.036	0.042
	Sig. (2-tailed)	0.077	0.013	0.613	0.556
K4 (Cost Effectiveness)	Spearman Rank Correlation Coefficient	0.128	**.222****	-0.120	-0.098
	Sig. (2-tailed)	0.073	0.002	0.092	0.172
K5 (Business /Work Process)	Spearman Rank Correlation Coefficient	**.172***	**.241****	-0.031	0.104
	Sig. (2-tailed)	0.015	0.001	0.665	0.147
K6 (Social Responsibility)	Spearman Rank Correlation Coefficient	.149*	0.027	0.057	0.082
	Sig. (2-tailed)	0.036	0.706	0.423	0.254
K7 (Environmental Responsibility)	Spearman Rank Correlation Coefficient	.142*	0.100	0.004	-0.042
	Sig. (2-tailed)	0.045	0.161	0.961	0.563
K8 (Creativity)	Spearman Rank Correlation Coefficient	0.010	0.135	-0.052	0.124
	Sig. (2-tailed)	0.887	0.059	0.470	0.083
PF (Professional Functional Competence)	Spearman Rank Correlation Coefficient	0.122	.143	-0.073	0.127
	Sig. (2-tailed)	0.087	0.046	0.303	0.077
PP (Professional Processual Competence)	Spearman Rank Correlation Coefficient	**.161***	**.234****	-0.071	0.010
	Sig. (2-tailed)	0.023	0.001	0.316	0.893
PG (Professional Holistic Shaping Competence)	Spearman Rank Correlation Coefficient	**.185****	0.128		
	Sig. (2-tailed)	0.009	0.074		
TOTAL PROFESSIONAL COMPETENCE SCORE	Spearman Rank Correlation Coefficient	**.171***	**.193****	-0.050	0.066
	Sig. (2-tailed)	0.016	0.007	0.479	0.359

Spearman's Rank Order Correlation Coefficients / Effect Sizes (R)
R ≤ 0.1 small effect size, indicative of only statistically significant relationship
0.2 ≤ R ≤ 0.4 medium effect size, that tends towards a practically significant relationship
R ≥ 0.5 large effect size, indicative of a practically significant relationship

The COMET Model's didactic enhancement of Electrical Engineering TVET students' occupation competence is clearly reflected by the large Cohen effect size values d=0.8, which are indicative of practically significant enhancements in participants' competence criteria, which are reported for: K4 - Cost Effectiveness, K7- Environmental Responsibility, KF - Functional Competence, and KP - Processual Competence. The overall effectiveness of the COMET model's didactic enhancement of TVET Electrical Engineering students' occupational competence, is scientifically proven by the practically significant enhancement (d = 0.8) in the total professional occupational competence scores of participants. Considering the relatively short time (between 2 days and 2 weeks) between the evaluations that were conducted of participants' baseline and main test solutions, one can deduce that the practically significant improvement in participants' total professional occupational competence rating scores, was mainly the result of students' didactic exposure to the COMET diagnostic model.

Spearman's rank order correlation coefficients (r-values) were calculated to determine to what extent students' competence levels (measured in the baseline and main tests) were being influenced by their respective age groups, as well as their years of training. Table 5.30 (included on the previous page) reports various medium effect size values (**in bold** in the table), calculated with Spearman's rank order correlation coefficients (r-values), which tend towards practically significant relationships between the various age groups and years of training and students baseline test results. In the main test, however, only small Spearman's rank order correlation coefficients (r-values) are reported, indicative of small statistical relationships between participants' age groups and years of training, and their main test results.

From these inferential statistical findings, it can therefore be concluded that prior to students' didactic exposure to the COMET diagnostic mode, their competence levels were to a medium extent, dependant on their age groups and training levels. However, after being exposed to the didactic application of the COMET diagnostic model, the impact of age and training levels played a less significant role on their occupational competence levels. It therefore seems that the initial role that age groups and training levels played in students' competence profiles, were displaced by the COMET model's didactic application that became more significant for their competence development. These findings affirmed that the COMET Didactical Model is domain specific, rather than module specific. In my study COMET Test tasks were developed in the field (domain) of Electrical Engineering with the NCV curriculum in mind, which made it suitable for all NCV levels to respond to at various competence levels. The NCV curricula focus predominantly on functionality and presentation, while this COMET study included more criteria such as business acumen, social aspects, environmental issues, and creativity.

Table 5.31: Cross-tabulation, indicating meaningful relationships (effect sizes) between various variables measured by in the questionnaire items

	Main COMET TEST													Base-Line COMET TEST											
	Age	Year of training	Post-K1	Post-K2	Post-K3	PostK4	Post-K5	Post-K6	Post-K7	Post-K8	TOTAL	Post-KF	KP	Pre-K1	Pre-K2	Pre-K3	Pre-K4	Pre-K5	Pre-K6	Pre-K7	Pre-K8	TOTAL	Pre-KF	Pre-KP	Pre-KG
Age	1.000	.169*	-0.082	-0.061	-0.036	-0.120	-0.031	0.057	0.004	-0.052	-0.050	-0.073	-0.071	0.139	0.089	0.125	0.128	.172*	.149*	.142*	0.010	.171*	0.122	.161*	.185**
Year of training	.169*	1.000	0.105	0.120	0.042	-0.098	0.104	0.082	-0.042	0.124	0.066	0.127	0.010	.194**	0.095	.177*	.222**	.241**	0.027	0.100	0.135	.193**	.143*	.234**	0.128
Post-K1	-0.082	0.105	1.000	.766**	.711**	.596**	.602**	.366**	.402**	.573**	.766**	.942**	.691**	.204**	.143*	0.138	.226**	0.121	0.133	0.075	0.010	.182*	.180*	.183**	0.123
Post-K2	-0.061	0.120	.766**	1.000	.805**	.641**	.719**	.502**	.535**	.629**	.857**	.931**	.788**	.197**	.143*	.168*	.221**	.148*	.169*	0.125	0.132	.215**	.186**	.214**	.166*
Post-K3	-0.036	0.042	.711**	.805**	1.000	.746**	.743**	.605**	.674**	.725**	.901**	.798**	.906**	.173*	.165*	.211**	.233**	0.126	.145*	0.135	0.064	.207**	.177*	.214**	.166*
PostK4	-0.120	-0.098	.596**	.641**	.746**	1.000	.725**	.577**	.581**	.676**	.812**	.646**	.906**	0.057	0.027	0.013	0.113	0.038	0.044	0.053	-0.003	0.067	0.053	0.068	0.055
Post-K5	-0.031	0.104	.602**	.719**	.743**	.725**	1.000	.695**	.666**	.724**	.864**	.689**	.898**	0.127	.141*	0.106	0.104	0.101	0.031	0.006	0.067	0.128	.140*	0.126	0.053
Post-K6	0.057	0.082	.366**	.502**	.605**	.577**	.695**	1.000	.811**	.613**	.765**	.454**	.685**	0.041	0.104	0.094	0.123	0.112	-0.005	0.001	0.024	0.103	0.080	0.127	0.051
Post-K7	0.004	-0.042	.402**	.535**	.674**	.581**	.666**	.811**	1.000	.701**	.794**	.486**	.704**	0.047	0.098	0.102	.153*	0.081	0.060	0.054	0.022	0.120	0.087	0.136	0.080
Post-K8	-0.052	0.124	.573**	.629**	.725**	.676**	.724**	.613**	.701**	1.000	.822**	.633**	.775**	.185**	.145*	.159*	.163*	0.103	0.034	0.011	0.051	.156*	.181*	.169*	0.057
Post-TOTAL	-0.050	0.066	.766**	.857**	.901**	.812**	.864**	.765**	.794**	.822**	1.000	.858**	.947**	.163*	.152*	.161*	.228**	.146*	0.116	0.100	0.085	.200**	.170*	.207**	.142*
Post-KF	-0.073	0.127	.942**	.931**	.798**	.646**	.689**	.454**	.486**	.633**	.858**	1.000	.776**	.216**	.152*	.162*	.243**	.139*	.163*	0.106	0.074	.212**	.196**	.212**	.154*
KP	-0.071	0.010	.691**	.788**	.906**	.906**	.898**	.685**	.704**	.775**	.947**	.776**	1.000	0.127	0.115	0.116	.166*	0.103	0.082	0.088	0.058	.148*	0.130	.149*	0.109
Pre-K1	0.139	.194**	.204**	.197**	.173*	0.057	0.127	0.041	0.047	.185**	.163*	.216**	0.127	1.000	.771**	.732**	.609**	.696**	.443**	.443**	.451**	.845**	.952**	.761**	.603**
Pre-K2	0.089	0.095	.143*	.143*	.165*	0.027	.141*	0.104	0.098	.145*	.152*	.152*	0.115	.771**	1.000	.795**	.550**	.613**	.356**	.353**	.499**	.784**	.919**	.721**	.512**
Pre-K3	0.125	.177*	0.138	.168*	.211**	0.013	0.106	0.094	0.102	.159*	.161*	.162*	0.116	.732**	.795**	1.000	.664**	.689**	.525**	.499**	.514**	.846**	.799**	.873**	.662**
Pre-K4	0.128	.222**	.226**	.221**	.233**	0.113	0.104	0.123	.153*	.163*	.228**	.243**	.166*	.609**	.550**	.664**	1.000	.700**	.639**	.614**	.475**	.824**	.617**	.889**	.753**
Pre-K5	.172*	.241**	0.121	.148*	0.126	0.038	0.101	0.112	0.081	0.103	.146*	.139*	0.103	.696**	.613**	.689**	.700**	1.000	.603**	.683**	.529**	.885**	.693**	.878**	.853**
Pre-K6	.149*	0.027	0.133	.169*	.145*	0.044	0.031	-0.005	0.060	0.034	0.116	.163*	0.082	.443**	.356**	.525**	.639**	.603**	1.000	.713**	.454**	.719**	.434**	.675**	.872**
Pre-K7	.142*	0.100	0.075	0.125	0.135	0.053	0.006	0.001	0.054	0.011	0.100	0.106	0.088	.443**	.353**	.499**	.614**	.683**	.713**	1.000	.505**	.717**	.429**	.666**	.900**
Pre-K8	0.010	0.135	0.010	0.132	0.064	-0.003	0.067	0.024	0.022	0.051	0.085	0.074	0.058	.451**	.499**	.514**	.475**	.529**	.454**	.505**	1.000	.602**	.492**	.577**	.552**
Pre-TOTAL	.171*	.193**	.182*	.215**	.207**	0.067	0.128	0.103	0.120	.156*	.200**	.212**	.148*	.845**	.784**	.846**	.824**	.885**	.719**	.717**	.602**	1.000	.868**	.961**	.884**
Pre-KF	0.122	.143*	.180*	.186**	.177*	0.053	.140*	0.080	0.087	.181*	.170*	.196**	0.130	.952**	.919**	.799**	.617**	.693**	.434**	.429**	.492**	.868**	1.000	.786**	.598**
Pre-KP	.161*	.234**	.183**	.214**	.214**	0.068	0.126	0.127	0.136	.169*	.207**	.212**	.149*	.761**	.721**	.873**	.889**	.878**	.675**	.666**	.577**	.961**	.786**	1.000	.845**
Pre-KG	.185**	0.128	0.123	.166*	.166*	0.055	0.053	0.051	0.080	0.057	.142*	.154*	0.109	.603**	.512**	.662**	.753**	.853**	.872**	.900**	.552**	.884**	.598**	.845**	1.000

R ≤ 0.1 small effect size, indicative of only statistically significant relationship / weak association
0.2 ≤ R ≤ 0.4 medium effect size, that tends towards a practically significant relationship / medium association.
R ≥ 0.5 large effect size, indicative of a practically significant relationship / strong association

A cross-tabulation was also conducted in order to measure the strengths of associations between the various variables in the quantitative dataset, for both the baseline and main tests, measured by Spearman's effect sizes (r-values). Large effect size values $r \geq 0.5$, which are indicative of large practically significant relationships / strong associations between the various measuring scales, are coloured green and orange in Table 5.31 on the previous page. Strong associations were found between various constructs of the COMET diagnostic model for the specific sample in this investigation, for example the r = 0.95 (almost perfect correlation in the main test between the K_p scale and the total professional competence score, as well as the strong correlation of r = 0.93 between post K_2 and post K_F, could be of interest for future COMET research.

5.5 Qualitative findings effectively responding to the third research sub-question: *How did TVET lecturers implement and apply the COMET diagnostic model in their classrooms?*

The findings derived from the qualitative thematic data analysis that was conducted on the focus-group interview data of TVET lecturers are reported in this section. Firstly, themes of data pertaining to lecturers' current didactic practices in preparing students for the requirements of the modern-day work, are presented. Furthermore, the way in which lecturers implemented the two learning tasks in their classes, are also explored, and lecturers' experience of the COMET learning task solution space, is outlined. In the last two sub-sections, TVET lecturers share their opinions on the strengths and weaknesses of the didactic use of the COMET diagnostic model within the domain of TVET Electrical Engineering.

5.5.1 TVET lecturers' current didactic practices in preparing students for the requirements of modern-day work.

With regard to TVET lecturers' current didactic practices in preparing students for the requirements of modern-day work, the following themes emerged from the Qualitative Thematic Data Analysis performed on the Interview data of TVET lecturers.

Theme 1: An Imbalance between theory and practical tasks in the Curriculum

TVET lecturers, who participated in the focus-group interviews, pointed out that an imbalance exists between theory and practical tasks within the current TVET Electrical Engineering curriculum. In the words of Participant 2:

> [The] "NCV [programme]… says on paper that students are supposed to have 60%... practical based and 40% theory, but in reality, that's not what is happens on the ground [level], so we have to spend more time with students… [teaching] ... theory, than practical… in certain subjects…"

Theme 2: Students receive none or very little exposure to authentic workplace experience

The lecturer participants explained that their students receive very little to no exposure to authentic workplaces or experiences, which results in students entering the workforce lacking occupational competence and not meeting the expectations and requirements set by industries:

> "The different task practicals… are still relevant… [with relation to] …the work environment. They are still relevant, but not all of them, especially in subjects like Electronics… I feel [that] subjects like Electronics, Workshop Practice… should [include]… more relevant tasks. But that's not exactly what happens and some of the topics in… Electronics are not really relevant [to the work environment]. They [are] either outdated or they are not tackling [relevant skills required for the work environment] … we're not touching any relevant subjects or topics for them to be ready for work environment. That's my take".

Participant 5 agreed by saying:

> "Our curriculum… is lacking behind. Uhm… even our lecturers [are lacking] … we are not getting… exposure… [to] workplace experience… No, [the curriculum] … is not preparing students sufficiently for the modern-day jobs".

Theme 3: Lecturers keep to conventional didactic practices due to the rigid curriculum.

Participant 6 stressed that TVET lecturers are keeping to standard/conventional didactical practices, because the current TVET system is too rigid, and lecturers do not have the flexibility and teaching time to adapt their curriculum, and to make use of other didactic methods to the benefit of their students, by preparing them industry expectations.

> "Sometimes you find out even the syllabus doesn't correspond that much towards what's happening out there [in the industry]. And then… most probably the biggest problem, as we even said earlier when we met the last time, is the System. Because you find out, even though sometimes we try to sneak into the System, but now the way it is built, it doesn't actually allow us to sneak in, in such a way that… you find out most of the time… it forces us to focus mostly on the stuff that doesn't necessarily benefit our students at all. Like mostly, it forces us… now you find out their due dates… that by this time, you must hand in [marks]. By this time this must be done and not work, even though sometimes you feel like you have a way of trying to make sure that you don't necessarily prepare the students for the exams, but you also want to prepare them to be able to survive outside in the [work] environment. But now, it's a matter of the System [that] doesn't actually allow us to use all those methods".

The Policy on Professional Qualifications for Lecturers in Technical and Vocational Education and Training (Department of Higher Education and Training, 2013b, p. 36) states that:

> Professionally qualified lecturers must be knowledgeable about demands that will be made on their students in the workplace and be able to use the subject that they are teaching to help equip their students to meet these demands".

For TVET lecturers to stay abreast of the latest industry demands, and to effectively integrate it into their didactical practices, they need to become life-long students who actively pursue continuous professional development opportunities. However, this is very difficult to attain, as explained by lecturer Participant 5, who stressed that TVET lecturers are lacking occupational skills mainly due to the lack of availability of new skills development opportunities for lecturers said:

> "I'm still having that workplace experience of 20 years ago. I… never had the opportunity to… better my skills…. which is detrimental to the students, because I have to have that".

