A STUDY OF ACADEMIC AND INDUSTRY CONCEPTIONS OF PROFESSIONAL KNOWLEDGE

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SUPERVISOR'S APPROVAL FOR SUBMISSION

As the candidate's supervisors we agree/do not agree to the submission of this thesis.

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ABSTRACT

This study explored conceptions of professional knowledge among academic and industry personnel in the field of chemical engineering. Its main purpose was to abstract from the participant narratives, industry and higher education institutions' conceptions of the *constructions* of professional knowledge that are at play within and across their sites in relation to how graduates are prepared for the workplace. Construction implies a conceptual understanding of what professional knowledge is (product) as well as a conception of how this knowledge is acquired or learnt (process). In presenting their conceptions, the participants invoke their reasons why such constructions of professional knowledge exist (purpose) from their points of view. While there are striking convergences within and across the study sites, divergences abound with regard to the constructions. The study thus unveils the complexities of what, how and why these constructions prevail in the way they do.

This research was located within an interpretive case study design. The sample consisted of 16 participants, eight from industry and eight from academia. A multi-method approach was employed to generate data, including semi-structured interviews with each participant. This was followed up with a virtual transect walk, a relatively new methodology drawn from agrarian studies which provided deeper insights into the phenomenon. Document analysis was also used to interrogate the genesis and development of the research sites.

The participants' understandings converged around the themes of theoretical knowledge, practice knowledge and personal knowledge, as well as on the factors that drive these conceptions, namely, competence in problem solving, the use of soft skills, professional identity and the role of work-integrated learning. The many divergences within and across the sites suggest that context plays a key role in shaping conceptions. For example, the industry site that was profit driven tended to produce hierarchical and compliant knowledge workers whose conceptions tended to characterise professional knowledge as compliance and regulation. The other site within industry which was service driven produced conceptions focused on creativity and problem solving.

Academic conceptions mainly focused on the importance of theoretical knowledge and while they viewed the regulatory function as pervasive and useful, they also regarded its gatekeeping function as prescriptive. Two notions of professionalism emerge from these conceptions, namely, an emancipatory conception and a regulatory conception. The study recommends that a relational phronetic professionalism be applied to better understand graduates' transition to engineering professionals.

DECLARATION

I, Mahomed Rafiq Jamal declare that,

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination at any other university.

(iii) This thesis does not contain any other person's data, pictures, graphs or other information unless specifically acknowledge as being sourced from other researchers.

(iv) This thesis does not contain any other person's writing, unless specifically acknowledged as being sourced from other researchers. Where other sources have been quoted, then:

(a) Their words have been re-written but the general information attributed to them has been referenced;

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(v) The thesis does not contain text, graphics, or tables copied from the Internet, unless specifically acknowledge, and the source being detailed in the thesis and in the References sections.

Signed: ……

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To Deanne: Thank for your editorial prowess.

To my family:

Sattar: This thesis is dedicated to you for your unflinching faith.

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Shabnum: Thank you for attending to all the chores that I should be doing.

Mikhail: Much have you endured in my endless quest to find myself.

To Rafiq - my other self

The courage to unlearn is the first step in the right direction.

LIST OF ABBREVIATIONS

APIP:	Amazon Purifying Industrial Plant
AUT:	Amir University of Technology
CHE:	Council of Higher Education
COP:	Community of Practice
COSAS:	Congress of South African Students
DHET:	Department of Higher Education and Training
DOE:	Department of Education
DRC:	Democratic Republic of Congo
ECSA:	Engineering Council of South Africa
EIT:	Engineer in Training
HEIs:	Higher Education Institutes
HEQC:	Higher Education Quality Committee
HSRC:	Human Science Research Council
HSSE:	Health, Safety, Security and Environment
LPP:	Legitimate Peripheral Participation
MUSTER:	Multi-Site Teacher Education Research
NQG:	Newly Qualified Graduate
NSOE:	New Sociology of Education
PCK:	Pedagogical Content Knowledge
PDP:	Professional Development Plan
PPIR:	Prometheus Petroleum Industrial Refining
QA:	Quality Assurance
SACCE:	South African Conference of co-operative Education
SAICHE:	South African Institution of Chemical Engineering
SALDRU:	South African Labour and Development Research Unit
SAQA:	South African Qualification Authority
SERTEC:	Certification Council for Technikon Education
SETA:	The Services Sector Education and Training Authority
SGG:	Standards Generating Body

SOE:	State-Owned Enterprise
SUT:	Sharrukh University of Technology
UCT:	University of Cape Town
UKZN:	University of KwaZulu-Natal
UNISA:	University of South Africa
UOT:	University of Technology
WIL:	Work-integrated learning
WITS:	University of Witwatersrand

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PART ONE: THE RESEARCH DESIGN

Part One of this thesis which comprises the first three chapters sets up the research design of the study. In Chapter One, I outline the background and theoretical context. This is followed by the key research questions followed by a justification for undertaking the study. Finally, I offer a brief overview of the thesis. Chapter Two explores the literature relevant to the notion of professional knowledge culminating in the crafting of a temporary lens to explore the data. Chapter Three engages with the research methodology and seeks to give assurance on the validity and reliability of the thesis in general. This chapter also interrogates the transect walk, a relatively new research method applied to research in higher education.

Part One of the thesis offers a framework for the design of the research project, while Part Two explores mainly the data in four chapters. Two chapters are devoted to exploring data generated from the University of Technology sector while two chapters are devoted to exploring data from the industry sites. Part Three abstracts the findings and enables the thesis to culminate in the production of a new lens with which the phenomenon of professional knowledge can be better understood.

CHAPTER ONE

SETTING UP THE STUDY

Orientation

This study explores the convergences and divergences of conceptions of professional knowledge held by academics within university settings and industry personnel in the field of chemical engineering. It may be argued that knowing about conceptions of the nature and scope of professional knowledge is pivotal to the expectations of what and how professionals ought to think and act.

Repeatedly, there appears to be complaints from the places of work that graduates from university are ill-prepared to tackle the pragmatics and scope of work expected (Robberts & Ryneveld, 2019; Wolff, 2020; Mungal & Cloete, 2016; Felder, 2012). Could these views about under-preparedness of graduates arise from the divergent conceptions of what kinds of knowledge are expected of a professional chemical engineering professional predominating in the academia and industry respectively? One argument may be that academia tends to foreground theoretical knowledge, whereas engineering workplaces tend to privilege practice knowledge. Are these representations of these two worlds caricaturing and reinforcing stereotypes? Are these depictions of these two worlds reinforcing dichotomous and alienating exclusive perspectives that hinder collaborative partnerships or professional dialogue across academic and the workplace?