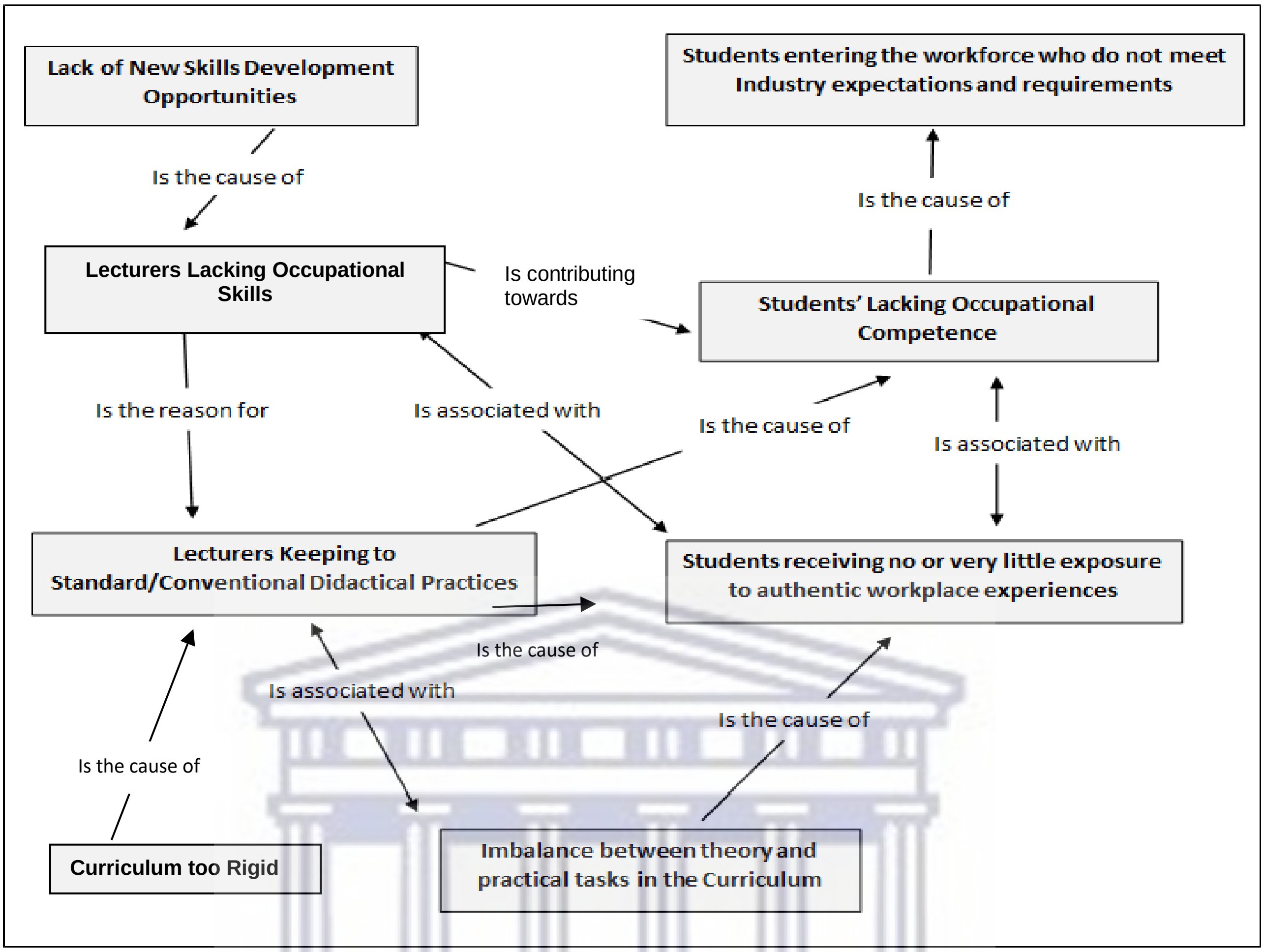


Figure 5.1: TVET lecturers' current didactical practices in preparing students for the requirements of modern-day work.

Figure 5.1 presents the visual network of data themes pertaining to TVET lecturers' current didactical practices in preparing students for the requirements of modern-day work. As illustrated in Figure 5.1, TVET lecturers indicated that they keep to standard/conventional didactic practices because they are lacking in occupational skills, due to the lack of availability of new skills development opportunities for TVET lecturers. Lecturers' use of conventional didactic practices is associated with curriculum that is too rigid, as well as an imbalance between theory and practical tasks in the curriculum, resulting in Electrical Engineering students receiving none or very little exposure to authentic workplace experiences. Furthermore, the use of conventional didactics contributes to students' lack of occupational competence, in addition to the negative effect that lecturers' lack of occupational skills already has on students' acquisition of occupational competence. The sketch of the current TVET didactic practices in Figure 5.1, ultimately results in TVET Electrical Engineering students entering the workforce and not meeting industry expectations and requirements.

5.5.2 TVET lecturers' experiences of implementing and applying the two learning tasks in their Electrical Engineering classes.

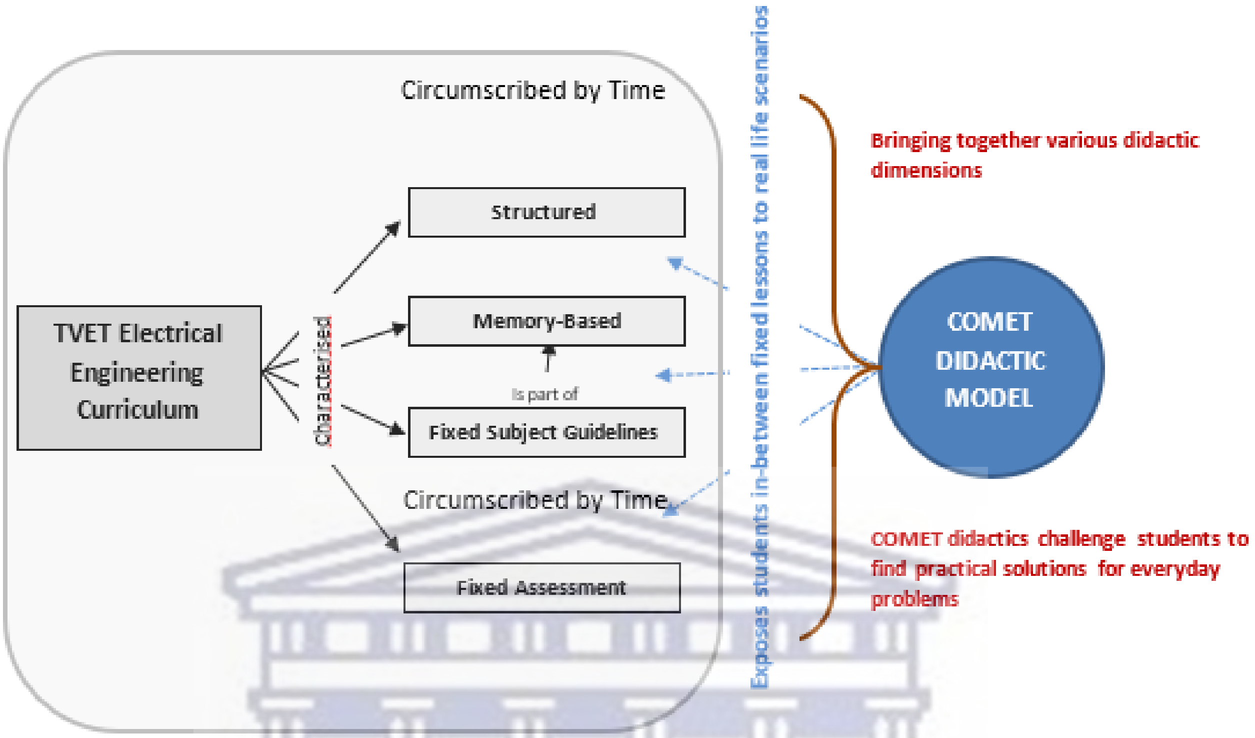


Figure 5.2: Visual network of data themes showing TVET lecturers' experiences of implementing and applying the two learning tasks in their classes

Figure 5.2 shows the visual network of data themes pertaining to TVET lecturers' experiences while implementing and didactically applying the two learning tasks in their Electrical Engineering classes. Participating TVET lecturers characterised the current TVET Electrical Engineering Curriculum as being very structured and memory-based, with fixed subject guidelines and assessments. Participant 7 elaborated as follows:

> Here's the model. As I have seen it… it's more like a real-life situation. One tries to incorporate [the COMET Model] in… our teaching, but the structure of our syllabus… actually, gives us very little possibility… [for] deviation from it. It is structured… [expecting students] mainly to memorize some of the stuff. Or rather, stick to what they normally call assessment guidelines [that form part of the] subject guidelines.

Participant lecturer 7 explained that the COMET diagnostic model can be used effectively in-between fixed lessons (indicated by blue arrows in Figure 5.2) to expose TVET students to real life scenarios, bringing together various didactical dimensions, and challenging students to find practical solutions for everyday problems:

> "… in-between the lessons, it becomes easier if you expose them. You give them a scenario which relates to everyday life, because… I think…. [for] most of them… if you talk about something practical, they can easily understand [it]. So the COMET in a way… was bringing together [various] dimensions. To broaden your teaching, rather study something practical, something that students can relate to, so that when you go deeper into theory, they have an idea what you're talking about. So… some of it was actually used in my teaching".

Another participant added that the current TVET Electrical Engineering curriculum's didactical practices are circumscribed by time:

> "just to add a little bit, yeah… I think we all are having a problem with time according to the system"

One of the limits of measuring occupational competence, is that COMET requires a greater effort and more time for measuring the learning gained by students that is based upon curricula (Hauschildt, 2016, p. 91; Rauner et at, 2013, pp. 13-16).

5.5.3 Lecturers' experience of the COMET learning task solution space

Participating TVET lecturers appraised the COMET learning task solution space positively, as it allows students to express themselves beyond the limitations of the existing Electrical Engineering Curriculum, which is too structured and fixed.

Participant 5 explained:

> …yes, I would… like… to use the COMET [solution space]. Current memorandums limit us so much. Where you can see… [that a] student wants to express him or herself… [and even though he/she] have the book knowledge that they memorize [in response to the memorandum] … they can't express themselves. [So, the memorandum], limits my ability to mark [assess] the student.

While Participant 7 added:

> I would just like to add… the limitation in terms of the marking guideline… [which is] the memorandum… it is very very strict. You have very little…. room to actually debate. The solution space… brings in creativity… [The] COMET… is quite broad…

Participant 6 joined the conversation:

> As much as we [would like to use] solution space…. based on the COMET, it becomes a problem… when they have to sit for the exams, because you find out the markers don't deviate…. from the memorandums. [So], they stick [to] memorandums, they don't even try to check whether… [the student's response] is…. making any sense or not. So, at some point, even though we try to [use] the COMET solution [space]…. at some point, we must… remind… [students] how [they] are going to be examined [in accordance to the memorandum] …. and [how] they must answer… exam [questions].

Even though lecturers seemed positive about the COMET diagnostic model, one got the sense that some lecturers remained sceptical about the integration of the solution space in their Electrical Engineering classes, as they feared students would fail exams if they did not rigidly comply with the standards set by structured memoranda. The scepticism of some lecturers was, however, contradicted by the optimistic findings obtained from TVET students' qualitative narrative responses to the open-ended qualitative questionnaire item, who indicated that the COMET diagnostic model enhanced their academic competence. The following are only a few examples of the many positive responses that were received from TVET students:

> COMET "improves… learning skills".
>
> COMET "…can help boost… marks.

COMET should be used “more for [TVET] training”, so that students “will pass with distinction”.

5.6 Quantitative findings were applied to respond to the fourth research sub-question, Sub-question 4: What were the vocational identity, attitudes, and occupational commitment of TVET students in the study?

Part I of the COMET Questionnaire (Motivational Questionnaire) collected quantitative data consisting of student participants’ responses to Likert-type of questionnaire items with regard to the following: the test site (TVET College), the COMET test task that the student worked on, the difficulty level of finding a solution for the task, the time spent on completing the assignment, how interesting and useful the test task was, how closely the test task relates to the student’s occupation, how diligently the student worked on the test task, as well as the effort that the student made towards working on the test task. Part I of the South African questionnaire also included a question on whether the student approved that similar tasks become part of his/her vocational training, as well as the reason for the student’s approval or disapproval thereof, which was qualitatively answered by students in the form of narrative answers (Rauner, 2016), and these are reported in Section 5.3 as part of the qualitative findings. Parts II and III of the COMET Questionnaire (Occupational Identity and Commitment Questionnaire) were developed by Rauner and colleagues (Kalvelage & Zhou, 2017) to quantitatively explore participants’ identity, commitment, attitudes and values towards their profession and training. Part II also collected general demographic information of participating students, as well as the experiences of their respective TVET Colleges. The descriptive statistical findings related to participating TVET Electrical Engineering Students’ Responses to the COMET Questionnaire (Addendum E) items, are reported in the sections that follow:

5.6.1 COMET Motivational Questionnaire Descriptive Findings (Addendum E, Part I)

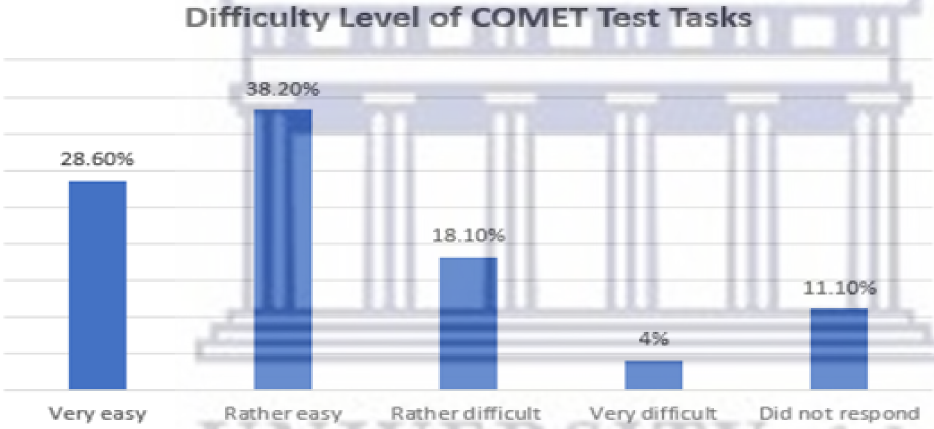
This section reports on purposefully selected findings derived from participating TVET students’ responses to the COMET Motivational Questionnaire (Part I of Addendum E) items, which are specifically relevant to this study.

Difficulty Level of the COMET Test Tasks According to Participating TVET Electrical Engineering Students

Table 5.32 shows the descriptive findings pertaining to the difficulty level of the COMET test tasks according to participating TVET students (N=199).

Table 5.32: Difficulty Level of COMET Test Tasks according to Student Participants

	Frequencies (n)	Frequency %
Very easy	57	28.6
Mostly easy	76	38.2
Mostly difficult	36	18.1
Very difficult	8	4.0
Did not respond	22	11.1
Totals	**199**	**100.0**

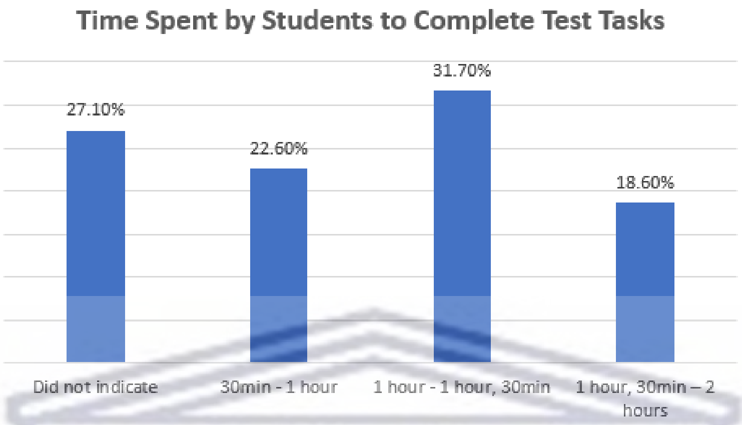


Four percent (n=8; 4%) of the respondents found the test tasks very difficult, 18.1%, mostly difficult, and 28.6% reported that the tasks were very easy. Most participating students found the tasks to be mostly easy (n=76; 38.2%), while 11.1% did not respond to this questionnaire item.

Time Spent by Participating Students to Complete the Test Tasks

Frequency Table 5.33, on the page that follows, shows the time spent by participating TVET students (N =199) to complete the test tasks.

Table 5.33: Time Spent by Student Participants (N=199) to Complete Test Tasks



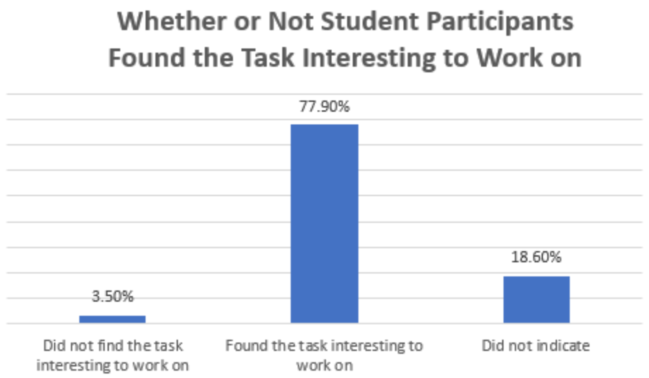
	Frequencies (n)	Frequency %
Did not indicate	54	27.1
30min - 1 hour	45	22.6
1 hour - 1 hour, 30min	63	31.7
1 hour, 30min – 2 hours	37	18.6
Totals	**199**	**100.0**

18.6% of the participants indicated that it took them between 1 hour, 30 min and 2 hours to find a solution for the test task, while 22.5% took between 30 min and 1 hour. Most of the participants (31.7%) took between 1 hour and 1 hour, 30 min to complete the task. It is unclear why 27.1% decided not to respond to this questionnaire item. It might be that some students were under the misperception that time was a factor in the rating of their solutions, and that by responding to this question they might be penalised.

Student participants' interest in the task

Frequency Table 5.34 (on the next page) reports the descriptive findings pertaining to, whether participating TVET students (N=199) found the test task interesting to work on.

Frequency Table 5.34: Student Participants (N=199) Found the Test Task Interesting to Work on



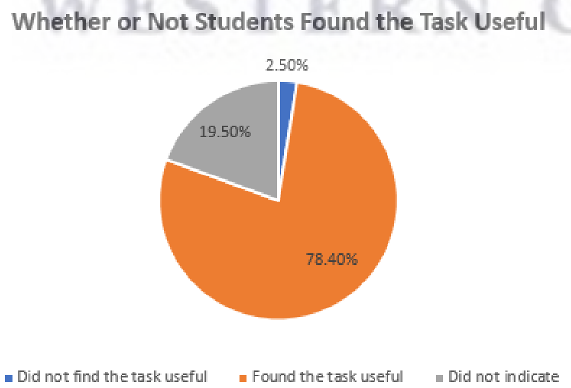
	Frequencies (n)	Frequency %
Did not find the task interesting to work on	7	3.5
Found the task interesting to work on	155	77.9
Did not respond	37	18.6
Totals	**199**	**100.0**

3.5% (n= 7) of the students indicated that the test task was not interesting to work on, while most participants found it interesting (77.9%; n=155). Of the total sample, 18.6% (n=37) did not respond to this questionnaire item. Again, one could only speculate why almost 20% refrained from responding to this questionnaire item.

Test Tasks' Usefulness in Preparing Students for their Future Occupations

Table 5.35, presented on the following page, shows the descriptive findings related to, whether student participants (N=199) found the test tasks useful for preparing them for their future occupations.