The study seeks to understand how professional knowledge is generated, circulated, and activated within both the world of universities and within the workplace as novices are socialised into becoming and being professionals. In addition, the thesis focuses on the political, social, cultural and personal factors that drive conceptions of professional knowledge across these two settings of academia and industry.

This chapter comprises three sections. In section one, I sketch the broad background and context of the study. I also explore the significance of the study highlighting the importance of this study to contribute to the body of knowledge about the phenomenon of conceptions of professional knowledge in academia and in industry. These reflections of the problematics of the study are drawn from 16 years of teaching experience as an academic at a University of Technology. Here I make explicit my positionality in the study. This section concludes with how these above issues contributed to the critical research questions that framed the study. In section two, I explain the rationale of this study, outlining the likely beneficiaries of this exploration. In the last section, I provide the structure of this thesis report and outline an overview of the chapters of this thesis.

1.1 Section One: Positioning the study

1.1.1 Context

In this section, I firstly, outline the two contexts in which the research takes place: namely. academia and industry. Then, I explore the learning processes that occur in each sector highlighting the potential kinds of questions being raised about professional knowledge practices in each one. Next, I chart some of the areas of concern I had when reviewing the journey of novices as they traverse these two spaces to become fully-fledged professionals. This essentially involves their passage through multiple communities of practice within and across the sites identified. I also discuss briefly the kinds of forces (Samuel, 2008) that impinge on the learning processes as novices proceed on their knowledge journeys towards becoming professionals. This thesis will also explore how the WIL programme can throw light on the relationships between the different forms of knowledge that may exist in the fields of practice. Here, I explore the nature of the link between academia and industry.

1.1.1.1 The context of post-apartheid higher education in transition: Shifting realities

To a large extent, South African higher education was shaped by apartheid and its predecessor colonialism (Badat, 2015; Hall, 2015). Since the aim of the Nationalist government was to advance white interests, the higher education system was highly segregated according to race, ethnicity and language (Jansen, 2013; Hay & Monnapulo-Mapesela, 2009). In many respects, these divisions were already entrenched through the colonial education system which was prevalent in South Africa. During the colonial era, very few higher education institutions enrolled black students, and often this was accompanied by social exclusion (Beale, 1998).

During the colonial era, it was the predominantly Afrikaans universities that legislated against the acceptance of black students, while the English universities, Wits and UCT were regarded as 'open universities' (ibid). Fort Hare, on the other hand, was the first university established in 1916 and named South African Native College to cater for a predominantly African community of South Africa (Cloete, Bunting & Bailey, 2018). Here, the curriculum served an ideological function in ensuring that African people were kept servile as reflected in the kinds of occupational roles that it encouraged, consistent with the British model of indirect rule (ibid, 2018). Despite this intention, the university had over the latter years of the colonial enterprise and including the apartheid era developed into one of the strongest producers of African leadership.

In 1953, legislation was passed by the Apartheid government to stop all white institutions from allowing entry to black students. In line with its policy of separate development, the apartheid state passed the University Education Act of 1959 which forced the Black universities to follow Afrikaans university

models with respect to curriculum and governance structures (Hay & Mabokang-Mapesela, 2009). These historically black institutions were poorly resourced, and were limited in terms of what they could offer as qualifications in the fields of science and engineering (ibid).

1.1.1.2 From technical college to a technikon

Universities of Technology owe their genesis to the humble technical colleges from which they have recently emerged (Jansen, 2003; Garraway & Winberg, 2019; Strydom, 2016; Mzangwa & Dede, 2019; Powell & McKenna; 2009). The technical colleges were created for sole purpose of training students with technical skills to fit into industry positions. Despite their transition to Technikons and thereafter, UoTs, they have still retained this legacy of a strong and distinctive purpose: to prepare candidates for the world of industry (Garraway and Winberg, 2019). In this section, I argue that the UoT's links with industry and its focus on preparing candidates for a vocationally oriented career makes it an ideal space in which to explore issues of epistemological dilemma facing the preparation of professionals in higher education (McKenna, 2013).

Right from the outset, the relationship of technikons with industry was formed during the latter's early conception as technical colleges. With the passing of the Advanced Technical Education Act (No. 40 of 1967) six Colleges of Advanced Technical Education (Powell, 2009) were established whose primary aim was to prepare graduates to meet the technical needs of industry. In 1979, they were rebranded as Technikons (Mohamedbhai, 2017), but they still retained their links with industry. These institutions were only allowed to offer two-year certificates and three-year diplomas to meet the immediate skills needs of the economy (Powell & McKenna, 2009). When technikons were allowed to offer degrees in 1993, this signalled a watershed moment in their history as they could be compared with traditional universities. But this blanket ruling did not automatically make traditional universities and technikons equal as the curriculum in each had its own development trajectory in terms of scope and purpose. Although the technikon was lodged in higher education, it was highly focused on the use of technology and aligned to industry with a clear purpose of vocational training. This agenda is reflected in the excerpt drawn from the Department of Education (DOE) policy document below:

> The technikon concentrates on (a) training in and practice of technology, and (b) the specific side of the spectrum of vocational preparation. The university concentrates on (a) training in and practice of science and (b) mainly the general side of the spectrum of vocational preparation (Department of National Education, 1988, p.22-23). The twin themes of technology and vocational training still have resonance today in the newly

formed University of Technology sector, despite twenty years of transitioning and which act as their defining features (Raju, 2005).

1.1.1.3 From technikon to university of technology – shifting identities

The dismantling of apartheid in 1994 brought with it the urgent need to transform the higher education landscape as it was riddled with the heinous policies of the apartheid regime. To address the issues of redress and equity, a broad Technikon identity underwent transformation in 2005 when they were formally legislated as UoTs (Powell & McKenna, 2009). With the new branding as an UOT, issues of institutional identity became further complicated: should they remain teaching intensive universities or should they become producers of knowledge or a combination of the two? This epistemological dilemma facing the newly formed UoTs was entrenched further with the imperative to merge institutions in 2002 (Hall, 2015).

1.1.1.4 Mergers

The merger process produced three types of institutions: traditional universities, universities of technology and comprehensive universities which offered a combination of academic and vocational qualifications (Hall, 2015). The merger reduced the number of higher education institutions from 36 to 23, as the agenda was to streamline the bloated bureaucracy of apartheid education (Powell & McKenna, 2009) and to bring higher education into a single industry/organisation. The distinctions between the types of institutions created were meant to serve different functions. In my sample, I draw on two different types of institutions in terms of the merger process: one an integrated UoT and the other, one that did not assimilate and was isolationist in nature.

To serve their different agendas, UoTs were expected to realign their curricula with the institution with which they were expected to merge. Often the mergers were not equal as the institutions with more money and size dominated. The process of curriculum reconstruction also came under the spotlight. One advantage of the mergers was the cross-pollination that took place between disparate institutions that were forced to come together which necessitated re-looking at their programme offerings. In the old dispensation, the Certification Council for Technikon Education (SERTEC) was designated as the central statutory body which regulated curriculum reconstruction at technikons. According to Winberg (2007), the process of changing the curriculum was an arduous one. Aside from being designated as a convenor technikon, the institution that intended to offer or change its programme not only had to invite other interested technikons in such an endeavour, but also had to invite relevant industry and community stakeholders (Winberg, 2007). This process also required the completion of a number of complex documents which were also quite dated (ibid).

As a consequence of such bureaucratic complexity, curriculum development and the offering of new programmes were often stunted. While technikon education was still locked in an old paradigm, the workplace was rapidly changing in the face of growing globalisation. While the role of the technician was still required in the workplace, the duties and skills required had changed dramatically with technikon education lagging behind in preparing the technician to meet the needs of industry. Despite this, the impact of WIL, and the influence of advisory bodies perhaps mitigated the complete irrelevance of technikon education by keeping it focused on the needs of industry.

Staff recruitment from industry ensured that some of the practices were adopted in the teaching of students. These staff members saw themselves primarily as aligned with their professions rather than as lecturers. Of course, the downside was that many did not have teaching practice as a background for their academic careers. In fact, it is only recently that the training of staff in professionalising their qualifications for teaching has begun in earnest. Another way in which the university of technology strengthened its close relation with industry was through the advisory committees. These committees were involved in some forms of curriculum selection and development. They played a key role in guiding UoTs to the ways in which they could improve student performance. In the WIL programme, an industry mentor provided students with guidance for a one-year period. This enabled the student to gain deep insights into the state of play in the industry workplace.

1.1.1.5 Academic drift

In this section, I use the notion of academic drift to argue that the UoT is an ideal space in which to explore conceptions of professional knowledge. I am tempted to explore my argument through the lens of academic drift theory proposed by Malcolm Tight (2015). While he posits that higher education is short on theory as research in higher education is still a growing field, he confesses that theory too is anchored in contested terrain. He cites the overlaps in notions like frameworks, concepts, ideas and models (2015, p. 86) to denote a field of study that is still growing. In this study, I will attempt to interpret the changes in higher education institutions and staff members over time.

Central to the notion of academic drift is the relationship between academic identity, institutional identity and knowledge (Coleman & Tuck, 2019; Kraak, 2018; Edwards & Miller, 2008). The post-apartheid restructuring of the higher education landscape in South Africa not only dismantled the rigid structures of apartheid in higher education but also fractured institutional identities as technikons were transformed into universities of technology and these UoTs changed further through the moulting of identities via the merger processes (Winberg, 2007). Technikons which traditionally viewed their roles as producing knowledge for workplace employment now had to shift gears and view themselves as research knowledge producers the way traditional universities produced knowledge. This process of

academisation is captured by Magnell & Geschweld (2019), who viewed the shift towards abstract knowledge as a shifting away from practice. Yet, not all scholars viewed academic drift in these binary terms. Some saw many benefits for institutions in marrying the two agendas of professional practice and research equally (Christensen & Erno-Kjolhede, 2011). While these benefits may be obvious in the European higher education landscape, where equal opportunities and education levels may be fairly homogenous, seeking benefits for institutions in the South African context may not be so obvious. UoTs had to re-orient themselves from teaching intensive universities to universities which also did serious research. With the simultaneous establishment of the audits by quality assurance mechanisms, pressure was placed on these institutions to rapidly make changes in this field. The crisis in identity which unfolded provides a fertile area of scrutiny in terms of how knowledge is conceived by staff in these institutions.

Recent scholarship on institutional identity has highlighted the critical role of knowledge in the differentiation of institutions. What knowledge is prioritised, re-contextualised and transformed will depend on how the institution conceives of itself. Traditional universities have historically emphasised blue-sky research, whereas universities of technology have tended to foreground knowledge that is useful in workplace contexts. This has implications for the way in which pedagogy occurs and curriculum is constructed at these sites of learning, influencing the way the academic self is constructed (Ashforth, Harrison and Corley, 2008). These theorists trace the evolution of academic identity to the working lives of academics thus focusing on issues of career progression, their growing professionalism as well as the influences of the discipline and the institution. In this study, I will explore how these insights can throw more light on the relationship between conceptions of professional knowledge and academic identity.

A paradigmatic shift in the way in which knowledge has been conceptualised at universities of technology has begun to take shape as these former technikons start to operate like traditional universities. The fracturing of identity (Akerlind, 2011) it appears, seems to suggest that the UOT may be an ideal space in which to explore shifting conceptions of professional knowledge. Hence, this study will trace the ways in which UoTs negotiate the tensions between professional relevance and academic credibility (Hordern, 2014), between teaching for employment and the workplace while at the same time ensuring that adequate space exists for the exploration of research in the disciplines (Djerasimovic & Villani, 2020).

The issue of academic drift not only highlights the tensions experienced by academics at UoTs, but also throws sharp relief into how students negotiate access to knowledge. While access to diploma programmes allow students with poor qualifications to register at universities and become part of the

employment market, the shift in offering degrees instead of diplomas will disadvantage a sector of the population as access to higher education will be denied to students who do not have a degree pass. UoTs also are a crucial feeding ground for mid-level workforce (Powell & McKenna, 2009). This appeal to a niche market – mid-level workforce will be lost to the UoTs as academic drift also works in reverse where traditional universities start to offer diplomas in order to capture more market share of students who will generate subsidies.

Exploring UoT choices about their curriculum offerings will in turn throw light on how they see the dynamic interplay between the different knowledge types that the university will peddle. In this thesis I intend to explore the scholarship into the relationship between practical, applied knowledge for the workplace versus disciplinary knowledge in the hope of gaining insights into this complex relationship. Scholars in the field of curriculum and pedagogy and those who have kept abreast of developments in the changes in status in higher institutions have reported that UoTs have been premature in making hasty cosmetic changes by offering degrees and introducing theory and research in undergraduate courses without first establishing a research culture (Winberg, 2007).

A research culture is seen as paramount to any institution of higher learning which hopes to offer postgraduate education. Research practices such as a strong publication record, the possession of higher degrees by staff, peer review of academic articles according to Winberg (2007) were missing from the technikon culture. However, she posits that the former technikons were able to easily adopt the practices of quality assurance ensuring that dominant discourses of development and materialism still flourished (ibid). It would appear that scholars concur that many challenges face the current UoTs as they seek to carve out a space for themselves in the higher education landscape. The drive to achieve academic credibility may mean sacrificing professional relevance in the process of shifting from a technikon to a University of Technology.