Frequency Table 5.35: Test Tasks' Usefulness in Preparing Students for their Future Occupations



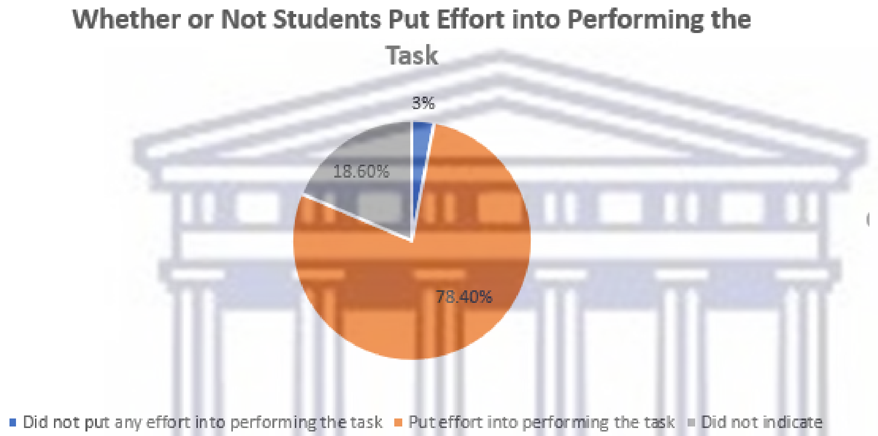
	Frequencies (n)	Frequency %
Did not find the task useful	5	2.5
Found the task useful	156	78.4
Did not respond	38	19.5
Totals	**199**	**100.0**

Most participants (78.4%; n=156) indicated that they found the test tasks useful for preparing them for their future occupations, while only 2.5% (n=5) did not find the test tasks useful.

Participants' Effort to Solve the Test Tasks

Table 5.36 reports the descriptive findings related to the efforts that students made, to solve the test tasks. The majority of participating TVET students (78.4%) indicated that they put effort into finding solutions for the test tasks; while only 3% (n=6) indicated that they did not put any effort into performing the tasks.

Table 5.36 (with Graph): Efforts that students made to solve the test tasks

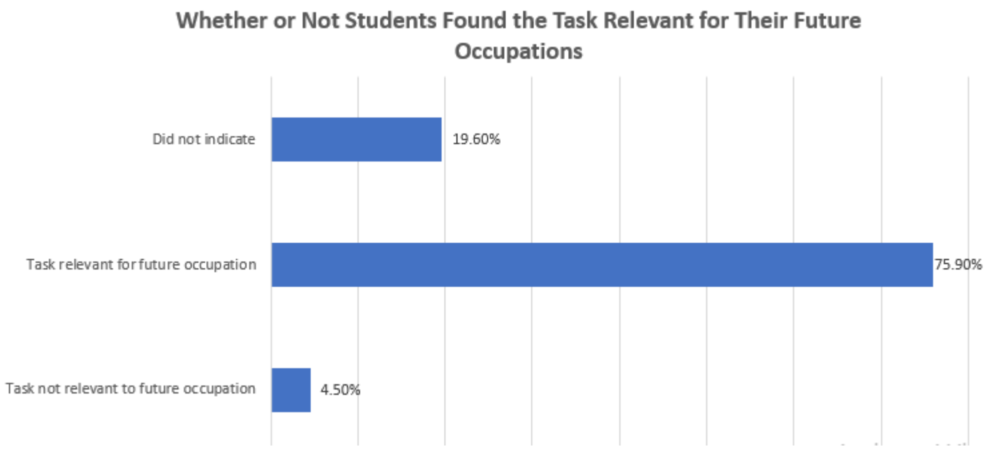


	Frequencies (n)	Frequency %
Did not put any effort into performing the task	6	3.0
Put effort into performing the task	156	78.4
Did not indicate	37	18.6
Totals	**199**	**100.0**

Relevance of Test Tasks for Students' Future Occupations

Table 5.37 (on the page that follows) reports the descriptive findings related to the relevance of the test tasks for students' future occupations.

Table 5.37: Relevance of Test Tasks for Students' Future Occupations



	Frequencies (n)	Frequency %
Task not relevant to future occupation	9	4.5
Task relevant for future occupation	151	75.9
Did not indicate	39	19.6
Totals	**199**	**100.0**

The majority of participating TVET students (75.9%; n=151) indicated that the test tasks were relevant for their future occupations, while only 4.5% (n=9) indicated that the test tasks weres not relevant. These results should only be viewed as students' perceptions of what would be significant for their future careers, rather than factual relevance of the test tasks, because all participants were still students with no prior occupational experience.

Students' Approval for Similar Tasks to Become Part of Their Curriculum

Table 5.38 (on the next page) reports the descriptive findings pertaining to, whether student participants (N=199) approve that similar tasks become part of their occupational training.

Frequency Table 5.38: Students' Approval that Similar Tasks Become Part of Their Curriculum

	Frequencies (n)	Frequency %
Do not approve similar tasks becoming part of occupational training	6	3.0
Approve similar tasks becoming part of occupational training	157	78.9
Did not indicate	36	18.1
Totals	**199**	**100**

Most participating students (78.9%; n=157) indicated that they approved that similar tasks become part of their occupational training, while only 3% indicated that they would not approve. The South African questionnaire also included an open-ended qualitative question which requested that students also provide the reason for their approval or disapproval thereof. The narrative answers that students provided are reported in Section 5.3 as part of the qualitative findings.

5.6.2 Descriptive Findings of the COMET Vocational Identity and Occupational Commitment Questionnaire (Parts II and III of Addendum E)

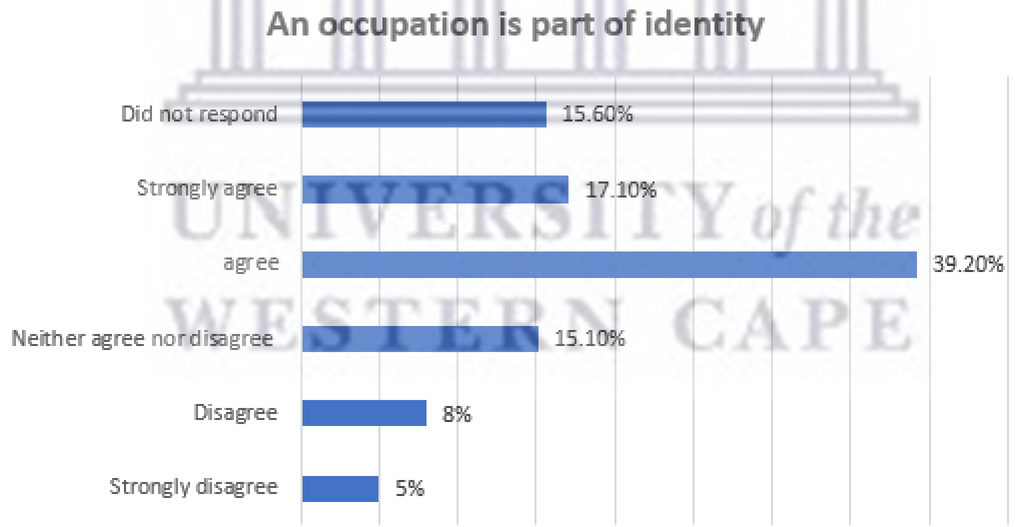
This section reports on purposefully selected findings derived from participating TVET students' responses to the items on the COMET Vocational Identity and Occupational Commitment Questionnaire (Parts II and III of Addendum E), which are specifically relevant to this investigation.

Whether student participants view occupation as part of one's identity

Table 5.39 reports the descriptive findings pertaining to whether students' viewed occupation as part of one's identity.

Table 5.39: An occupation is part of identity

	Frequencies (n)	Frequency %
Strongly disagree	10	5.0
Disagree	16	8.0
Neither agree nor disagree	30	15.1
Agree	78	39.2
Strongly agree	34	17.1
Total	168	84.4
Did not respond	31	15.6



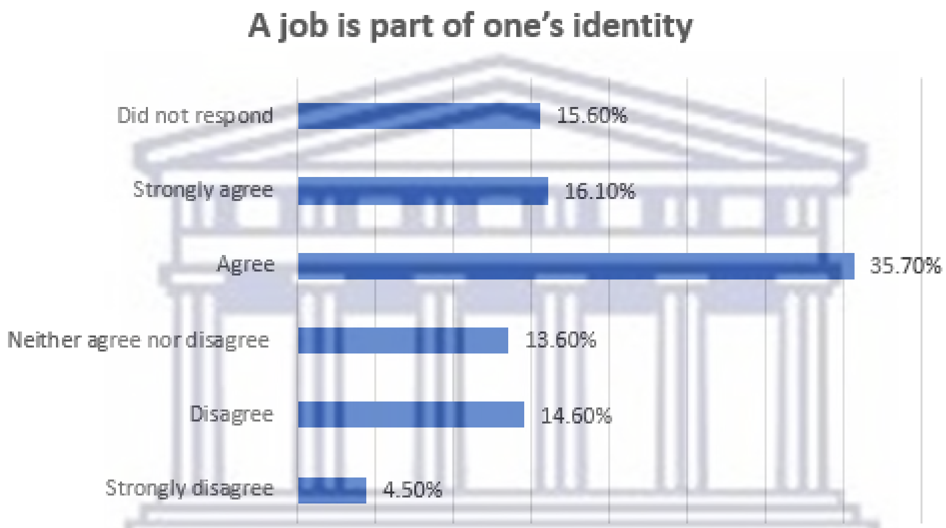
In Table 5.39, 39.2% agreed that an occupation is part of the identity. 15.1% did not agree and 17.1% strongly agreed.

Viewing a job as part of one's identity

Table 5.40 reports the descriptive findings related to whether student participants view their jobs as part of their identity.

Table 5.40: A job is part of one's identity

	Frequencies (n)	Frequency %
Strongly disagree	9	4.5
Disagree	29	14.6
Neither agree nor disagree	27	13.6
agree	71	35.7
Strongly agree	32	16.1
Total	168	84.4
Did not respond	31	15.6



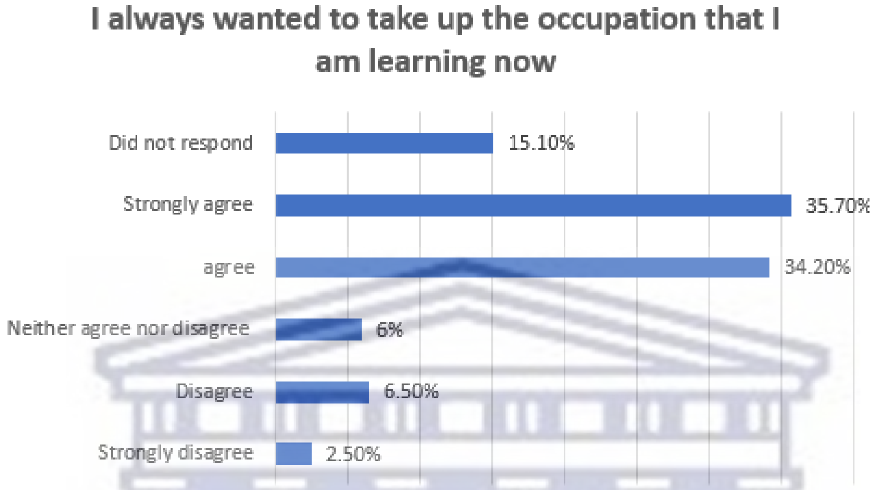
In Table 5.40, 35.7% agreed that a person's occupation is part of his/her identity, while 16.1% strongly agreed and 14.6% disagreed.

Whether participating students always wanted to pursue Electrical Engineering as an occupation

Table 5.41 (on the page that follows) reports the descriptive findings related to, whether participating students wanted to take up the occupation that they are studying for.

Table 5.41: Whether participating students always wanted to take up the occupation that they are studying for

	Frequencies (n)	Frequency %
Strongly disagree	5	2.5
Disagree	13	6.5
Neither agree nor disagree	12	6.0
Agree	68	34.2
Strongly agree	71	35.7
Did not respond	30	15.1



Most of the students who took part (79.9%) said they had always intended to work in the field for which they were studying.

Whether participating students wanted to study for other occupations

Frequency Table 5.42: Whether participating students wanted to study for other occupations

	Frequencies (n)	Frequency %
Strongly disagree and disagree	62	36.2
Neither agree nor disagree	19	9.5
Agree and Strongly Agree	78	39.2
Did not respond	30	15.1

Whether participants rather wanted to study for other occupations instead of Electrical Engineering

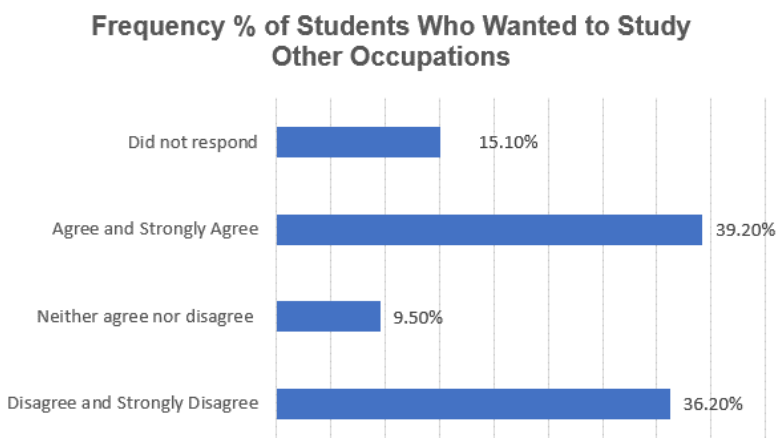


Table 5.42 reports that 39.20% of the student participants indicated that they originally rather wanted to study for other occupations, instead of Electrical Engineering. Frequency Table 5.43 shows the descriptive findings related to other occupations that students indicated as their preferred occupation.

Table 5.43: Preferred Occupations of Participants

	Frequency n	Frequency %
Did Not Indicate	173	86.9
Pharmacist	1	0.5
Teacher	3	1.5
Chemical Engineering	1	0.5
Civil Engineer	1	0.5
Doctor	1	0.5
Electrician	2	1.0
Engineer	1	0.5
Fitter & Turner	1	0.5
Geologist	1	0.5
Lecturer	1	0.5
Locksmith	1	0.5
Mechanic	2	1.0
Nursing	3	1.5
Physiotherapist	1	0.5
Private Investigator	1	0.5
Professional Rugby Player	1	0.5
Psychologist	1	0.5
Safety and Security	1	0.5
Social Worker	1	0.5
Tourism	1	0.5
Total	**199**	**100.0**

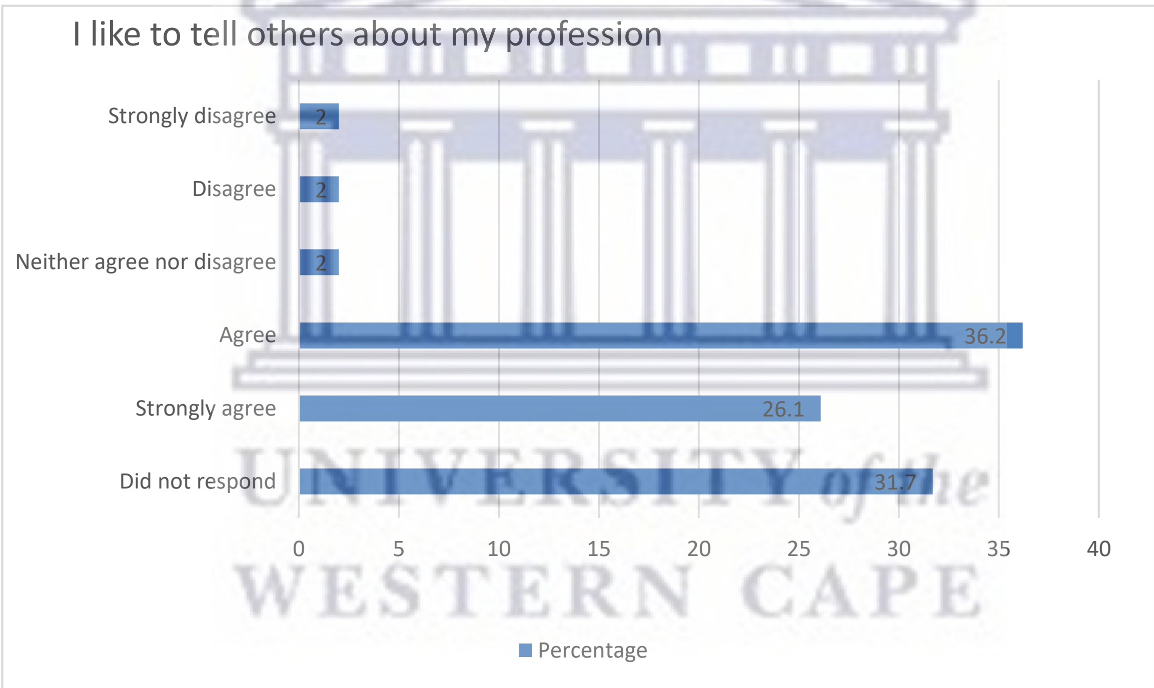
It is interesting to note that 86.9% of the total sample did not indicate anything when asked to indicate their preferred choice of occupation. One can merely speculate that students perhaps thought that they might be judged should it be revealed that they are studying for an occupation that is not their first choice. It can further be surmised that the 36.2% of the total sample of students who reported in Table 5.43 that they would not prefer to be studying for other occupations, possibly form part of the 86.9% who did not indicate another occupation, as they possibly thought it unnecessary to do so, based upon their previous answer.

Whether participating students like to tell others about their occupation

Table 5.44 reports the descriptive findings pertaining to whether participating students like to tell others about their occupation.