The study will also be able to track and be sensitive to the kinds of fractures and tensions regarding the curriculum and pedagogical changes accompanying the UoT crisis in identity. Aside from exploring the epistemic relations between knowledge types and their influence on the conceptions of knowledge at play in higher education, the thesis will also explore whether other factors influence conceptions of knowledge. These factors may include the influence of regulatory bodies, UoT culture, staff personal attributes, and the influence of globalisation.

1.1.1.6 Contestations and the chemical engineering curriculum within UoTs

In this section, I argue that a UoT is a living laboratory of knowledge contestations as staff re-curriculate their syllabuses in response to the demands of a research agenda. In order to stay relevant in a

knowledge-driven economy (Vahed & Cruikshank, 2017), UoTs have adopted the research practices of traditional universities. These practices include the major drive to improve the Masters and PhD profiles of staff, increase publications, make curricular changes to offer more undergraduate and post-graduate degrees (Kraak, 2018; Powell & McKenna, 2009; Coleman & Tuck, 2019).

By exploring the enacted curricula at the two UoTs identified for study, I hope to render visible any tensions evident as UoTs seek to become more academically credible through various research practices and yet stay professionally relevant. By probing the views of academic and industry personnel with regard to the curriculum, I intend to highlight the different ways in which UoTs negotiate the tensions played out in their curriculum choices. In this way, I hope to investigate the relationships between different forms of knowledge and what forms are privileged by the UoTs and reflected in the knowledge conceptions of academics and industry staff.

Definitions of academic drift have ranged from viewing it as a form of institutional change where lower status institutions make curricular changes to imitate more traditional research universities (Tight, 2015) or as academisation, in which practice is viewed as shifting towards science and research (Harwood, 2010). According to Vahed & Cruikshank (2017), academics currently face challenges in trying to negotiate their roles as researcher and as teacher as they constantly try to meet the needs of discipline specific programmes. As a consequence, the curriculum has come under pressure to comply with competing forces in academia. Meeting the research agenda at UoTs has been particularly challenging for academics as a research culture does not prevail at these institutions (Mtshali & Sooryamoorthy, 2019) as they try to copy their counterparts who are much better resourced (Tight, 2018).

This thesis intends to probe the dialectical tensions UoTs experience as they face the dilemma of either remaining teaching-intensive institutions or to commit towards a more research-focused agenda. I am hoping to explore these impulses as they are played out in the enacted curriculum, in the teaching and learning activities and in the WIL programme. I view the UoT as a useful platform in which to interrogate forms of knowledge that are constrained or enhanced in periods of crisis and change.

1.1.1.7 Work-integrated learning

This section argues that the historical relationship that UoTs share with industry provides a robust justification for choosing the UoT as a site of research in which to explore conceptions of professional knowledge. Unlike their research-intensive counterparts, the UoTs have traditionally enjoyed a strong partnership with industry as reflected in their WIL programmes, and are therefore suitably positioned to explore how professional knowledge is transferred from one context to the other.

Knowledge transfer from university to industry and vice versa has taken many forms that include collaborative research, contract research, patenting and licensing, and broad distinctions have been drawn between commercial and academic forms of knowledge (Govind & Kuttim, 2016; Ankrah & Al-Tabbaa, 2015; Boyd, Smith & Bayaztas, 2015). My study will limit its engagement with knowledge forms that arise from collaborations between university and industry that are strictly academic. This thesis will draw on the insights into knowledge transfer from four different vantage points in industry and the UoT. I am expecting that the insights drawn from four levels of the university hierarchy and their corresponding vantage points in industry will hopefully engender diverse understandings of professional knowledge. I am surmising that each participant will be well-grounded in their knowledge of how learning and teaching occur in the two sites namely university and the workplace and how these sites connect and integrate in the enactment of the WIL programme (Billet, 2014; Tynjala, 2008; Sappa & Aprea, 2014; Akkerman & Bakker, 2012).

What knowledges these participants prioritise and how their industry counterparts view the same (Wedekind & Mutereko, 2016; Choy & Delahaye, 2011) will offer a useful comparative study between industry and university perspectives. By focusing on the ways in which academia and industry negotiate the practicum, I intend to provide unique insights into some of the ways in which they conceive of professional knowledge. Within industry, a range of different forms of learning partnerships exists with universities. The specific context of the WIL programme that will be explored is the year-long practicum that diploma students at UoTs are expected to complete before they graduate. WIL programmes also exist for other types of students who occupy different streams of qualification. These arrangements for WIL will differ according to the qualification offered. Despite these differences, the WIL programme is usually the responsibility of the academic institution in partnership with the relevant industry host.

This study expects to glean insights from the relationships that develop between the academic and industry collaborations. In this regard, academics who act as mentors for the students in the WIL programme were chosen as participants. The industry mentors also were selected as participants so that a dialogue between the two levels can be initiated. In this way, the study aims to access the first-hand experiences of mentors regarding how they see the relevance of various forms of knowledge appropriate for the learning and mastery of workplace learning. These viewpoints were also compared with the voices of other participants in the research like the novices and managers. The student is expected to transfer knowledge from the university to the workplace setting and to engage unproblematically with the challenges in the workplace. This study intends to interrogate this assumption, and to show what factors either constrain or enhance the transfer of knowledge across the two sites.

The graphic below provides a useful snapshot of the WIL model in terms of knowledge transfer. The arrow below indicates the flow of knowledge from university to industry and from industry back to the university. Students will try and activate knowledge that they have acquired at the university in WIL and workplace contexts and will transfer knowledge from their WIL experiences back to the university. In lifelong learning scenarios, employees who embark on further studies will share their insights and expertise with university mentors and staff and colleagues in these inter-professional encounters. The graphic also attempts to show the effects of macro and micro forces on the forms and shapes of the knowledge generated in each context. Further elaboration of the WIL phenomenon is described more personally in the section entitled: Journey into an engineering qualification