Table 5.44 (with Graph): Whether participating students like to tell others about their occupation

	Frequencies (n)	Frequency %
Strongly disagree	4	2.0
Disagree	4	2.0
Neither agree nor disagree	4	2.0
agree	72	36.2
Strongly agree	52	26.1
Total	136	68.3
Did not respond	63	31.7



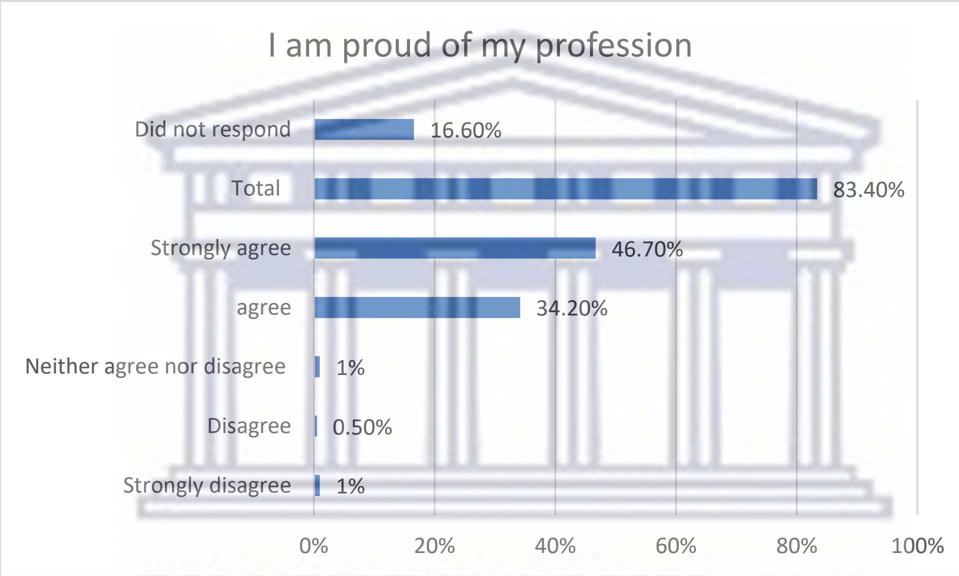
Of the total sample of TVET students, 36.2% agreed that they like to tell others about their profession. 26.1% strongly agreed that they tell other about their profession. Only 2 % were not sure and another 2% strongly disagreed.

Whether participating students are proud of the occupation they are studying for

Frequency Table 5.45 bellow reports the descriptive findings pertaining to whether participating students are proud of the occupation they are studying for.

Frequency Table 5.45: ***Whether participating students are proud of the occupation they are studying for.***

	Frequencies (n)	Frequency %
Strongly disagree	2	1.0
Disagree	1	0.5
Neither agree nor disagree	2	1.0
Agree	68	34.2
Strongly agree	93	46.7
Total	166	83.4
Did not respond	33	16.6



Amongst the total sample of participants, 46.7% strongly agreed that they are proud of their profession, 34.2% agreed and 1% disagreed. This is consistent with the findings reported in Table 5.45 that most students tell others about their profession. This illustrates a strong Identity and occupational commitment.

How participating TVET students' experience their learning environment (TVET colleges) and their fellow students

Table 5.46 reports that most of the students had a positive experience of their learning environments (TVET Colleges). 84.5% of students indicated that they feel comfortable at their respective TVET colleges, while only 2.5 indicated that they feel uncomfortable.

Table 5.46: TVET students' experience of their learning environment (TVET colleges) and their Fellow Students

	Strongly Disagree		Disagree		Neither Agree Nor Disagree		Agree		Strongly Agree		Did Not Respond		Totals	
	n	%	n	%	N	%	n	%	N	%	n	%	n	%
I feel comfortable at college.	3	1.5	2	1	7	3.5	68	34.2	100	50.3	19	9.5	199	100
Mostly, I find the lessons interesting.	4	2	4	2	11	5.5	74	37.2	87	43.3	19	9.5	199	100
Interaction between students and Lecturers is friendly and trusting.	5	2.5	2	1	19	9.5	84	42.2	70	35.2	19	9.5	**199**	**100**
Students are often disturbing the lessons.	36	18.1	53	26.6	40	20.1	37	18.6	15	7.5	18	9	**199**	**100**
Students do not show much respect for other students.	41	20.5	67	33.7	29	14.6	31	15.6	12	6	19	9.5	**199**	**100**

Furthermore, 80.5% indicated that they find the lessons at the colleges interesting, while 77.4% said that they and their fellow students have friendly and trusting interactions with their TVET lecturers. Regarding the influence that other students have on their learning, 26.1% indicated that other students often disturb lessons at their TVET Colleges, while 21.6% indicated that their fellow students disrespect each other.

Participating TVET students' experiences of their TVET lecturers

Frequency Table 5.47 reports on how participating students experience their TVET lecturers. Most students (71.8%) indicated that TVET lecturers consider the interest of students during their lessons, while 75.3% said that their TVET lecturers take students seriously.

Frequency Table 5.47: TVET Students' experiences of their TVET lecturer

	Strongly Disagree		Disagree		Neither Agree Nor Disagree		Agree		Strongly Agree		Did Not Respond		Totals	
	N	%	n	%	N	%	n	%	n	%	N	%	n	%
In the lessons, our lecturers consider the students interests.	6	3	6	3	23	11.6	94	47.2	49	24.6	21	10.6	199	100
Our lecturers present interesting lessons.	2	1	5	2.5	23	11,6	89	44.7	59	29.6	21	10.6	199	100
Our lecturers take students seriously.	3	1.5	2	1	21	10.6	92	46.2	58	29.1	23	11.6	199	100
Lecturers are in touch with the expectancies and requirements of industries	4	2	1	0,5	18	9	76	38.2	76	38.2	24	12.1	199	100
The lecturers take care of individual students.	2	1	6	3	32	16,1	83	41.7	51	25.6	25	12.6	199	100
The lecturers are co coordinating their lessons among each other.	4	2	3	1.5	39	19.6	80	40.2	41	20.1	30	15.1	199	100

Most students (74.3%) indicated that their lecturers present interesting lessons, 76.4% felt that their lecturers are in touch with the expectancies and requirements of industries, 67.3% indicated that lecturers take care of individual students, while 60.3% believed TVET lecturers are co-coordinating their lessons with each other.

Participating TVET students' preferences about cooperation, teamwork, and responsibilities

Frequency Table 5.48 reports on the descriptive findings pertaining to students' preferences about cooperation, teamwork, and responsibilities. Half (51.8%) of the total sample (N=199) of students indicated that they prefer to work autonomously, 57.3% said whenever possible they avoid working autonomously, while 65.4% indicated that they prefer to work in teams. Most participants (77.9%) indicated that they like to take over the responsibility for their own work tasks, and 71.9% said that when they take responsibly for their work tasks, they generally succeed.

Frequency Table 5.48: Participating TVET students' preferences about cooperation, teamwork and responsibilities

	Strongly Disagree		Disagree		Neither Agree nor Disagree		Agree		Strongly Agree		Did Not Respond		Total	
	N	%	n	%	N	%	n	%	N	%	n	%	n	%
I like to work autonomously.	5	2.5	21	10.6	35	17.6	70	35.2	33	16.6	35	17.6	199	100
I like to work in teams.	3	1.5	8	4	23	11.6	69	34.7	61	30.7	35	17.6	199	100
I like to take over responsibility for my work tasks.	2	1	2	1	4	2	74	37.2	81	40.7	36	18.1	199	100
Whenever possible, I avoid working autonomously.	9	4.5	16	8	26	13.1	63	31.7	51	25.6	34	17.1	199	100
Generally, I succeed when I take over responsibility for work tasks.	2	1	3	1.5	9	4.5	71	35.7	72	36.2	42	21.1	199	100

5.7 Qualitative findings responding to the fifth research sub-question, i.e. *What were the strengths of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?*

Although the themes which relate to the COMET diagnostic model's didactic strengths and weaknesses were identified from the qualitative narrative responses of some participating students and lecturers, qualitative research primarily focusses on the unique way that individuals experience, interpret and understand the World (Creswell, 2014). As the goal of qualitative research findings "is not to generalize, but rather to provide a rich, contextualized understanding of some aspect of human experience through the intensive study of particular cases" (Polit & Beck, 2010, p. 1451), the findings below should be regarded as reflecting the unique opinions and first-hand experiences of participating students and lecturers concerning the didactic application of the COMET diagnostic model. The fact that these qualitative findings are derived from the unique context-sensitive experiences of individual participants, does not make these findings less valuable or relevant than the empirical findings derived from large samples of participants in quantitative studies. In fact, such a rich variety of clearly defined data themes identified from the qualitative data analysis, would only be detected as meaningful relationships between variables and clustering of empirical values in empirical research. For the most part, quantitative researchers may merely speculate about the nature and meaning of such unforeseen regularities and patterns found by empirical analyses. The advantage of qualitative research is that the researcher can reach a much clearer understanding of the unique lived experiences of participants.

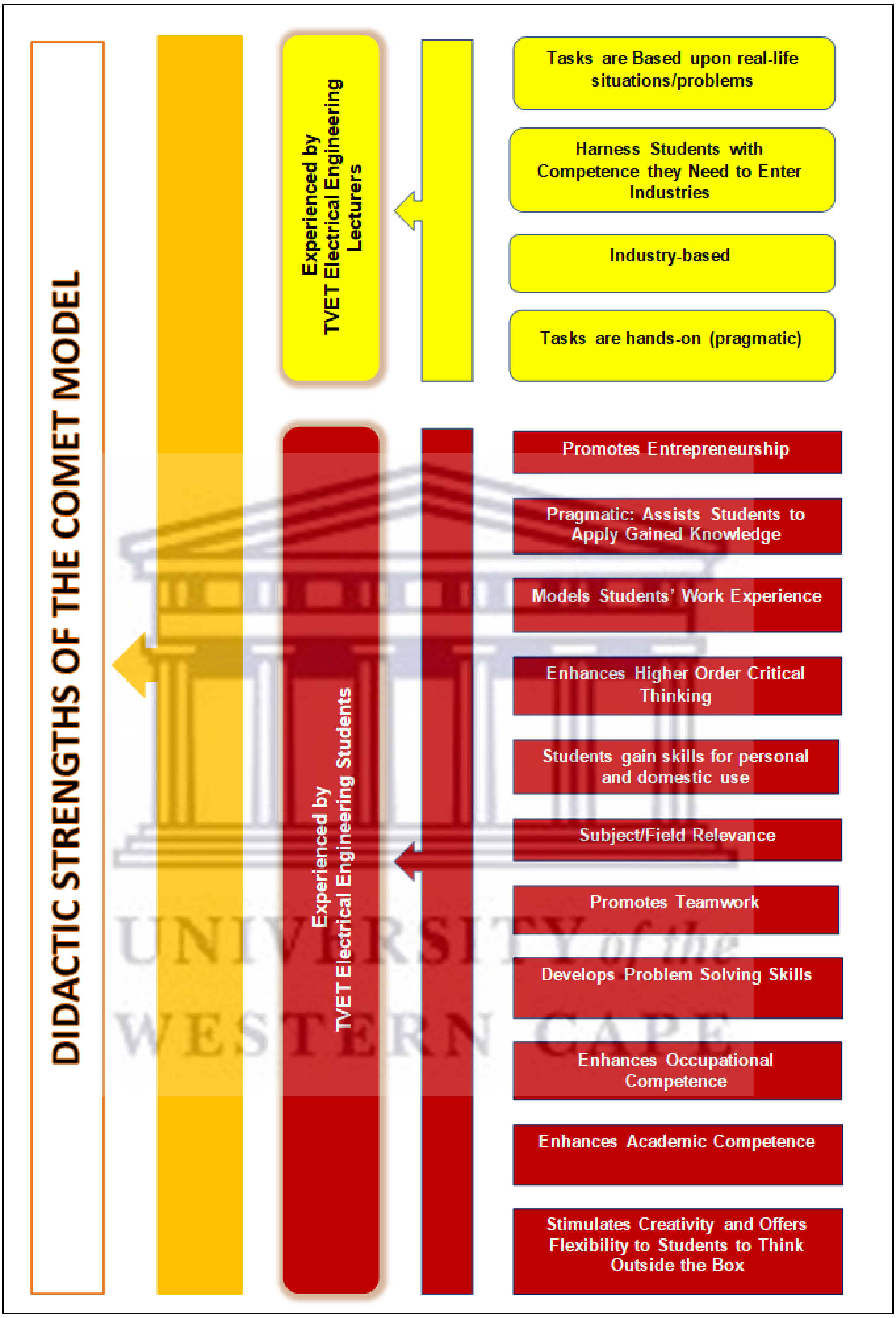


Figure 5.3: Combined visual network of data themes pertaining to the didactic strengths of the COMET Diagnostic Model, as reported by TVET Electrical Engineering lecturers and students

Figure 5.3 (included on the previous page) shows the combined visual network of data themes pertaining to the didactic strengths of the COMET Diagnostic Model, as reported by both TVET Electrical Engineering lecturers and students. These data themes are elaborated upon in the two sections that follow.

5.7.1 Qualitative Themes Pertaining to the Didactic Strengths of the COMET Diagnostic Model According to TVET Lecturers

Figure 5.3 includes the data themes distilled from the qualitative focus-group interview narratives of participating TVET lecturers, concerning the COMET Model's didactic strengths.

TVET lecturers identified four didactic strengths inherent to the COMET diagnostic model as being: (i) It is based-upon real-life situations or problems, (ii) it is hands-on (pragmatic), (iii) it is industry-based, and (iv) It gears TVET students with the occupational competence they need, to enter industries successfully. The four strengths are echoed in the following extracts from TVET lecturers' data. Participant 7 indicated:

> "Here's the model. As I have seen it… it's more like a real-life situation".

Participant 4 agreed, and further elaborated:

> "I think for me… if I look at the COMET model… it's more hands on… It's covering what is happening in industry. But the only challenge is. It's not easy to implement the way we operate in our… TVET colleges. We need to change the way we operate in the TVET colleges so that even if the COMET curriculum is more hands-on [pragmatic]… we [would not be] able to implement it. I see it as a very good curriculum, but the implementation is what is wrong? So, the COMET… [has] advantages in the sense that it is more hands-on [pragmatic]. [The COMET] … is addressing what is supposed to happen in the industry. If students are… exposed to the COMET [Methodology] …the moment they leave the [TVET] college, they… [will be] able to fit in… [the] industry…. [and]… in the workplace. So that's the advantage of the COMET…. It is more hands-on…"

Participant 7, enthusiastically agreed:

> What I like about COMET… [is that] it is very practical. It's quite real. I so wish maybe curriculum developers they can think along those lines… It is quite cool so…. I can say the... COMET…actually has more strengths, and very little weaknesses…

5.7.2 Qualitative Themes of Data Pertaining to Didactic Strengths of the COMET Diagnostic Model according to TVET Students

As already reported in the quantitative findings, 78.9% of the total sample of N=199 TVET students who completed the quantitative questionnaire indicated that they would approve of COMET tasks becoming part of their occupational training, 3% indicated that they disapprove, while 18.1% refrained from giving their opinion. This quantitative questionnaire item was directly followed by a qualitative questionnaire item requesting participants to qualitatively justify their responses. By qualitatively analysing the narrative responses received from participating students, twelve themes pertaining to the strengths of COMET, and four themes relating to students' perceived weaknesses of COMET, came to the fore, as reported in the sections that follow.

The combined visual network of data themes pertaining to the didactic strengths of the COMET Diagnostic Model (Figure 5.3) includes the network view of themes pertaining to the didactic strengths of the COMET diagnostic model that were identified from the qualitative thematic data analysis performed on the narrative questionnaire responses of participating TVET students.

Theme 1: Enhances Higher Order Critical Thinking

The first COMET strength reflected by the responses of participating TVET students, is that COMET enhanced their higher order critical thinking. One student said: *"it helps [one] to be a critical thinker*", while another indicated COMET *"offers a different level of understanding".* Yet another explained that COMET opened his *"mind to a lot of things relating to [his] studies".*

Theme 2: Stimulates Creativity and Offers Flexibility to Students to Think Outside the Box

Creativity is one of the essential 21st Century skills that TVET lecturers and students should acquire, in order to participate in the Information Age, as discussed in Chapter 2, Figure 2.1 (Teis & Els, 2021, adapted from Madhav, Simelane-Mnisi, Hardman, Dlamini & Lilley, 2018, p. 115). Participating TVET students noted that COMET tasks challenged them to be creative and think out of the box. One participant explained that he would like to do more COMET tasks:

> "Because it really helps to think outside the box and come up with some new idea".

While another student remarked:

> "The task is relevant to my studies and encourages creative thinking… and brightens your mind".

According to Rauner (2021), individual duties of professionally qualified workers were previously defined as separate areas of responsibility, based upon a Taylorist division of labour, and unforeseen situations occurred less frequently because the inside of the company was systematically screened off from the random workings of the market. These days, the areas of responsibility of professionally qualified workers are less segmented and less isolated, and consequently, professionally qualified workers should be flexible and independently respond to new and unforeseen situations. Participating TVET students highlighted that their exposure to the COMET task, allowed them to be flexible:

> "Because it makes you know, and it allows you to be flexible enough".

A possible reason for the COMET diagnostic model's flexibility is that COMET tasks are open-ended and are formulated in such a way that they do not lead students to the answers. Other contributing factors could be that students are aware that COMET tasks are not evaluated according to memorandums but use solution space, therefore there are no pre-determined answers. This provided students creative freedom and flexible in their responses, without the fear of losing marks.

Theme 3: COMET's Influence on Students' Work Experience

The COMET didactic approach enables TVET students to be proficient in terms of professional competence, at least at a beginner level. The students are aware that one key requirement to enter the job market, is work experience. The nature of the COMET task allows students to feel confident enough that they can actually execute professional tasks. This can be seen by one student who responded that:

> "Because it would allow me to show my training experience".
>
> "Because I will gain a lot of knowledge and experience".

And another one remarked that the COMET task prepares the students for what they may encounter in future occupations:

> "Because it gives me confidence and prepare me for what I would face in the future".

The responses above are indicative of the clear role that the COMET diagnostic model can play in preparing Electrical Engineering students to able to succeed in an occupation.

Theme 4: Promotes Entrepreneurship

The primary focus of the current TVET system is to prepare students to enter the labour market. Participants in the current investigation, however, also took cognisance of the COMET diagnostic model's inherent potential to cultivate entrepreneurship amongst students:

> "Because its where I can put more effort for the business to succeed and I like working with hands including my mind".

The respondent recognises the empowering benefits of becoming competent, which unlocks the possibility for one to initiate one's own business enterprise.

Theme 5: Enhances Academic Competence

Students agreed that the use of the COMET diagnostic model has the potential to enhance their academic competence. One of the participating students indicated that COMET "improves… learning skills", while another student responded that COMET "…can help boost… marks". Yet another student proclaimed that, should COMET be used "more for [TVET] training", that he "will pass with distinction".