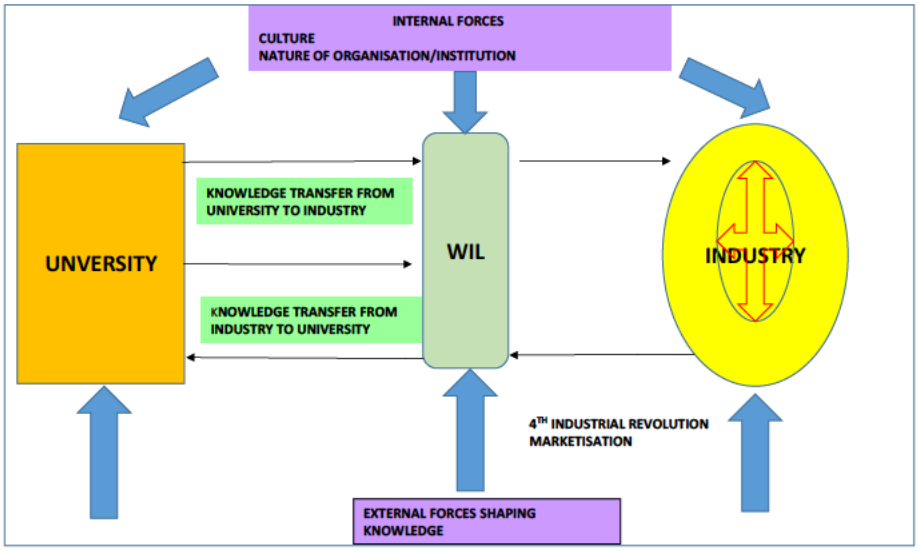

Figure 1: Transfer of knowledge between the university and industry

1.1.2 Positionality of the researcher

1.1.2.1 A personal journey

This section draws on three seminal experiences that nudged me towards an exploration of professional knowledge in the world of academia and industry. Firstly, my own experiences as a novice lecturer left me grappling with issues of curriculum and teaching for the workplace for which I found few answers. Secondly, listening to student and lecturer voices of their experiences of WIL, inspired me to give expression to my curiosity about the knowledge requirements and practices of the 'other side'. The third

motivating factor and most important was my chance encounter with Professor Wally Jensma[1], a poet whose activism despite being Dean perplexed me. These issues pushed me into thinking about the kinds of knowledge that students needed at the university and at the place of employment. Finally, I also needed to interrogate who I was and my identity as a lecturer. Did I belong to the Department of Communication or to the Department of Chemical Engineering or both? Was I like Professor Jensma, a hybrid professional?

1.1.2.2 Curriculum capers

As a novice academic, teaching at a University of Technology (UoT) or what was previously called a Technikon, I was expected to prepare students to meet the demands of the workplace. Without a much need induction, I was provided a curriculum, a timetable, chalk and a duster and expected to teach. The curriculum was one that was shared by several Technikons with very little space for customisation. As the system was a vestige of the apartheid era, my assumption that the one-size-fits-all type of curriculum was formulated to slot students into a particular space in the stratified workplace. Technikons were mandated to prepare technicians for various industries essentially. These institutions as part of the architecture of apartheid were meant to serve and to keep members of different communities separate and servile.

But apartheid was dead, at least in the statute books and institutions needed to change. Suddenly the notion that one could create one's own curriculum became real. And so I was tasked with the responsibility to re-curriculate the syllabus for my course – Communication in Chemical Engineering. Preparing students to meet the demands of the chemical engineering workplace presented me with a challenge. On the one hand, I had to follow the curriculum supplied by the convenor Technikons which was outcomes-based and on the other hand, ensure that students were ready to take on the demands of industry in terms of their communication needs.

One of the first things that I did was to seek guidance from academic staff who were teaching in the department of chemical engineering and chemistry since I had no experience of the chemical engineering industry. An informal survey amongst staff provided me with much-needed knowledge, but this was not enough - and so began my foray into the workplace teaching. The disciplinary-based teaching meant that all content needed to be re-contextualised for the chemical engineering workplace. Also outdated textbooks needed to be replaced with ones that had relevant South African content. But side by side with teaching workplace genres of writing, I had to also prepare students to meet the demands of academic literacy. This meant that students needed to be equipped with various types of

[1] I have used a pseudonym to protect the identity of the participant

communication skills. The classes were populated with differently able students with a varied repertoire of skills in communication in English. Students needed to read, understand, analyse and respond to both written texts and follow instructions in science-based disciplines.

Looking out to the world of work as to what was relevant or not took a great deal of time and effort. Fusing these insights with the content "communication" was challenging. As an academic with no formal induction, and no experience in industry, this was a formidable task, although I had varied experiences of teaching in schools and teacher training institutions. I desperately needed to gain deeper insights into the issues of pedagogy and syllabus design.

1.1.2.3 Student voices

Interacting with my students was immensely rewarding and there was much to learn from them. One of the most useful experiences was to listen to their stories of the practicum experiences while on WIL. Stories of these 6 months filled the classes with wonderment and enrichment as some students who attended the WIL programme early recounted their narratives. These narratives formed the basis of discussion and debate in class.

Student experience in these WIL programmes were mixed. While some had a very formal experience; others felt that there was not much they learnt. There were some students for whom the WIL programme was a chance of obtaining employment. They appreciated the fact that they could experience first-hand the real world of employment. Others were given menial tasks at work. This did not seem fair. The whole programme of WIL seemed well-structured but there many complaints about workplace mentors and university supervisors who did not give adequate support to students. I was convinced that a formal project needed to be undertaken that explored the issue of WIL in detail. In doing this project, I have deepened my insights into the process of WIL and its application.

Many students complained that the knowledge that they received at University did not adequately prepare them to meet the demands of the workplace. Some also suggested that they needed to do far more fieldwork as they were unfamiliar with the equipment that was being used in the workplace. Academic supervisors complained that students could not apply their knowledge and that they were taught many of the processes that were evident in the workplace. A critical component that was discussed was the fact that students could not communicate effectively. Since I taught communication, I took these comments personally and was determined to explore in detail the role of communication in the workplace. I wondered how Engineers in the workplace conceived of communication skills and what role it played in the chemical engineering workplace.

1.1.2.4 A chance encounter with a poet

A chance encounter with the Dean of Engineering, Professor Wally Jensma dissipated all my preconceptions about Engineers. I was not prepared for the revelations that a pre-workshop informal tea-time interaction would provide. I learnt humbly that the hard-nosed scientist type in front of me was a recognised poet and painter. I was immediately intrigued. Here was a scientist who was quoting Shakespeare and classic literature. My curiosity was aroused. I was determined to find out if all Engineers had a similar mind-set or was Professor Wally Jensma an exception. On reflection later, I pondered how he juggled the roles of an activist and a Dean, someone who, in a managerial capacity, had to implement rules and regulations that in many ways were highly regulatory and counter-revolutionary. These questions perhaps sowed the first seeds into trying to understand the diverse roles of professionals in the workplace. I needed to solve the mystery of professional identity, in particular, the hybrid nature of professionals. While the study did not respond to all the issues raised in my narrative, it did provide the impetus to deepen my knowledge about the relationship between industry and the university.

Journey to professionalism: A professional knowledge perspective

This story of a journey is told in two parts. The first part traces the narrative of the engineering student journey to becoming an engineering technician / engineer. The second part recalls his/her adventure as a novice engineer to a fully-fledged professional. This section attempts to explore the learning processes involved, the varied influences as well as the knowledges required in order to make these journeys successful.