Theme 6: Enhances Occupational Competence

Participants felt that the COMET diagnostic model enhanced their overall occupational competence. The COMET diagnostic model promotes the notion that individuals should be competent, in addition to being qualified. Participating TVET students recognised that the test task consists of activities that are required for their future occupations. One of the students indicated:

> "Because it was all about my career and everything I am expected to do in my daily work".

In the same vein, another student replied:

> "Because it is the work from our future profession".

Some participants felt confident that the COMET task made them more attractive for future possible employment. In the words of one of the respondents:

> "Because if I've done this practical training, massive company could hire me to do the job and have a certificate of compliance".

These findings resonate well with the fundamental learning theory of competence, which according to Billet (2017), is the belief that occupational competence is something that one can learn and demonstrate. Industries, with modern forms of organisation, are exponentially transforming and developing in profound new ways (Baethge & Schiersmann, 1998, p.16), which in turn, expects employees to constantly adapt to the changing work environment throughout their working lives (Gergen, 1994).

Theme 7: Students Gain Skills for Personal and Domestic Use

The value of TVET training should extend beyond the classroom. One of the extra advantages of the COMET task, according to the students, is that they can fix some domestic appliances on their own.

> "I can go home and fix the problem".

Two students pointed out that the exposure to COMET tasks give them opportunities to save money by fixing domestic appliances for themselves.

"Because it will help us a lot, we get to experience how to repair damaged things than to waste our money buying new products".

And another one suggested that the COMET tasks can encourage students to also do them at home as illustrated below:

"I am studying Renewable Energy but love to do these kinds of jobs at home".

Theme 8: Pragmatic - Assists Students to Apply Gained Knowledge

According to some students the COMET tasks assisted them in applying attained knowledge. The COMET activity could also be used as a test to see what knowledge students may have acquired. According to the student, the COMET diagnostic model can actualise the knowledge they have acquired in the classroom:

"To test if I can apply what I have learnt".

This view was further supported by other students who said that the COMET task affords them the opportunity to put their knowledge into practice. As stated below:

"It's always good to put your knowledge into practice".

"Because it is very good experience to put what you learnt into practice".

"I engage myself in practical work".

"Because I've learnt about it. This task gave me a lot of knowledge and understanding".

As it can be noted from the quotes above, most students characterised the COMET tasks as pragmatic in nature. This confirms the idea that the COMET task represents authentic work experience, which is one of the main requirements in the design of COMET tasks.

Theme 9: Promoting Teamwork

Teamwork is one of the main requirements for an individual to succeed in the work environment. One student suggested that that COMET tasks promote teamwork. This can be seen from the manner, in which the tasks are designed. COMET tasks are designed to reflect authentic work experiences. This suggests that the student will not be able to execute the task alone, hence this student noted that teamwork is needed to successfully complete the COMET tasks. Hence the student recognised that he\she would like to do the task with a team as stated below:

"I would love to do this with my team".

This finding supports Hodkinson's (2004) description of the competence development process as being a product of experiences in which individuals are involved in work related activities and interactions with others to effectively acquire experience and sufficiently develop occupational competence.

Theme 10: Subject/Field Relevance

For some students, the COMET tasks were relevant to the subjects and learning fields that they are currently completing. One student noted that COMET tasks are compatible (fit) to the subject they are doing as can be seen below:

"Because they discuss elements related to my course".

"Because it fits in with my subjects".

However, we must note that the COMET diagnostic model promotes domain specific knowledge rather than subject specific knowledge. Despite this, the TVET students were able to note that the tasks would fit within their course which is part of the Electrical Engineering domain.

Theme 11: Develops Problem Solving Skills

Holistic problem solving is the highest of the COMET diagnostic models' competence levels, which is also one of the required skills of the 21st century. The students were able to identify this critical skill as one of the major contributions of the COMET tasks. Students expressed problem solving in different ways. Some viewed the tasks as promoting problem solving, while others said that the tasks required them to be innovative in solving occupational problems, and saw the tasks as assisting them in diagnosing and rectifying problems, as illustrated below:

"It showed me how to solve the problem".

"As an electrician I must come up with new ways to solve a problem".

"Because it will help me to able to solve these types of problems".

"Because it helps us in the future to find faulty and rectifying them".

5.8 Qualitative findings responding to research sub-question 6: What were the weaknesses of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

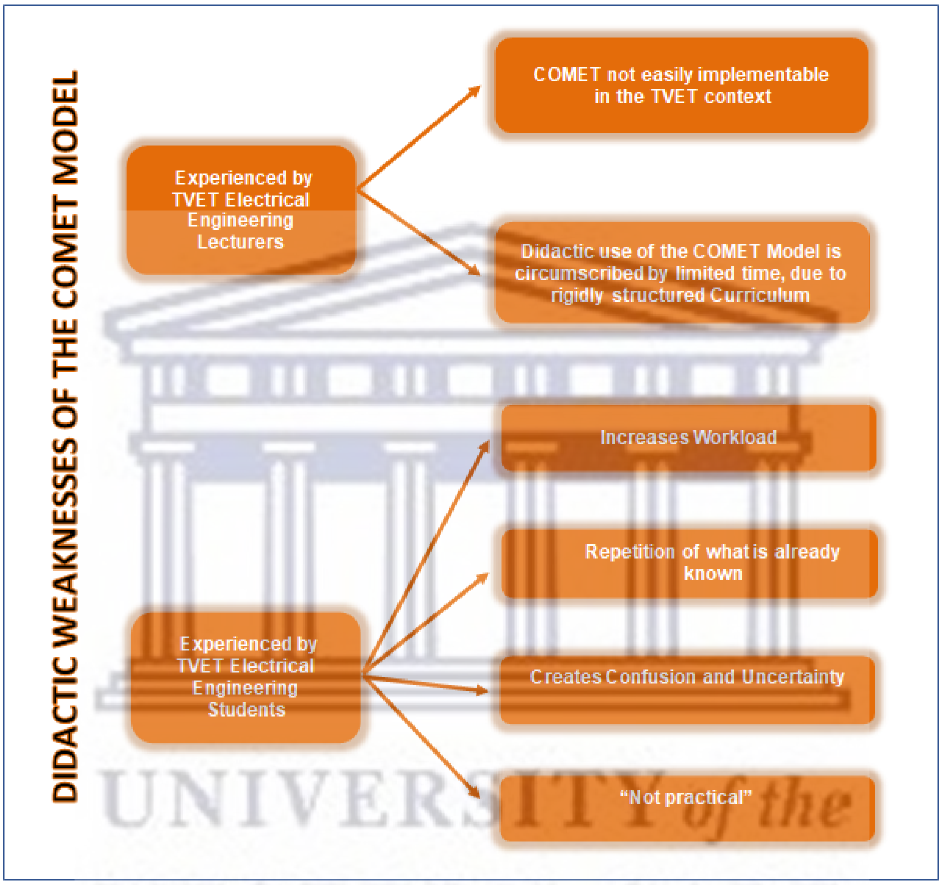


Figure 5.4: Combined Visual network of data themes pertaining to the didactic weaknesses of the COMET Diagnostic Model, as experienced by both TVET Electrical Engineering lecturers and students.

Figure 5.4 shows the combined Visual network of themes pertaining to the didactic weaknesses of the COMET Diagnostic Model, as experienced by both TVET Electrical Engineering lecturers and students. These themes are discussed in the sections that follow.

5.8.1 Didactic Weaknesses of the COMET Diagnostic Model according to TVET Lecturers

As already stated above, qualitative research mainly focusses on the unique way that individuals experience, interpret and understand the World (Creswell, 2014). As the goal of qualitative research findings is not to generalize, but rather to provide a rich, contextualized understanding of the unique experiences of individuals in particular cases (Polit & Beck, 2010, p. 1451), the findings below should be regarded as the unique reflections, opinions and first-hand experiences of a small group of participating lecturers with regard to the didactic weaknesses of the COMET diagnostic model. As qualitative research is not measured by numerical values, frequencies or frequency percentages, the following qualitative responses of participating lecturers cannot be quantified and reported as percentages. Participating TVET lecturers mentioned only two weaknesses of using the COMET model for didactical purposes (included in Figure 5.4 above):

(i) that the COMET is not easily implementable in the TVET context, and
(ii) that the didactic use of the COMET diagnostic model is circumscribed by limited time, due to the TVET Electrical Engineering Curriculum being too rigidly structured. In the words of Participant 4:

> "…the only challenge is. It's not easy to implement the way we operate in our… TVET Colleges. We need to change the way we operate in the TVET Colleges, so that even if the COMET Curriculum is more hands-on… we are able to implement it. Otherwise, we will end up with the same challenges that we have everywhere… [in the] NCV curriculum".

While Participant 7 explained:

> "One tries to incorporate that in… our teaching, but the structure of our syllabus, the way it is, actually gives us very little possibility of deviation from it".

One of the limitations of measuring occupational competence is that COMET takes more time and effort to measure students' learning which is specifically dependent on the curricula. (Hauschildt, 2016, p. 91; Rauner et at, 2013, pp. 13-16).

5.8.2 Didactic Weaknesses of the COMET Diagnostic Model according to TVET Students

Figure 5.4 also includes the network view of four themes pertaining to the didactic weaknesses of the COMET diagnostic model that were identified from the qualitative thematic data analysis which was performed on the narrative questionnaire responses of participating TVET students. These findings should be regarded as the unique reflections, opinions and first-hand experiences of a small group of participating students with regard to the didactic weaknesses of the COMET diagnostic model. As qualitative research is not measured by numerical values, frequencies or frequency percentages, the following qualitative responses of participating students cannot be quantified and reported as percentages. From the qualitative analysis, the following themes were identified pertaining to the didactic weaknesses of the COMET model, as indicated by individual students.

Theme 1: Increases workload.

Three percent (3%) of the students disapproved of the didactic use of the COMET diagnostic model, because of an increased workload, and because more effort is required, to complete the COMET tasks, as expressed by one of the participants:

> "I hate the part whereby they say… renovate a building, which means heavy work".

Theme 2: Repetition of what is already known.

Only zero point five percent (0.5%) of the participating students disapproved of using the COMET didactic model, because he said: "I already know what to do".

Theme 3: Creates confusion and uncertainty.

One percent (1%) of students suggested that the COMET test tasks created confusion and required them to complete test tasks that do not relate to the subjects needed for their future work. One student commented: *"I was not sure what I was writing",* while another remarked*: "I won't be able to understand what is being done, due to work related subjects, because I am doing renewable energy"*. The confusion experienced by the first student, most likely emanated from the student's limited participation in some of the COMET study activities, due to a lack of interest or absenteeism. The argument put forth by the second student, that he did not understand what was being done, due to the irrelevant nature of the test tasks for the subjects required for his future work, is unfounded. The COMET tasks used in the current study were specifically designed to be domain-specific rather than subject-specific, to provide students the opportunity to develop sufficient occupation competence within the domain of Electrical Engineering.

Theme 4: COMET seen as "not practical".

The last didactic weakness of the COMET diagnostic model that was mentioned in the narrative responses 1.5% of participating TVET students is that the model is "not practical". One student expressed his disapproval of the COMET diagnostic model *"because we are not doing practically*". In their narrative responses another two students defended their disapproval of the COMET diagnostic model respectively, "*because I did not do a practical, I only did paperwork*" and *"I would like to do practicals based on these tasks".*

It can be seen from the responses above that an extremely small percentage of participating TVET students did not actually consider the COMET tasks as practical tasks. This finding is not unusual given that in practical tasks participants are typically expected to perform these physically rather than relying on verbal or written responses to accomplish learning objectives. The test tasks of the COMET diagnostic model should be regarded as "thought experiments" in which students participate in "work processes… based on action-orientated research discussions and action-orientated exploration… using the explorative character of the participating observation to redesign work situations in a quasi-experimental way" (Rauner, 2021, p. 36). Therefore, the finding that some participating students experienced the COMET diagnostic model negatively and as being non-practical in nature, should rather be interpreted as a misconception on the part of some students rather than being a didactic weakness inherent to the COMET diagnostic model. This is considering that the majority of participating students praised the COMET learning tasks' pragmatic value, as exemplified by the following three positive responses received from TVET students:

> "It is always good to put your knowledge into practice".
>
> "Because it is very good experience to put what you learnt into practice".
>
> "I engage myself in practical work".

5.9 Chapter Synopsis

In this chapter, the findings of a mixed-methods study were presented to effectively respond to all six research sub-questions that were identified in the first chapter of this thesis. Both the quantitative findings derived from descriptive and inferential statistical analyses, as well as the qualitative themes identified through the qualitative thematic data analysis were reported and discussed, supported by competence profile radar graphs, frequency tables, inferential statistical tables, as well as qualitative network visualisations of themes from the data. The answers reported in this chapter for the six research sub-questions are taken together and interpreted in the final chapter in an attempt to answer the main research question and are substantiated by the scientific results reported in this chapter.

Chapter 6

Summary, Recommendations and Conclusions

6.1 Introduction

In this final chapter, a summary of the findings, recommendations and conclusions derived from both the quantitative and qualitative research components presented and discussed in Chapter 5, are used to address the research questions that were identified at the beginning of this thesis in Chapter 1 (Section 1.5). This Chapter reports how the goals of the study have been achieved, and answers are provided for the research questions that were identified in the first chapter of this thesis. This is followed by a discussion of the major contributions of this investigation, i.e. (i) The study's contribution towards bridging the competence divide between existing TVET education and the competence requirements of rapidly evolving industries; (ii) The study's contribution towards the growing body of knowledge pertaining to the didactical application of the COMET diagnostic model; and (iii) The study responding to the realisation of national post-school education and training policies. The limitations of the study are pointed out, and recommendations are made based upon the general findings of the current research. This research report concludes with specific research questions posed for future research consideration and concludes with some final words from the researcher.

6.2 Revisiting the Research Aim, Objectives and Questions

As previously stated in Chapter 1, Section 1.4, the aim of this research was to explore how the didactic application of the COMET diagnostic model for teaching and learning might enhance the development of occupational competence of National Certificate Vocational Electrical Engineering students at TVET colleges. The more specific objectives of the study were:

Objective 1: To determine the occupational competence levels of electrical engineering TVET students prior to the application of the COMET diagnostic model.

Objective 2: To determine to what extent the didactic application of the COMET diagnostic model enhanced the occupational competence levels of Electrical Engineering students.

Objective 3: To determine how TVET lecturers implemented and applied the COMET diagnostic model in their classrooms.

Objective 4: To determine the vocational identity, attitudes, and occupational commitment of TVET students in the study.

Objective 5: To explore the strengths of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET Colleges.

Objective 6: To explore the weaknesses of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET Colleges.

In line with these objectives and the research aim, the main research question that this investigation sought to answer, was: ***How can the COMET diagnostic model be didactically applied in teaching and learning to enhance the occupational competence of National Certificate Vocational Electrical Engineering students at TVET colleges?***

6.3 SUMMARY OF RESEARCH FINDINGS

In Chapter 5, both the quantitative and qualitative findings of this mixed-methods investigation were presented and discussed to respond to the six research sub-questions. The following sections provide a summary of the empirical findings to each of the six research sub-questions using the combined data.

6.3.1 Sub-question 1: What was the occupational competence level of electrical engineering TVET students prior to the application of the COMET diagnostic model?

Quantitative findings pertaining to the occupational competence level of electrical engineering TVET students prior to the application of the COMET diagnostic model, were reported in Chapter 5, Section 5.3, Table 5.8. The overall occupational competence profile of participating TVET students (N=199), measured in the baseline test, initially showed a weak competence profile with a total professional competence mean score of 13.56. Furthermore, the qualitative findings reported in Chapter 5, Section 5.5.1, showed that lecturers' current didactic practices are insufficient in preparing students for the requirements of modern-day work. The visual network of data themes in Figure 5.1 indicates that TVET lecturers keep to standard/conventional didactic practices because of the rigid nature of the existing curriculum, as well as lecturers' lagging behind in occupational skills, due to none or very few available new skills development opportunities for TVET lecturers. Lecturers' use of conventional didactic practices is associated with an imbalance between theory and practical tasks in the curriculum, resulting in Electrical Engineering students receiving none, or very little exposure to authentic workplace experiences. Furthermore, the use of conventional didactics contributes to students' lack of occupational competence, in addition to the negative effect that lecturers' lack of occupational skills already has on students' acquisition of occupational competence. As a result, TVET Electrical Engineering students are currently entering the workforce without meeting the level of occupational competence that is expected and required by fast evolving industries in the country.

6.3.2 Sub-question 2: To what extent was the occupational competence of electrical engineering TVET students enhanced through the application of the COMET diagnostic model?

The quantitative findings pertaining to the occupational competence level of Electrical Engineering TVET students after they have been exposed the didactical application of COMET diagnostic Model through COMET learning tasks were presented in Chapter 5, Section 5.4, Table 5.29. These findings support the viewpoint of Billet (2017), who maintains that occupational competence can be learned and demonstrated. The large Cronbach α = 0.97 coefficient reported in Table 4.4 for the total professional occupational competence score of participating students, affirmed the good reliability (internal consistency) of the COMET diagnostic model and its measuring instruments for the current investigation. Reliability is relative to a specific situation or situations. A reliability coefficient value of 0.5 is typical for ordinary classroom assessments (Downie, 1967, p. 92). The good reliability coefficient values reported for the COMET model's didactical application, could: (i) Be indicative of the fact that the TVET Electrical Engineering students who participated in the current study, experienced the COMET tasks as practical and relevant for their future occupations in Electrical Engineering, and (ii) could be indicative that the learning tasks, as practice items, positively affected the test task scores of participating students (Downie, 1967, p. 89). Lecturers found the implementation of COMET learning tasks useful in helping improve the competencies of their students. This is supported by one lecturer who remarked during the interview that students were coping with the COMET tasks because they were related to everyday life. The lecturers further motivated that the COMET model "broadened" their teaching, and assisted them when they were teaching theory (Section 5.2.2).

Concerning the two focal points of the Department of Higher Education and Training's (2019) Teaching and Learning Plan (TLP), i.e. (i) quality assurance of curriculum delivery, and (ii) student success, it has been shown that student success is dependent on the quality of teaching and learning, and ultimately, on the quality of lecturers (Badenhorst & Radile, 2018; Oketch, 2007). Human capital TVET provisioning is demand-driven, and is curriculum competence-based (Rasool & Mahembe, 2014). Competence-based training primarily focusses more attention on students and their ability to master practical tasks and the ability to acquire competence, than on the level or type of qualification, or the length of training, and is "developed in accordance with identified skills needs derived from the workplace" (UNESCO, 2012, p. 16). The current study successfully explored how the didactical application of the COMET diagnostic model enhanced the occupational competence development of South African students enrolled for the National Certificate Vocational Engineering at five TVET Colleges across four South African Provinces.

The percentages of students who attained the various competence levels in the Baseline and Main COMET tests were compared in Chapter 5, Table 5.28. The percentages of students who scored competence on a nominal level reduced from 67.37% in the Baseline to 2.01% in the Main tests (65.36% improvement in competence). In the baseline test, 21.1% of students attained a Functional Competence level, which increased with 51.56% in the main test (30.46% improvement in competence). This means that in the main test, 51.56% of the students at all test sites attained a Functional Competence level, having basic technical knowledge and technical-instrumental skills. Their professionalism is reflected by their decontextualised technical knowledge and corresponding skills ("know that"). In the baseline test, 8.42% of students attained a Processual Competence level, which increased with 19.24% to 27.64% in the main test. This means that in the main test 27.64% of the students at all test sites attained the Processual Competence level to perform professional tasks that are interpreted in the context of company work processes and situations. These students were also able to apply their knowledge ("Know how") to solve work-related tasks. Furthermore, 3.01% of students in the baseline test attained Holistic Shaping Competence, which then increased by 16.09% to 19.1% in the main test. This means that 19.1% of students in the main test attained a Holistic Shaping Competence level, in which they fully realised the complexity of professional work tasks, and were able to solve the test tasks, while focusing on the divergent demands in the form of intelligent compromises.

The visible increase in participating TVET students' competence profiles between the Baseline Test and Main Test was statistically confirmed by the inferential statistical results. Section 5.4, Table 5.29 reports satisfactory Cohen's effect size values measuring the differences between the base-line test scores and the main test scores. Medium effects sizes, tending towards practically significant enhancements in competence, were found and reported for the following COMET criteria: K1 - Clarity/Presentation (d=0.7), K2 – Functionality (d=0.7), K3 - Sustainability\utility (d=0.7), K5 - Business/Work Process (d=0.7), K6 - Social Responsibility (d=0.6), K8 – Creativity (d=0.6), and KG - Holistic Shaping Competence (d=0.7). Five of these

COMET measures had 0.7 d-values that strongly suggest the enhancement of practically significant competence; therefore, these effects may likewise be regarded as such. The COMET diagnostic model's effective didactic enhancement of Electrical Engineering TVET students' occupation competence is clearly reflected by large effect size values (d=0.8), which are indicative of practically significant enhancements in participants' competence criteria, reported for: K4 - Cost Effectiveness, K7- Environmental Responsibility, KF - Functional Competence, and KP - Processual Competence. The overall effect of the COMET model's didactic enhancement of TVET Electrical Engineering students' occupational competence, is scientifically proven by the practically significant enhancement (effect size d = 0.8) found and reported between the total professional occupational competence profiles in the Baseline and Main Test scores.

The COMET diagnostic model typically discards the data obtained from students whose baseline scores are on a nominal non-competence level (< 5), from being analysed and reported. The findings reported in Table 5.26, however, clearly show that the mean total professional competence score (1.93) of the 39 students, who all scored < 5 in the baseline test, increased with 18.17 to a mean total competence score of 20.1 for the main test. This increase in competence development is larger than the increase in competence development of the main study sample (N=199). The radar graphs in Table 5.26 clearly show a significant increase in the competence profile of this group of n=39 students whose competence developed from nominal competence (i.e. superficial conceptual knowledge that does not guide activity; the meaning of the professional terms remains at the level of colloquial language) to a Functional Competence level (i.e. basic technical knowledge leads to technical-instrumental skills. "Professionalism" is displayed as de-contextualised technical knowledge and corresponding skills ("know that")).

6.3.3 Sub-question 3: How did TVET lecturers implement and apply the COMET diagnostic model in their classrooms?

A visual network of qualitatively derived data themes, pertaining to the way in which TVET lecturers didactically implemented and applied the two learning tasks in their classrooms, was reported in Chapter 5, Section 5.3.1.2, Figure 5.2. Participating TVET lecturers characterised the current TVET Electrical Engineering Curriculum as being very structured and memory-based, with fixed subject guidelines and assessments. Furthermore, the current curriculum's didactic practices are restricted by time. One of the limits of measuring occupational competence is that COMET requires a greater effort and requires more time for measuring the learning gained by students that is based upon curricula (Hauschildt, 2016, p. 91; Rauner et at, 2013, pp. 13-16). However, participating lecturers indicated that they implemented and applied the COMET learning tasks didactically and effectively in-between fixed lessons to expose TVET students to real life scenarios, bringing together various didactic dimensions of the curriculum, and challenging students to find practical solutions for everyday domain-specific problems.

6.3.4 Sub-question 4: What were the vocational identity, attitudes, and occupational commitment of TVET students in the study?

With regards to the findings obtained via the COMET Motivational Questionnaire, almost 40% of the participating students indicated that they found the test tasks mostly easy to solve. The majority of the participants (31.7%) took between 1 hour and 1 hour, 30 min to complete the test tasks, 77.9% found the test tasks interesting to work on, and 78.4% indicated that they put effort into finding solutions for the test tasks. The majority of students (78.4%) indicated that they found the test tasks useful for preparing them for their future occupations, 75.9% indicated that the test task was relevant for their future occupations, while 78.9% indicated their approval that similar tasks should become part of their occupational training.

Findings obtained from students' responses to the COMET Vocational Identity and Occupational Commitment Questionnaire, revealed that 39.2% of participating students view their occupation is part of their identity, 79.9% indicated that they always wanted to pursue an Electrical Engineering occupation, while 39.2% originally wanted to pursue a different occupation. 62.3% of students reported that they like to tell others about their profession, while 80.9% indicated that they are proud of their profession. With regard to students' experiences of their learning environment (TVET colleges), 80.5% indicated that they find the lessons at their colleges interesting, while 77.4% said that they and their fellow students have friendly and trusting interactions with their TVET lecturers. Regarding the influence that other students have on their learning, 26.1% indicated that other students often disturb lessons at their TVET colleges, while 21.6% indicated that their fellow students disrespect each other. Most students (74.3%) indicated that their lecturers present interesting lessons, 76.4% felt that their lecturers are in touch with the expectancies and requirements of industries, 67.3% indicated that lecturers take care of individual students, while 60.3% were of the opinion that TVET lecturers are co-coordinating their lessons amongst each other. One in every two students indicated that they prefer to work autonomously, while 65.4% indicated that they prefer to work in teams. Most participants (77.9%) like to take over the responsibility for their own work tasks, and 71.9% indicated that they generally succeed when they take responsibly for their work tasks.

6.3.5 Sub-question 5: What were the strengths of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

Figure 5.3 (in the previous Chapter) shows a summative visual network of data themes pertaining to the didactic strengths of the COMET diagnostic model, as experienced by both TVET Electrical Engineering lecturers and students. These didactic strengths were fully discussed in Sections 5.7 of the previous chapter.

Participating TVET lecturers indicated the following strengths of using the COMET diagnostic model for didactical purposes in the National Certificate Vocational Electrical Engineering programme: the COMET tasks are based upon real-life situations/problems; the COMET diagnostic model provides students with the necessary occupational competence required by industries on entry level; the COMET diagnostic model is industry based; and the COMET model's training and test tasks are hands-on (pragmatic) in nature.

Participating TVET students, on the other hand, identified the following strengths of using the COMET diagnostic model for didactic purposes in the National Certificate Vocational Electrical Engineering programme: The COMET diagnostic model promotes entrepreneurship; it is pragmatic in nature, as it assists students in the practical application of the knowledge they gained; and its models students' work experience. Furthermore, the COMET diagnostic model enhances higher order critical thinking and helps students gain skills for personal, as well as professional use. In addition, the COMET Model is a subject/field relevant diagnostic model; it promotes teamwork between students; develops students' problem-solving skills and abilities; enhances both students' occupational competence, as well as academic competence; and stimulates creativity and offers students flexibility to think outside of the box.

6.3.6 Sub-question 6: What were the weaknesses of the COMET diagnostic model in the National Certificate Vocational Electrical Engineering programme at TVET colleges in the study?

Figure 5.4 (in the previous chapter) provides a summative visual network of qualitative data themes pertaining to the weaknesses of using the COMET diagnostic model for didactical purposes, as experienced by both the participating TVET lecturers and students in this study (discussed in Sections 5.8 of the previous chapter). Participating TVET lecturers qualitatively identified only two weaknesses: (i) The COMET diagnostic model is not easily implementable in the current TVET educational context; and (ii) the didactic application of the COMET diagnostic model is circumscribed by limited time, due to the rigidly structured curriculum.

The COMET diagnostic model which was used for didactic purposes had the following four weaknesses which participating TVET students qualitatively highlighted: (i) Increased workload (the opinion of 3% of students); (ii) It sometimes repeats what is already known (the opinion of 0.5% of students); (iii) It can sometimes create confusion and uncertainty, and required them to complete test tasks that do not relate to the subjects needed for their future work (the opinion of 1% of students); and (iv) the COMET diagnostic model is sometimes seen as impractical (the opinion of 1.5% of students). On closer examination, however, it should be noted that the last two weaknesses (in Figure 6.3) were derived from the qualitative responses received from only three participating students (representative of 1.5% of the total sample). The responses seem to be due to a misinterpretation by these students, as these two perceived weaknesses were contradicted by the large number of positive responses that were received from the majority of participating students. One could speculate that the confusion experienced by one of the students most likely emanated from the student's limited participation in some of the COMET study activities. The COMET tasks used in the current study were specifically designed to be domain-specific rather than subject-specific, so as to provide students with the opportunity to develop sufficient occupation competence within the domain of Electrical Engineering.

One student who characterised the COMET tasks as being 'unpractical' (sic), was most probably due to students' misconception of what practical tasks entail. Practical tasks are often associated with tasks that are physically executed, rather than being verbally explained or executed in written form. The test tasks of the COMET diagnostic model in its application here can be regarded as "thought experiments" in which students participate in "work processes… based on action-orientated research discussions and action-orientated exploration… using the explorative character of the participating observation to redesign work situations in a quasi-experimental way" (Rauner, 2021, p. 36).

The combined findings reported in Sections 6.3.1 to 6.3.6 effectively respond to the six research sub-questions, and when taken together, answer the main research question of this investigation: *How can the COMET diagnostic model be didactically applied in teaching and learning to enhance the occupational competence of National Certificate Vocational Electrical Engineering students at TVET colleges?*

In addition, by offering creative strategies for integrating the COMET didactics model into the current curriculum, and notwithstanding the rigidity of the centralised college curricula that drives teaching and learning in the TVET system, the COMET diagnostic model was, in its didactic application able to:

- expose students to the authentic workplace by designing tasks derived from the components of professional work activities;
- structure professional work tasks in occupational curricula in accordance with developmental sequencing that takes cognisance of multiple competencies and caters for these in the didactical opportunities offered by the COMET model;
- build student confidence in that through the open solution spaces students could work creatively and without fear of there being only one 'right' answer, which is often the case in norm referenced assessments.

6.4 Attainment of Research Objectives and Aim

By successfully answering the six research sub-questions (Section 6.3), the six corresponding research objectives of this study have been successfully attained, and consequently, the main research aim has been achieved. The most salient finding was that occupational competence levels of students improved after COMET Learning Tasks were implemented, from 21.1% to 51.56% (30.46% improvement) at a Functional level, 8.42% to 27.64% (19.24% improvement) at Processual level; and 3.01% 19.1% (16.09% improvement) at Holistic competence level. Nominal competence decreased from 67.37% to 2.01%, i.e. a competence improvement of 65.36%). The poor holistic occupational competence levels signal the need for TVET didactic reforms that enhance holistic and innovative problem-solving competence. The fact that 8.42% of the students responded to the COMET base line test tasks at the know-that level of Work Process Knowledge is indicative of a "Teaching to Test" approach. This type of teaching approach is contrary to what the COMET diagnostic model proposes in section 3.3. The lack of understanding and reflective thinking that are key elements of modern work, places TVET students at risk. The initial improvement towards the "know-why" level of Work Process Knowledge in the main COMET test task is indicative of the didactic impact of COMET.

In the main test, 27.64% of the students at all test sites attained the Processual Competence level to perform professional tasks that are interpreted in the context of company work processes and situations. These students were also able to apply their knowledge ("Know how") to solve work-related tasks. Furthermore, 3.01% of students in the baseline test attained Holistic Shaping Competence, which then increased by 16.09% to 19.1% in the main test. This means that 19.1% of students in the main test attained a Holistic Shaping Competence level, in which they fully realised the complexity of professional work tasks, and were able to solve the test tasks while focusing on the divergent demands in the form of intelligent compromises.

6.5 Research Contribution

This thesis sought to add scientific knowledge to the body of knowledge already available in the field of occupational competence development and to effectively contribute to the testing and continuous deployment of the COMET diagnostic model within the South African TVET setting. More specific contributions of this research are:

6.5.1 Contributing Towards Bridging the Competence Divide Between Existing TVET Education and the Competence Requirements of Industries

Considering the overall improvement, measured by practically significant increase (measured by Cohen's d effect sizes and reported in Table 5.29) in TVET students' occupational competence after being exposed to COMET didactics in the current study; as well as the positive feedback received from the TVET lecturers who applied the model in their classrooms, it is clear that the COMET diagnostic model for occupational competence development and assessment is a supportive tool that TVET colleges can successfully implement to bridge the gap that exists between students' competence development and the actual industry-related competence required for entry level positions. There is a growing concern in South Africa about the quality of TVET graduates, and whether the training offered at TVET colleges adequately produces graduates with cutting-edge industry-based knowledge, skills and occupational competence (Teis & Els, 2021; Zungu, 2015). One way to improve the quality of TVET graduates is to focus on teaching and learning that will improve both the performance of TVET colleges, as well as the occupational competence of their students (Department of Higher Education and Training, 2013a, 2013b, 2013c). The production of competent workers with cutting-edge knowledge and skills needed by industry is currently one of the biggest challenges facing South African TVET colleges. (Makgato, 2019; Nzimande, 2021; Teis & Els, 2021). While TVET college students' theoretical knowledge is measured by the administration of examinations, practical skills and competence should also be measured to determine the range of skills that students have obtained for the diverse demands of various occupations. The training and transfer of skills is vital to ensure that students receive the requisite skills and occupational competence that will allow them to flourish in the workplace. For students to be classified as competent after completing an occupational programme, it is crucial that they complete the entire process of learning through theory and practical training. The didactical application of the COMET model in this study exposed students to typical authentic work-tasks. These tasks allowed students to develop and apply work-process knowledge, thereby narrowing the existing divide between existing TVET education and the competence that students need for entering the world of work at an advanced beginner level.

The following findings of this investigation have direct implications for TVET Electrical Engineering students' professional development:

- Findings of the current research show that the occupational competence of participating Electrical Engineering students significantly increased after the COMET intervention. The general occupational competence profile of the TVET students clearly improved from a competence profile that was initially weak, to a strong competence profile, due to the COMET learning tasks intervention. Participants' total professional competence profile mean score increased with 41.59%, after participating in the COMET tasks.
- Furthermore, 3.01% of students in the baseline test attained Holistic Shaping Competence, which then increased by 16.09% to 19.1% in the main test. This means that 19.1% of students in the main test attained a Holistic Shaping Competence level, in which they fully realised the complexity of professional work tasks, and were able to solve the test tasks, while focusing on the divergent demands in the form of intelligent compromises.

These findings suggest the great potential of COMET research and development for the future training and development of Electrical Engineering students within the South African TVET context.

The overall findings in this study shows that the COMET model can be a viable model to prepare TVET college Electrical Engineering students to be fit for the world of work.

6.5.2 Contributing Towards the Growing Body of Knowledge Pertaining to the Didactical Application of the COMET Diagnostic Model

The current study was a direct response to Section 3.6 of the merSETA (2016, p. 47) report's call for further research into the application of the COMET diagnostic model as a didactic tool to develop and assess occupational competence in the South African TVET context. The findings of the current study contribute positively towards merSETA's mandate to increase students' access to high quality and relevant skills development and training opportunities.

It became clear from the exposition of literature in Chapters 1 and 2 that occupational competence can be measured in various ways, of which the COMET diagnostic model stands out amongst other available models found in literature to effectively develop and assess occupational competence development amongst TVET students. In previous research applying the COMET methodology it was found that the application of the COMET competence diagnostic model offered the opportunity to enhance classroom teaching and learning through a didactic approach that focused on developing students from beginners to advanced levels. Prior to the current investigation, no other research study has specifically investigated the didactic application of the COMET diagnostic model for the development of occupational competence amongst Electrical Engineering students within the South African TVET landscape – a knowledge gap that the current investigation successfully addressed by means of a mixed-methods research initiative. This thesis lays the foundation and offers a point of reference for future South African research studies furthering the didactic application of the COMET diagnostic model for competence development and assessment at South African TVET colleges. The findings of this research report also contribute to the growing corpus of knowledge pertaining to the trans-cultural didactical application of the COMET model for effective competence development and assessment across various TVET systems around the globe.

6.5.3 Responding to the Realisation of National Post-School Education and Training Policies

The real challenge facing the TVET system in South Africa is to make high quality technical occupational education accessible to all, without losing sight of TVET's special relationship with the world of work (McGrath, 2012). The issue of occupational competence is identified by the National Skills Development Strategy 3 (NSDS III) (2013) as being amongst the hindrances that affect the expansion of the South African economy negatively and on its ability to increase employment. The National Skills Development Strategy 3 (2013) mentions poor work readiness and inadequate skills levels of TVET graduates, which impacts negatively on young people entering the labour market for the first time. The current study supports the realisation of the policy's vision for TVET students to practically acquire the necessary occupational skills and competencies to be able to add value to South Africa's existing workforce. The findings of the current investigation substantiate the COMET diagnostic model as a reliable didactical tool that TVET lecturers can use to effectively develop and assess the occupational competence of their students. This, in turn, could support the realisation of the South African Government's commitment to produce 30 000 artisans by 2030 (Department of Higher Education and Training, 2013a), in line with the aspirations of the White Paper on Post-School Education and Training (PSET) (Department of Higher Education and Training, 2013c, p. 16) for TVET colleges to effectively prepare students for the workplace.