Students at a UOT have many pathways to becoming a fully-fledged professional in the field of engineering. They can either be engineering technologists, engineering technicians or engineers. While the borders between the three occupations have become porous, they are distinct as professions. Students who undergo a period of study at a University of Technology will need to complete a compulsory practicum period at a suitable workplace in their final year of study. This contract is termed work-integrated learning (WIL). Generally, it involves students spending twelve months at a place of work. During this time, they are attached to a workplace mentor who guides them in the kinds of work performance activities in which they will engage. Assessments during this period can vary from institution to institution in terms of what they want from the students. Academic mentors also visit the students periodically to ensure that they are fully integrated into the company.

During this period, students are expected to acculturate into the company, where they are usually allocated various tasks and linked to a mentor or team. The student is expected to become part of the company and gain as much practice knowledge as possible. S/he may be given a chance to use some of

the theoretical knowledge that s/he received at university. The student also develops various other skills during his/her sojourn. These are soft skills including communication skills, leadership skills and use of technology After the student completes her/his period of WIL, she is then allowed to graduate. It is at this point that the company may decide to take her/him on or s/he may seek employment elsewhere as is the current practice.

From student to engineer

Becoming a qualified engineer and graduating successfully from university involves acquiring a range of different types of knowledges. Essentially this means competence in codified knowledge as well as in academic literacy required in the field of engineering. The student will be expected to get knowledge in the core science subjects like mathematics and physical science and other basic sciences course over a three or four-year period. In the case of a diploma, this means that s/he has three years in which to graduate. At the university, the student will be assessed in the codified knowledge and exposed to the full range of other assessment requirements of the course. A major requirement is the WIL programme where the students will be required to spend at least twelve months at the company. This will entail being involved in the daily rituals required by the mentors at the company concerned. Here the student is required to get the experience necessary to return to any workplace and be able to practice like a professional. At the university, the student will have been exposed to a number of informal learning contexts where he may derive great benefits of interacting with people or artefacts. In these informal networks, the students will have accumulated a range of different types of knowledges that may come in handy later in life and the workplace.

During the WIL component, the student is expected to be exposed to various practice situations in which he is expected either to familiarise himself with the kinds of machinery that is used as well as the various practices in which he will be engaged as an employee later on. During his sojourn at the company, the student is expected to develop his communication skills as well as his ability to interact with all members.

This study will explore the many influences that impact learning during this journey. As a lecturer, I am aware of various stakeholders that may impact on the learning process. I hope my findings and analysis may reveal the extent of these influences on conceptions of professional knowledge. I hope to reveal both the external and internal forces that may play a role in shaping academic and industry conceptions. Broad outside forces like regulatory forces in the form of the Council of Higher Education (CHE), Engineering Councils and the Department of Higher Education and Training (DHET) will usually inform how various processes are structured at the university through the relationships they share with UoTs (HESA, 2012). The study hopes to interrogate at the experiential level the impact of

these bodies, if any. While anecdotal evidence may suggest the role of marketisation and globalisation, how these forces play a role in determining the nature of the knowledge that is transferred from one context to another will be engaged at the level of the participants. The structure of the university in terms of its power dynamics also serve to shape the experiences of the student and his learning experiences. In casting my net as widely as possible, I intend to investigate the political, cultural and social contexts that impinge the learning processes at university and the workplace in the hope of revealing patterns of influence on conceptions of professional knowledge.

As a novice

On entering formal employment in a company as a novice technician or engineer, the incumbent is equipped with a range of skills that should equip him/her to deal with some of the challenges in the workplace. S/he may undergo a further training period at the company to train him for the specific jobs he will be expected to perform. After this further training in terms of professional development depends on the novices' interest and training requirements. As a novice technician or engineer, the novice has to register with ECSA to graduate with a professional registration. The technician can also study further to qualify as a fully-fledged engineer, but this will depend on the route he takes.

From novice engineer to professional

The journey from a novice engineer to a professional involves acquiring competence in a range of skills to be an expert. What exactly it means to be an expert is contested and is a question that needs explicating. Using a fluency model, Ben Kotzee (2012) tries to show that expertise is conceived differently by those adopting different conceptions, although for Kotzee (2012), developing expertise is the aim of all professional teaching and learning activities. He defines expertise not as expert theoretical knowledge but by operating in the field of expertise to gain mastery.

He cites Schön's (1987) notion of artistry, and Eraut's (2004) practice wisdom as constructivist thought which takes as its focus 'knowing in practice'. These ideas find representation in his description of the fluency account of expertise. The genesis of this model of expertise, he claims, can be found in the distinction made in Ryle's concepts of knowing that and knowing how (Kotzee, 2012). "Knowing how" comes to represent "having knowledge" while "knowing that" suggests "performance". Expertise or competence appears to mean both "knowing that" and "knowing how".

The university of technology is uniquely positioned for the role it plays in preparing students for the workplace. Recently, the focus on research has placed these UoTs under severe pressure to conform to the requirements of research-led universities. Traditionally UoTs have enjoyed a strong relationship with industry producing technician and technologists for industry. With the transformation of UoTs as

former Technikons into universities of Technology pressure has been mounting for greater focus on independent research. As Universities of Technology are focused on the business of teaching and in this sense they can be viewed as extensions of school. Although they are teaching-intensive, many of the staff are drawn from industry and many who have graduated and given employment as lecturers do not possess a teaching qualification. With the current pressure to have a vertical qualification like an MA and PhD, the focus on a teaching qualification recedes in the background despite the efforts of the University structures.

The act of teaching relevant content means re-contextualising the material from disciplinary textbooks and make it accessible for teaching purposes. Yet, the material must also be relevant to needs of industry. In other words, the focus is on codified knowledge but it is made relevant to the workplace and also integrated with innovative teaching knowledge. Sometimes the lecturer concerned has not experience of industry except for his own WIL many years ago. Time has marched and technology has improved rapidly. Much of the knowledge that the older employee possesses is jaded and needs a more contemporary twist. The need for the professional development of academics is high and to my knowledge, very few professional development workshops take place to upgrade the teaching skills of academics. As a consequence, they continue to use the same old material and teaching tactics that their lecturers used many years ago. The outcomes-based education which had failed dismally still is embedded in some UoT's curriculum.

Academics need to update themselves in two respects – firstly they need to become more aware of the situational demands of the workplace and secondly to learn how to teach more effectively in their classes. Also, the ways in which a traditional lecture takes place needs attention. The structure is hierarchical with all the attention focused on the lecturer. Ways in which to disrupt this structure must be taught to lecturers who should be more mobile in classes. Academics do not make any attempt to restructure their infrastructure as limitations in budget place a great of constraints on their intentions. However, creative thinking and a bit of critical reflection can overcome limitations.