The findings, conclusions and recommendations made by the current research could possibly inform the development and re-visioning of existing and future national Post-School Education and Training policies, by providing strategic information to policy makers regarding occupational competence development and assessment of Electrical Engineering students in TVET education and training.

6.6 Limitations of this Research

The current investigation was limited by the following:

- The study was conducted during the ongoing COVID-19 pandemic, which had a negative impact on (i) the availability of time, as the TVET colleges were running on rotational timetables; and (ii) the availability of lecturer participants, due to health precautionary measures. These limitations made the full didactic implementation and application of the COMET model very challenging. Consequently, the true potential of the COMET model might not have been fully realised in this study. TVET lecturers embraced the use of the COMET model but with caution, fearing that the implementation of the learning tasks in their classrooms would rob them of the already limited time that they had with their students due to rotational timetables. Nonetheless, the COMET model was applied well, although it was necessary to make use of a smaller sample and less TVET Colleges that were originally anticipated. All test material was developed and validated prior to lockdown.

- South African TVET colleges are mainly catering for students who have a history of struggling academically. It can be inferred from the findings of this investigation that within South Africa's unique TVET context, both lecturers and students could possibly have benefited more if more than two learning tasks were used and if these were implemented over a longer period.

6.7 Recommendations

The following recommendations are based upon the overall findings of this investigation:

- Longitudinal studies on the didactical use of the COMET diagnostic model in TVET teaching and learning are recommended to study the impact of the application of the COMET model over time.
- For lecturers and students to fully engage in the didactic process and make use of the didactic potential of the COMET diagnostic model, training workshops should be offered, and the engagement time should be extended. TVET colleges are not sufficiently focussed

on competence and its characteristics, especially those competencies that will be required for students to successfully enter industries. The COMET diagnostic model empowers students with competencies and entrepreneurial aspirations that are not currently being provided by the curriculum of the Electrical Engineering National Certificate Vocational Programme. The implementation and application of the COMET diagnostic model is therefore recommended as a supplementary didactic tool to support the National Certificate Vocational programmes, and to empower students to participate in the country's economic activities effectively.

- The COMET diagnostic model should be introduced throughout the South African TVET system for the continuous professional development of TVET Electrical Engineering lecturers.

COMET offers an innovative model for TVET didactics, comparable to what Germany has long used. In the current study, participating TVET lecturers used the COMET occupational competence learning tasks to enhance the existing TVET Electrical Engineering curriculum, in-between traditional Electrical Engineering lessons, to expose TVET students to real-life and industry-based scenarios, bringing together various didactical dimensions of the curriculum, and challenging students to find holistic solutions for modern work problems.

6.8 Questions for Future Research

The following research questions have arisen for future investigation:

(i) How can South African TVET benefit didactically from the inclusion of more COMET learning tasks?

(ii) How should the COMET methodology be integrated into college curricula for effective diagnostic and didactic purposes?

(iii) What intervention strategies are necessary to didactically support TVET students who perform at the "at risk" nominal competence level, in line with South African Inclusive Education Policies?

(iv) What didactic actions are needed to develop TVET college students from "know that" to "know how" and "know why" Work Process Knowledge levels?

6.9 Concluding Comments

My journey in conducting this study was both exciting and challenging. The most exciting part of the study was having to investigate an idea that holds the potential to improve the occupational development of TVET students in our country. The idea of exposing TVET lecturers to COMET didactics was both intimidating and exciting. This was due to the tendency for people to resist new ideas. However, it was very refreshing to be welcomed at all the campuses by TVET college principals, campus managers, lecturers, and students, who were all willing to participate and contribute towards this study. These stakeholders were all aware of the many challenges facing the TVET sector and were willing to actively assist in finding practical solutions.

The biggest challenge was having to collect data during the Covid-19 pandemic. However, the motivation and support I received from my supervisors during these challenging times, made these challenges seem insignificant, because they shared my aspiration for this project to bear fruit.

This study presented me with the opportunity to work with TVET lecturers and students from diverse cultural and language backgrounds and significantly boosted my professional development as a researcher, giving me a first-hand opportunity to observe competence development at grassroots level, and to contextualise the COMET diagnostic model for the unique South African TVET landscape. This COMET research significantly added value to how lecturers and students alike saw their work, and their own competence development.

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Addenda

Addendum A	Ethical Clearance Certificate
Addendum B	Letter of Proofreading and Language Editing
Addendum C	Formal Permission Letters Obtained from TVET Colleges
Addendum D	Example of Informed Consent Letter
Addendum E	Motivational, Occupational Identity and Commitment Questionnaire
Addendum F	COMET Rating Sheet
Addendum G	Main and Baseline Tasks
Addendum H	Turnitin Report (Similarity Index)
Addendum I	Transcriptions of Focus-Group Interview Narratives

Addendum A: Ethical Clearance Certificate

UNIVERSITY *of the* WESTERN CAPE

RESPICE PROSPICE

60 YEARS *of hope, action & knowledge*

05 February 2021

Mr J Sibanda
IPSS
Faculty of Education

Ethics Reference Number:	HS19/8/24
Project Title:	Using the comet diagnostic model to enhance occupational competence of electrical engineering students in TVET colleges.
Approval Period:	04 February 2021 – 04 February 2024

I hereby certify that the Humanities and Social Science Research Ethics Committee of the mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report by 30 November each year for the duration of the project.

The permission to conduct the study must be submitted to HSSREC for record keeping purposes.

The Committee must be informed of any serious adverse events and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

NHREC Registration Number: HSSREC-130416-049

Director: Research Development
University of the Western Cape
Private Bag X 17
Bellville 7535
Republic of South Africa
Tel: +27 21 959 4111
Email: research-ethics@uwc.ac.za

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Addendum B: Letter of Proofreading and Language Editing

Faculty of Education

Cape Peninsula University of Technology

Jan van Riebeek Road

Wellington

7654

24/4/2023

To whom it may concern,

This letter serves to inform you of the fact that I undertook standard editing procedures for the doctoral thesis entitled:

Using the COMET diagnostic model to enhance occupational competence of electrical engineering students in TVET colleges

The editing process included the following:

- Checking spelling, grammar and punctuation
- Checking syntax and morphology
- Correction of concord errors and the appropriateness of verb tenses
- Correction of active and passive voice errors
- Transitional phrasing
- Continuity of thoughts
- Supporting statements and argumentation

Thank you for your consideration in this matter.

Yours sincerely

Prof Candice Livingston

Associate Professor (English) and Research coordinator

Faculty of Education

Cape Peninsula University of Technology

livingstonc@cput.ac.za

Addendum C: Formal Permission Letters Obtained from TVET Colleges

UNIVERSITY *of the* WESTERN CAPE

REQUEST FOR PERMISSION FOR SITE PARTICIPATION

For Att: Training Provider CEOs / PRINCIPALS

15 July 2019

Dear Sir/madam

I am currently undertaking a research project within the scope of a supervised PhD topic:

Using the COMET diagnostic model didactically enhance the occupational competence of Electrical Engineering students in TVET colleges.

The questions I plan to answer in this study are as follows:

Main Question

How can the COMET diagnostic model didactically enhance the occupational competence of Electrical Engineering students in TVET colleges?

Sub-questions

1. What are the strengths and weaknesses of COMET occupational competence assessment for quality assurance practices in Electrical Engineering studies at TVET Colleges?

2. Can the COMET model didactically enhance occupational competence development of Electrical Engineering students at a conceptual level?

DHET statistics show that that there are 50 colleges in the country however, we have identified your college to participate because of the infrastructure that you have at your institution and the variety of programs that you offer in the Electrician engineering occupation.

Research methodology:

The study will be a longitudinal study implemented to measures change in development of research participants' occupational competence at two separate points before and after intervention. Therefore, data will be collected at your sites in the period of January to June 2020, where final COMET test will take place

CONTACT DETAILS OF RESEARCHER AND SUPERVISOR/CO-SUPERVISOR:

CONTACT DETAILS OF RESEARCHER AND SUPERVISOR:

Researcher: James Sibanda
Mobile number:
Email: 3783792@myuwc.acza

Supervisor: Prof. J. Papier
Contact number: 021 959 9594
Email: japapier@uwc.ac.za

Co-Supervisor: Dr. P. Jacobs
Contact number: 021 959 9596
Email: pajacobs@uwc.ac.za

SIGNATURE OF PRINCIPAL/CEO:

I ___________________________ (name of CEO/Principal) have read the information provided…………I therefore agree to the participation of _______________________ (name of institution) in this study.

Signature of participant: ____________________________ Date: _______________

Addendum D: Example of Informed Consent Letter

UNIVERSITY of the WESTERN CAPE

CONSENT FORM TO PARTICIPATE IN RESEARCH

July 2019

Dear TVET Student

Request and intention of the letter............................

Purpose of the study.

Potential benefits of the research.

Participation and withdrawal. (Ethics)

Confidentiality.

Please provide the information ....:

PERSONAL DATA OF RESEARCH PARTICIPANT:

Last name / surname: ______________________________

First name / given name: ______________________________

Your year of training:

Gender: Male / Female

Study programme: ______________________________

SIGNATURE OF RESEARCH PARTICIPANT:

I ______________________________ (name of research participant)........................

Signature of participant: ___________________________ Date: _______________

CONTACT DETAILS OF RESEARCHER AND SUPERVISOR:

Researcher:
Mobile number:
Email:

Supervisor: Prof. J. Papier
Contact number: 021 959 9594
Email: japapier@uwc.ac.za

Co-Supervisor: Dr. P. Jacobs
Contact number: 021 959 9596
Email: pajacobs@uwc.ac.za

UNIVERSITY of the
WESTERN CAPE

INFORMATION SHEET FOR RESEARCH PARTICIPANTS

July 2019

Dear ___________________ (name inserted),

This information sheet provides you with background information about the research study we will be conducting at your site.

Importance of study and participation
The finding of this study will assists future policy decisions. The study will also assist in discovering if the COMET way of teaching and assessing may improve results. The participants in the study will be exposed to a different method of teaching that have a potential to improve their competence as well as their performance.

During the course of the study, data will be collected on three separate occasions, that is two for the test tasks and once for the final COMET test. In between the test tasks and the final COMET test students will be exposed to the COMET teaching and assessment methods by their lecturer is the classroom.

What happens after research has been completed at your site?
After the study has been completed at your site we shall inform you in writing. Data collected during the course of the study will be locked away in a safe for the period of five years, then after it will be destroyed in a way that is approved by the University so that the participants are protected. We will also make the findings of the study available to you.

This research aims to find alternative ways of teaching and learning to enhance occupational competence of Electrical Engineering students in TVET colleges. Therefore, your participation will assist in making positive contribution and add a voice in the current TVET discourse.

Further enquiries can be made to the researcher directly or her supervisor indicated below:

<u>CONTACT DETAILS OF RESEARCHER AND SUPERVISOR</u>:

Researcher: Mr James Sibanda
Mobile number: 0729698706
Email : jamessibanda32@gmail.com

Supervisor:	Professor Joy Papier	Co-Supervisor :
Contact number:	021 959-9595	Contact number:
Email:	Jpapier@uwc.ac.za	Email:

Addendum E: Motivational, Occupational Identity and Commitment Questionnaires

Part 1 : Motivational Questionare for students

First name (given name): ___________________
last name (surname): ___________________

Year of apprenticeship: ☐ 1 ☐ 2 ☐ 3 ☐ 4

Sex: ☐ male ☐ female Age: ____ years

Apprenticed profession (Please indicate the occupation you are learning):

☐ electrician ☐ mechatronic ☐ welder ☐ Other (please indicate)

Test site:	1	*Sample test site 1*	☐
	2	*Sample test site 2*	☐
	3	*Sample test site 3*	☐
	4	*Sample test site 4*	☐
	5	*Sample test site 5*	☐
	6	*Sample test site 6*	☐

1. Which task did you work on?

____

2a. How difficult did you find the solution of the task?

☐ very difficult
☐ rather difficult
☐ rather easy
☐ very easy

2b. Why? ____

____

____

3. How long did you work on the test task?

☐ less than half an hour
☐ ½ - 1 hour
☐ 1 – 1½ hours
☐ 1½ - 2 hours

Addendum E Continues…

3a

	very much			*not at all*
Was it interesting to work on the test task?	☐	☐	☐	☐
How useful do you consider this kind of test tasks?	☐	☐	☐	☐
How closely is the test task related to your occupation?	☐	☐	☐	☐
How concentrated did you work on the test task?	☐	☐	☐	☐
How much effort did you make working on the test task?	☐	☐	☐	☐

3b. Would you approve if this kind of task would become part of your vocational training?

☐ yes ☐ no

3c. Why?

____

____

____

____

____

Thank you

Part 2 : Personal and general questions

Given name, first name: ________________________

Year of apprenticeship: 1 2 3 4

Sex: ☐ male female Age: __ years

Addendum E Continues…

Post code of your home town: ______________

Which language do you and your parents usually speak at home?

☐ Africaans	☐ English
☐ IsiZulu	☐ IsiXhosa
☐ Ndebele	☐ Sepedi
☐ Sesotho	☐ Setswana
☐ Siswati	☐ Tshivenda
☐ Xitsonga	☐ another:

Which entry qualifications did you obtain before applying for this apprenticeship?

☐ Some credits from University based on an engineering qualification	☐ Technical Grade 12 with maths and science Vocational (NCV) – Level 4
☐ NQF 2 to 4	☐ NTC 1 +2
☐ NTC 3 + 4	☐ NTC 5 + 6
☐ Grade 10 – 11 with Maths and Science	☐ Grade 9
☐ another (please indicate) :	

What were your grades at general school…

	more than 75	**70 -75**	**65 - 70**	**60 - 65**	**55 - 60**	**50 - 55**	**less than 50**
in English?	☐	☐	☐	☐	☐	☐	☐
in Maths?	☐	☐	☐	☐	☐	☐	☐
in foreign languages	☐	☐	☐	☐	☐	☐	☐

My parents…

	strongly disagree	disagree	neither agree nor disagree	agree	Strongly agree
are interested in my apprenticeship.	☐	☐	☐	☐	☐
are supporting me in my apprenticeship.	☐	☐	☐	☐	☐
are proud of me doing this apprenticeship	☐	☐	☐	☐	☐

	yes	**no**
My father is working in a similar profession.	☐	☐
My mother is working in a similar profession.	☐	☐
One of my relatives is working in a similar profession.	☐	☐

Addendum E Continues…

What is your father's/mother's school degree? (Multiple answers possible)

Mother: ☐no fomal education ☐elementary school ☐secondary school
☐high school ☐college or university

Father: ☐no fomal education ☐elementary school ☐secondary school
☐high school ☐college or university

Please comment the following:

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
The notions 'occupation', 'profession', 'vocation' and 'job' have more or less the same meaning.	☐	☐	☐	☐	☐
It does not matter that much which vocation I learn, what counts is employment.	☐	☐	☐	☐	☐
It is true, that one can change jobs easier than an occupation.	☐	☐	☐	☐	☐
An occupation is a part of one's identity.	☐	☐	☐	☐	☐
A job is a part of one's identity.	☐	☐	☐	☐	☐

Which of the following statements regarding the reason you choose this occupation are the ones that describe your motivations best?