A similar problem may play itself out in the workplace. Supervisors and mentors may not be qualified to teach young recruits and the latter may be left to their own devices because of inherent weaknesses in mentors. Pedagogical knowledge may be wanting as well as. Thus, the partnership between the workplace and the university should also continue with regard to the professional development of workers at industry.

1.1.3 Background

The focus of this research is two-fold. Firstly, it explores how academics in Universities of Technology (UoTs) in KwaZulu-Natal respond to the challenges of preparing students to transition to the workplace in terms of the professional knowledge that students require. Secondly, it explores how industry personnel's conceptions of what knowledges are required for novices to transition to experts. While this may suggest another foray into the theory/practice debate, I believe that this debate has tended to distract researchers from a more rigorous and intimate study of professional knowledge in terms of the how professional knowledge is generated, sourced, shared and deployed.

The intention of this study is to render visible knowledge forms that have hitherto remained invisible within the debates that have characterised research into professional knowledge. While discussions of theoretical knowledge and practical knowledge have been under the spotlight, tacit knowledge and the use of practical wisdom have to a large extent been rendered invisible as these are difficult areas to articulate. Tacit knowledge has challenged theorists into merely providing token mentions of its presence but they fail to argue how such knowledge can be identified, transferred or studied (Young, 2018; Collins & Reber, 2013; Fernandez, Cyr, Perrault and Brault, 2020; Lejeune, 2011).
Any serious study must account for this knowledge, hence the need for the study. A further reason that the study needs to be undertaken is to explore another dimension of professional knowledge which is practical wisdom or intuition based on moral judgement. This is an area of professional knowledge which has been greatly neglected, and which is beginning to find favour among theorists who have expanded the concept to deepen understandings of how knowledge in their respective fields (Costello, 2019; Massingham, 2019; Kim et al., 2019; Kinsella, 2012).

I hope to apply this concept to understand conceptions of professional knowledge in the field of Chemical engineering as the study of phronesis in the field of engineering is a relatively new field. As a lecturer at a University of Technology for the past 16 years, I have noticed that many students do not have access to theoretical knowledge in terms of the textbooks, access to the internet and other resources of knowledge. Poverty and lack of resources been severely limiting for students. Despite the many challenges faced by these students, they are still able to cope with demands of the curriculum. Furthermore, there is no doubt that access to theoretical knowledge is problematic because of a language issue. The dominant academic medium of teaching and learning within the higher education environment is English. However, many students in the context of the universities of technology within the South African context, use English as an additional language to their mother tongue/home languages. Both lectures as well as textbooks are in English, a medium that they have not fully mastered as a consequence of restricted quality language pedagogy in their pre-tertiary education systems (Hoadley, 2017).

As a lecturer who teaches in the Chemical Engineering Department, I noticed that while students had adequate disciplinary knowledge, they were unable to rise beyond their worldviews in relation to the ethical dilemmas confronting the practices and uses of that knowledge. For example, they remained largely unconnected to the hazards of releasing dangerous chemicals into the environment, nor were they vociferous about the roles of some of the chemical engineering industries' complicity in the degradation of the global, social and community ecosystems. While they envisioned working within the chemical engineering sector, the students were blind to the hazards of dumping of chemicals in the environment. This suggested that there was a need to explore whether environmental sensitivity or ethical issues were part of their vocational training as professional engineers. This raised the issue of what kinds of professional knowledge were prioritised by the stakeholders in academia and how these conceptions differed from the conceptions of professional knowledge held by stakeholders in industry. Winberg, Jacobs, Winberg, Garraway & Engel-Hills (2016) elaborate on this conundrum faced by academics as they try to bring practice into the classroom. Of course, in this way they try to simulate authentic practices and discourses. In making engineering knowledge accessible in this way, academics re-appropriate knowledge from the field and codify it into an academic discourse. While there are advantages of the process of re-contextualisation of forms of knowledge between varying contexts, it creates its own problems. The knowledge from the practice context is re-appropriated to the logic of the academic discourse and in the process loses its authenticity Winberg, Jacobs, Winberg, Garraway & Engel-Hills (2016). Billet (2008) has suggested that transfer of knowledge between contexts is categorically problematic and needs to be explored more fully. My present study responds to this critique that little research has been undertaken in this area.

In his discussion of the transferability of knowledge between contexts, Billet (2008) engages with the cognitive and socio-cultural perspectives to provide an understanding of the way in which knowledge is constructed. Billet's framework provides a useful way of exploring how procedural and propositional knowledge can be optimised for transfer from one context to another. My own study proposes to explore further how this movement of conceptions of professional knowledges occurs across contexts in the domain of Chemical Engineering. In this regard, I find Eraut's (2009) summary of the steps for the successful transfer of knowledge from one context to another very useful, particular, his insights into knowledge sharing when the contexts are dissimilar or complex. He defines knowledge transfer as the use of previously acquired skills, competencies and knowledge in a new situation. Eraut (*ibid.*) describes the five stages as follows:

The first stage is the extraction of the knowledge from its context. This is followed by gaining insights into the demands of the new situation. Next is identifying the skills and competences needed. The last

stage is transforming and integrating them to meet the needs of the new situation. I was interested to know how these evolving discursive movements occurs between two spaces of academia and the world of industries.

The notion of transfer has been critiqued by Lave (1988) in his book *Cognition in Practice* (1988). He describes attempts to study and engage in the transfer processes as "unnatural, laboratory games because there is a tendency to pander to the expectations of the experimenter" (p.20). Further, he believes that the main problem with the transfer issue is the pervasive and deep-seated functionalist view of knowledge (1998, p.41). As a consequence of Lave's dissatisfaction with the prevailing notions of transfer, he mooted the idea of participation as an alternative (Guile, 2018). In her summary of the debates around transfer, Sfard (1998) posits two key metaphors, namely a*cquisition and participation* as crucial to the debate about how learning occurs in the process of transfer. She advises that a more balanced view could be obtained by harmonising the cognitive and situative perspectives that seem to be the characteristic poles of the transfer debate in the 1980s. Since then, the issue of transfer has been revisited many times and more recently has found expression in Guile's (2018) concept of contextualisation.

The study of the field of knowledge transfer is highly contested and a number of conceptions of transfer has been suggested by theorists. Conceptions such as expansive transformation, legitimate peripheral participation and learning trajectories are just a few that describe the complexities of learning and knowledge transfer across various contexts**.**

Eraut's (2009) concept of learning trajectories provides a useful critique of the earlier more dominant notion of 'learning transfer' (Saljo, 2003) by cognitive theorists who view knowledge as objective and rational. Eraut's (2009) notion provides a useful balance by showing the importance of social and cultural in the learning and transfer process**.**

1.1.4 Critical questions

Three key questions guide the development of this thesis. They are as follows:

1. What are the conceptions of professional knowledge held by both academics in Universities of Technology and industry personnel in Chemical Engineering?