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
I always wanted to take up the occupation that I am learning now.	☐	☐	☐	☐	☐
I rather wanted to learn a different occupation but did not get a position.	☐	☐	☐	☐	☐
If another, which occupation did you originally prefer?					
It was important for me to do the training at this college (if relevant)	☐	☐	☐	☐	☐
It was important for me to do the training at this company (if relevant).	☐	☐	☐	☐	☐
My training company is likely to offer me employment after I have finished my apprenticeship.	☐	☐	☐	☐	☐
Later (after finishing apprenticeship), I will be able to earn a lot of money in my vocation.	☐	☐	☐	☐	☐
My friends think my profession is ok.	☐	☐	☐	☐	☐
My profession has a good reputation in society.	☐	☐	☐	☐	☐

Addendum E Continues…

What is your opinion? Please comment on the following statements:

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
I like to tell others about the profession I am learning.	☐	☐	☐	☐	☐
I like to tell others about my training company.	☐	☐	☐	☐	☐
I ‚fit' to my **profession**/my profession suits my personality	☐	☐	☐	☐	☐
I ‚fit' to my **company**.	☐	☐	☐	☐	☐
I feel motivated no matter what my work tasks are.	☐	☐	☐	☐	☐
I am not that interested in my **profession**.	☐	☐	☐	☐	☐
I do not feel much "attached" to my **company**.	☐	☐	☐	☐	☐
I am proud of my **profession**.	☐	☐	☐	☐	☐
I am proud of working in/for my **company**.	☐	☐	☐	☐	☐

Addendum E Continues…

Part 3: Questions about situation at your college

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
I feel comfortable at college.	▯	▯	▯	▯	▯
Mostly, I find the lessons interesting.	▯	▯	▯	▯	▯
Interaction between students and Teachers is friendly and trusting.	▯	▯	▯	▯	▯
Class-/Schoolmates are often disturbing the lessons.	▯	▯	▯	▯	▯
Class-/Schoolmates do not show much respect for other students.	▯	▯	▯	▯	▯
Schoolmates sometimes vandalise.	▯	▯	▯	▯	▯
Schoolmates often skip school.	▯	▯	▯	▯	▯
Our teachers....					
In the lessons, our teachers consider the students interests.	▯	▯	▯	▯	▯
Our teachers present interesting lessons.	▯	▯	▯	▯	▯
Our teachers take students seriously.	▯	▯	▯	▯	▯
The teachers have a good picture of the real work life/the reality in the companies.	▯	▯	▯	▯	▯
The teachers co-operate with trainers from my company.	▯	▯	▯	▯	▯
The teachers take care of individual students.	▯	▯	▯	▯	▯
The teachers are co-coordinating their lessons among each other.	▯	▯	▯	▯	▯
Cooperation between learning venues (FET college / apprenticing company)					
My college and the company offering in-company training are co-ordinating the training.	▯	▯	▯	▯	▯

Addendum E Continues…

The FET college and the training company are conducting learning projects together.	☐	☐	☐	☐	☐
The college only co-operates with the training companies if students do not show up or if there are other serious problems.	☐	☐	☐	☐	☐
I think that the training company is pleased with the education at the FET college.	☐	☐	☐	☐	☐
The significance that my training company attaches to the role of the college is very high.	☐	☐	☐	☐	☐
I think that the FET college is pleased with the training at the company.	☐	☐	☐	☐	☐
What I learn in the vocational school and what I learn in the company fits well.	☐	☐	☐	☐	☐
I learn more during my training in the company than at college.	☐	☐	☐	☐	☐
At the college, I can make good use of what I learned at the company.	☐	☐	☐	☐	☐
At the company, I can make good use of what I learned at school.	☐	☐	☐	☐	☐
Lessons at the college can be applied to real world issues within the company.	☐	☐	☐	☐	☐
Further estimations:					
I feel confident to have a good command of what is trained at college.	☐	☐	☐	☐	☐
I am sure that I can achieve good results in my tests at college.	☐	☐	☐	☐	☐

What I learn at vocational school is important for my profession.	☐	☐	☐	☐	☐
I am certain to understand even the most complicated things I have to learn at college.	☐	☐	☐	☐	☐

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
I like to work autonomously.	☐	☐	☐	☐	☐
I like to work in teams.	☐	☐	☐	☐	☐
I like to take over responsibility for my work tasks.	☐	☐	☐	☐	☐
I feel good when I work autonomously.	☐	☐	☐	☐	☐
I feel good when I work in teams.	☐	☐	☐	☐	☐
I feel good when I take over responsibility form my tasks.	☐	☐	☐	☐	☐
Whenever possible, I avoid working autonomously.	☐	☐	☐	☐	☐
Generally, I am good in working in teams.	☐	☐	☐	☐	☐
Generally, I succeed when I take over responsibility for work tasks.	☐	☐	☐	☐	☐

Addendum E Continues…

	very seldom	rarely	some-times	often	very often
How often do apprentices work in teams during the **theoretical** part of your training / in VET colleges?	☐	☐	☐	☐	☐
How often do you work in teams during the **practical** part of your training, i.e. in a training company?	☐	☐	☐	☐	☐
	not enough	rather not enough	just right	rather too much	too much
What is your estimation on the amount of team work in the **theoretical** part of your training?	☐	☐	☐	☐	☐
What is your estimation on the amount of team work in the **practical** part of your training?	☐	☐	☐	☐	☐
	not at all	rather not	fairly well	well	very much
How do your teachers support or facilitate team work in **VET colleges**?	☐	☐	☐	☐	☐
How do your trainers in your **training companies** support or facilitate team work with other apprentices or colleagues?	☐	☐	☐	☐	☐

Addendum F: COMET Rating Sheet

Rating Sheet
Task No: Verification
Teacher

		Requirement...			
		not met at all	rather not met	rather met	fully met
	(1) Clarity /Presentation				
1	Is the solution's presentation understandable for the client/orderer/customer/employer?				
2	Is the solution presented on a skilled woker's level?				
3	is the solution visualised (e.g. graphically)?				
4	Is the presantion on the task's solution structured and clearly arranged?				
5	Is the presantion adequate? (e.g. theoritically,practically,mathematically,causative)?				
	(2) Functionality				
6	is the solution operative?				
7	Is the solution state-state-of-the art?				
8	Are practical implementation and construction considered?				
9	Are the relations to professional expertise adequately presented and justified?				
10	Are presentations and explanation right				
	(3) Use value/Sustainability				
11	Is the solution easy to maintain and repair?				
12	Are expandabilities and long term usability considered and explained?				
13	Is countering susceptibility to faults considered in the solution?				
14	How much user-friendly is the solution for the direct user?				
15	How good is the solution's practical use value (e.g. of some equipment) for the order/ client				
	(4) Cost effectiveness/Efficiency				
16	Is the solution efficient and cost effective?				
17	Is the solution adiquate in terms of time and persons needed?				
18	Does the solution consider the relation between time and effort and the company's benefit?				
19	Are follow-up costs considered?				
20	Is the procedure to solve the task(work process) efficient?				

		Requirement...			
		not met at all	rather not met	rather met	fully met
	(5) Orientation on Business and Work Processes				
21	Is the solution embedded in the company's work and business processes (in company/at the client)?				
22	Does the solution based on work experiences?				
23	Does the solution consider preceeding and following work/business processes?				
24	Does the solution express skills related to work processes that are typical for the profession?				
25	Does the solution consider aspects that go beyond the particular profession?				
	(6) Social Responsibility				
26	To what extent does the solution consider possibilities of a humane work organisation?				
27	Does the solution consider aspects of health protection?				
28	Does the solution consider aspects ergonomical aspects?				
29	Does the solution follow the relevent rules and regulations regarding work safety and prevention of accidents				
30	Does the solution consider social consequences?				
	(7) Environmental Responsibility				
31	Does the solution consider the relevent environmental regulations?				
32	Do the materials used comply criteria of environmental compatibility?				
33	To what extent the solution consider an environmentally friendly work organisation?				
34	Does the solution consider recycling, re-use and sustainability				
35	Does the solution address possibilities of energy saving and better energy efficiency?				
	(8) Creativity				
36	Does the solution include original aspects in excess of the solution space?				
37	Have different criteria been weighted agaist each other?				
38	Has the solution some creative quality				
39	Has the solution show awareness of the problems?				
40	Does the solution tap the task's leeway?				

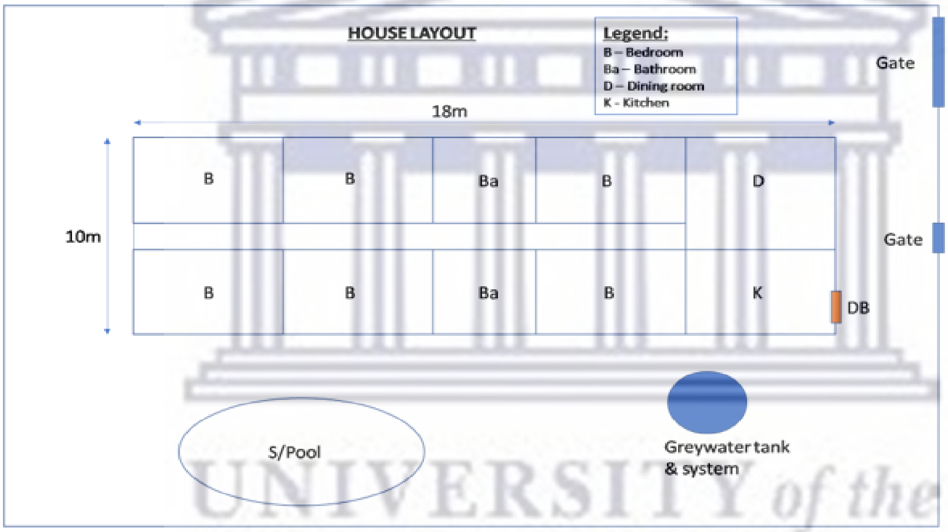
Addendum G - Example of COMET test

Main test

COMET TEST TASK 20: HOUSE RENOVATIONS AND UPGRADES

Background

A client purchased an abandoned house in an upmarket suburb at an auction for a bargain price. His intention is to get an income by putting the house up for rental and he wants to attract the younger generation. To make the house more marketable in terms of getting a good tenant he wants to renovate the house. He wants to make the house energy efficient. There are no electrical plans or a certificate of compliance available for the house. Currently the problems at the house include, but are not limited to, earth leakage tripping, swimming pool pump not working, and the bathrooms do not have hot water. The house layout is given in the diagram below.



Assignment

Assignment

The client contacted you, the electrician, and would like you to advise him on the best solution for the electrical repairs, replacements, and installations.

Prepare the required documentation that explains and covers the task at hand in detail. Write down any additional steps to implement the client's requirement/s. Write down additional questions and /or suggestions to be asked or made in follow up meeting/s with the client or with workers from within or outside the trade.

Provide a comprehensive explanation of your proposed solution by considering the following criteria:

a. The **clear presentation** of your solution to be able to discuss it with the customers, your work group, and your work supervisors.
b. The **functionality** of a good complete solution.

COMET TEST SERIES: 2020	Original date developed: 22 November 2019
Title: Test Task 20- House Renovations and Upgrades	Last review: 10 March 2020
Occupation: Electrician	

c. Aspects of **value in use** and over time.
d. The cost **effectiveness** and cost **efficiency** of your solution.
e. The effectiveness of the **process** and its **integration** into business operations.
f. The **social responsibility**, including aspects of work, health, and safety.
g. The aspects of **environmental compatibility** and related regulations.
h. You are encouraged to show your **creativity**.

Additional material

You may use all standard materials such as tables, manuals, textbooks, calculators, data sheets, the internet, your own notes and the applicable regulations and standards, including but not limited to the South African National Standards (SANS) and the Occupational Health and Safety Act (85) of 1993 with the various amendments to do the assignment.

Baseline Tests

COMET TEST TASK 8: MAINTENANCE AND REPAIRS OF POWER TOOLS

Background situation

Tony's Tool Hire, in Durban, Kwa-Zulu Natal, has various power tools that are out of order/faulty. Tony's business is now suffering because he cannot supply the power tools to clients/ contractors in the region. Tony cannot replace the power tools as they are costly, so he wants the faulty power tools, repaired. He also requests any innovation to the tools that would make them more marketable. The list of faulty power tools includes:

1] Drilling machines.

2] Circular saws, Cut-off machines.

3] Jig saws.

4] Angle grinders.

Assignment:

Tony has contacted you, his reliable electrician, and requires you to assist him. He asks that you test and repair all the faulty power tools and equipment. Careful consideration must be given to the fault-finding, methods and techniques that you will use. You will also need to list the various tests that you will perform on the above power tools, including the internal components. Make a detailed list of the maintenance procedures so that it can be used for future references.

COMET TEST SERIES: 2020	Original date developed: 22 November 2019
Title: Test Task 8 – Maintenance and Repairs of Power Tools	Last review: 11 March 2020
Occupation: Electrician	Page **1** of **2**

Provide a comprehensive explanation of your proposed solution by taking into account the following criteria:

a. The **clear presentation** of your solution so as to be able to discuss it with the customers, your work group and your work supervisors
b. The **functionality** of a good complete solution
c. Aspects of **value in use** and over time
d. The **cost effectiveness** and cost **efficiency** of your solution
e. The effectiveness of the **process** and its **integration** into business operations
f. The **social responsibility**, including aspects of work, health and safety
g. The aspects of **environmental compatibility** and related regulations
h. You are encouraged to show your **creativity**.

Additional material

You may use all standard materials such as tables, manuals, textbooks, calculators, data sheets, the internet, your own notes and the applicable regulations and standards, including but not limited to the South African National Standards (SANS), Construction Regulations; Mine Health and Safety Act, Municipal by-laws, environmental standards, traffic regulations, operating regulations for high voltage systems and the Occupational Health and Safety Act (85) of 1993 with the various amendments to do the assignment.

COMET TEST TASK 6: PROBLEMATIC STOVE

Background situation

A client has encountered a problem with his four plate stove/oven (diagram 1). When the stove switches are in the OFF position the indicator lights for each of the four plates are slightly lit (diagram 2). Further to that the front left plate is not working at all. When the client uses any two of the remaining three plates the circuit breaker trips (see circuit breaker closest to the main switch in diagram 3). Diagram 4 shows that the stove is connected to a three-pin plug using insulation tape.

Diagram 1: Stove/oven

Diagram 2: Stove switches in OFF position

Diagram 3 : Current Distribution Board with all circuit breakers OFF.

Diagram 4: Power connection to stove

Assignment

The client wants you (the contractor) to assist him in solving and fixing the problem and he wants his stove to be fully operational.

COMET TEST SERIES: 2020	Original date developed: 22 November 2019
Title: Test Task 1 – Problematic Stove	Last review: 24 February 2020
Occupation: Electrician	Page **1** of **2**

Prepare the required documentation that thoroughly explains and covers the task at hand. Write down any additional steps to implement the clients requirement/s. Write down additional questions and/or suggestions to be asked or made in follow up meeting/s with the client or with workers from within or outside the trade. Provide a **comprehensive** explanation of your proposed solution by taking into account the following criteria:

a. The **clear presentation** of your solution so as to be able to discuss it with the customers, your work group and your work supervisors
b. The **functionality** of a good complete solution
c. Aspects of **value in use** and over time
d. The **cost effectiveness** and cost **efficiency** of your solution
e. The effectiveness of the **process** and its **integration** into business operations
f. The **social responsibility**, including aspects of work, health and safety
g. The aspects of **environmental compatibility** and related regulations
h. You are encouraged to show your **creativity**.

Additional material

You may use all standard materials such as tables, manuals, textbooks, calculators, data sheets, the internet, your own notes and the applicable regulations and standards, including but not limited to the South African National Standards (SANS), Construction Regulations; Mine Health and Safety Act, Municipal by-laws, environmental standards, traffic regulations, operating regulations for high voltage systems and the Occupational Health and Safety Act (85) of 1993 with the various amendments to do the assignment.

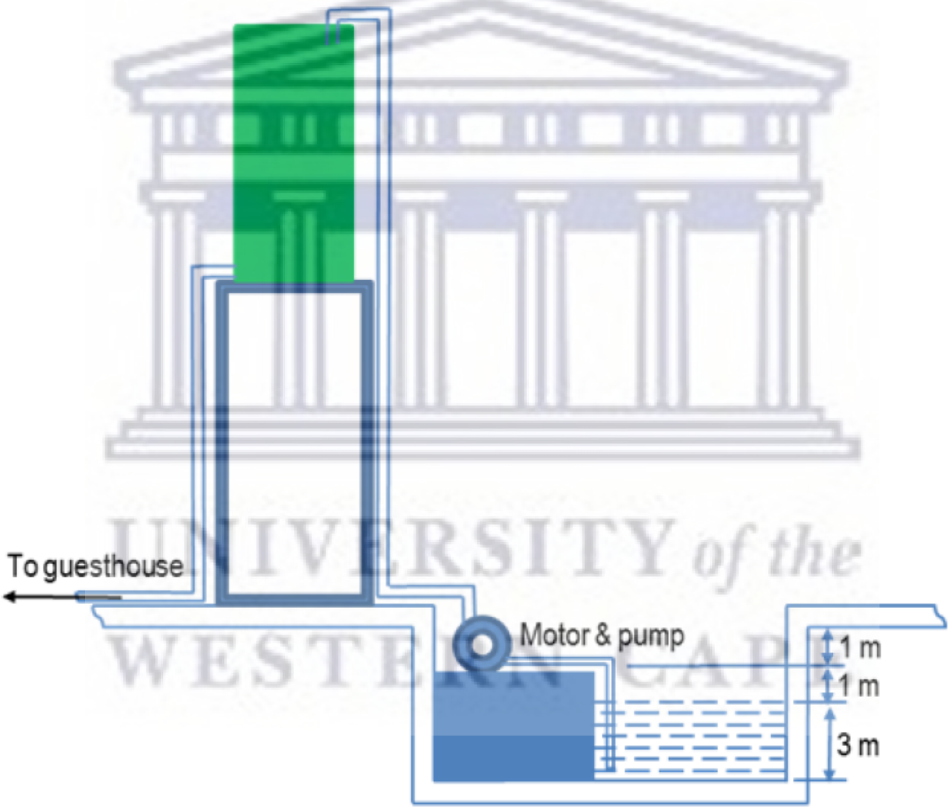
COMET TEST TASK 1: GUESTHOUSE WATER PLANT

Background situation

The diesel price tripled since the opening of a "Green" guesthouse, next to a highway in the drought-stricken Karoo, in South Africa. The guesthouse is dependent on spring water from a man-made sump 4 km from the guesthouse. The sump and supply tank are fenced in and is physically inspected 3 times per day to ensure correct operation and water levels. The fact that the sump pump relies on electricity to operate makes the guesthouse vulnerable in the event of a power outage.

The pump is driven by a 3kW three phase motor. The water level in the tank is controlled by a float switch which must ensure that the water level will not drop to less than half the tank level.

The client provides a diagram of the water system in use.



Assignment

In a meeting the client expressed the need to ensure that the perimeter of the pump house is secure at all times and that the guest house must be supplied with water at all times. He requires that the solution be as innovative as possible. Use the diagram to provide further sketches and a detailed explanation of what you would do to meet this client's requirements.

COMET TEST SERIES: 2020	Original date developed:22 November 2019
Title: Test Task 1 - Guest House Water Plant	Last review: 10 March 2020
Occupation: Electrician	Page **1** of **2**

Prepare the required documentation that thoroughly explains and covers the task at hand. Write down any additional steps to implement the client's requirement/s. Write down additional questions and/or suggestions to be asked or made in follow up meeting/s with the client or with workers from within or outside the trade.

Provide a **comprehensive** explanation of your proposed solution by taking into account the following criteria:

a. The **clear presentation** of your solution so as to be able to discuss it with the customers, your work group and your work supervisors
b. The **functionality** of a good complete solution
c. Aspects of **value in use** and over time
d. The **cost effectiveness** and cost **efficiency** of your solution
e. The effectiveness of the **process** and its **integration** into business operations
f. The **social responsibility**, including aspects of work, health and safety
g. The aspects of **environmental compatibility** and related regulations
h. You are encouraged to show your **creativity**.

Additional material

You may use all standard materials such as tables, manuals, textbooks, calculators, data sheets, the internet, your own notes and the applicable regulations and standards, including but not limited to the South African National Standards (SANS), Construction Regulations; Mine Health and Safety Act, Municipal by-laws, environmental standards, traffic regulations, operating regulations for high voltage systems and the Occupational Health and Safety Act (85) of 1993 with the various amendments to do the assignment.

Addendum H – Turnitin Report

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by JAMES SIBANDA

Addendum K – Transcript of Focus Group Interview

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Addendum I – Transcription of focus group interview

Available on Request to protect the identities of participants.