2.1 What are the sources of these conceptions?

2.2 How are these sources activated?

3. Why is professional knowledge conceived in the way it is

1.2 Section Two: Significance of the study

1.2.1 Rationale

The study is significant because it addresses a gap in the literature with regard to how academics view the professional knowledge that graduates need to transition into the workplace. The research shows how research at Universities of Technology as vocational spaces can deliver deep insights into the relationship between industry and academia. Further, professional knowledge is a poorly understood concept amongst academics as well as industry personnel. Fleshing out its details and contributing to studies that illuminate its multi-dimensional aspects will contribute to the knowledge on epistemologies. The study also focuses on industry which is rare because the majority of studies tend to focus on academics and students. This study contributes to the much-needed research on how professional knowledge is generated and circulated within industries in South Africa. Also, the thesis does not only provide a comparative study of two industries but also offers a comparison across sectors.

This thesis hypothesises that one of the reasons for the gap can be attributed to the conceptions that are held by academics and industry personnel. Student understandings of what constitutes workplace knowledge is also influenced by the conceptions of academics that teach them. This is compounded by the fact that much of the knowledge generated in the workplace is tacit in nature. According to Schön (1987), knowledge in action is the knowledge learnt in the process of doing. This notion contrasts with the idea of knowledge about action which is the theoretical knowledge one derives from the academic site. Academic or codified knowledge tends to be explicit, and may be located mainly in the various textbooks used at universities. This knowledge tends to be ossified as academics rarely have a chance of going to the world of work and updating their knowledge about the practices that are considered important. At best, they rely on anecdotal reports from returning students and mentors about the kinds of knowledges required by the workplace.

Sources of knowledge also include advisory boards which comprise representative of various stakeholders including personnel from the workplace. Often complaints about student lack of preparedness are conveyed via these meetings. Ironically, this then serves as a means of making adjustments to curriculum. One of the reasons why academic knowledge seems to be unchanging in character is the fact that core engineering principles may be reflected in these texts, which gives them a semblance of unchanging nature. Perhaps it is this fact that makes academics reluctant to engage in curriculum renewal.

Knowledge taught at universities of technology are general in nature so that students may find employment, for example, in any relevant field of chemical engineering. Practice knowledge in the

workplace, in contrast, is highly specific to the practices within that industry. Hence, a novice graduate may need to spend some time training at the workplace in order to be ready for deployment in the field. These gaps in understanding the world of practice and the knowledge required for satisfactory acculturation into the workplace needs to be resolved as the same problems are raised in advisory boards year after year without any remediation of the problem. Gaps in practice, in curriculum structure, in pedagogy and in mentoring and the structure of the WIL programme need to addressed systemically to engage with the problems head on. At the centre of all of these issues is the notion of what constitutes professional knowledge, how it is activated and why it is constituted the way it is. This thesis then tries to address these three key questions in order to throw light on what professional knowledges are deemed essential in the two domains of academia and industry in the field of chemical engineering.

The study addresses the higher education imperatives of providing social justice is an important theme of the study. A key critical question focuses on why conceptions of professional knowledge are conceived in the way that they are. This question links powerfully to notions of state control and capitalist enterprise where certain types of knowledges are prioritised to main the current capitalist structures in place and which perpetuates inequality in terms of access to knowledge. Methodologically, the study contributes to innovative practices by using a novel data generating method. The transect walk is new in the sense that there are very rare instances of its use in education studies. This method is deployed to show how professional knowledge can be ascertained in the workplace by observing and interviewing staff. A more fully fleshed out discussion on this method will be provided in the research methodology chapter.

1.2.2 Beneficiaries

It is envisaged that this investigation will provide deep insights into the phenomenon of professional knowledge in the context of academic learning and workplace practice. This thesis explores the link between the academia and industry as two domains of knowledge generation by highlighting the way different forms of knowledge are created, circulated and deployed within and across each of these domains. Also, I investigate the forces and drivers of such knowledge.

This project will inform current practices in academia at three levels. Firstly, it will provide insights the ways in which the intended curriculum is enacted; secondly, it will contribute to ways in which pedagogy can change to make relevant knowledge accessible and thirdly, suggest how the two systems engage in more robust networks to enhance their practices of knowledge generation. A phronetic engagement is suggested at all three levels mentioned in order to provide education with a moral framework informed by wise counsel.

The thesis views beneficiaries as being students as changes to curriculum by planners to make collaborations between entities more robust will benefit them as their WIL experiences will be greatly enhanced with appropriate practices. Industry will be better informed regarding the ways in which academics conceptualise what happens in the workplace and hence will try and correct these perspectives if they are inappropriate. Industry will also provide lecturers and mentors with appropriate training to update them on the requirements and practices in industry.

1.3 Section Three: Structure of the thesis

1.3.1 Overview of chapter

Chapter One of this study provides the background, research focus and purpose of the study. It contextualises the research in terms of the theoretical background and development of issues on professional knowledge raised.

Chapter Two attempts to craft a theoretical lens with which to probe notions of professional knowledge in the data. I do this by first exploring the paradigmatic shifts in understandings of professional knowledge over time. Then I assemble useful constructs drawn from various theories of knowledge. Aristotle' phronesis, Schön's reflective practice, Eraut's trajectory of learning and Lave and Wenger's Community of Practice theory and his notion of legitimate peripheral participation provide the initial building blocks for a temporary lens.

In Chapter Three, I provide a rationale for using an interpretive research approach, and I justify the use of the multiple case-studies within the case-study design of the project. This section also defends the use of the multi-method approach in generating data. Here I show how the semi-structured interview, transect walks and document analysis are particularly suited to the research design. Although I devote a substantial portion of the chapter to the transect walk methodology because it is innovative, I ensure that this chapter is also focused on ensuring issues of rigour and quality. In conclusion, I suggest a few limitations of the study.

Chapter Four presents the findings from the first case study namely, Sharrukh University of Technology. The analysis and the representation of the data are at the first level of analysis, namely, the descriptive level. I first offer a contextual background by providing a history of the site drawn mainly from the document analysis. This is followed by the construction participant narratives which draw on the semi-structured interviews. In the final section, I identify key themes linked to the notion of professional knowledge which predominate in the data.

Chapter Five presents the findings from the second case study, namely Amir University of Technology. Data analysis and representation is at the first level of abstraction. A history of the site is provided via document analysis and the narratives constructed from the semi-structured interviews. Four key themes related to the phenomenon of professional knowledge are selected for further scrutiny and discussion.

Chapter Six outlines the findings from the third case study, namely Amazon Purification Industrial Plant. The analysis of the findings in this chapter were limited to the descriptive level. The history of the site as well as participant narratives animate the first two sections of this chapter. These sections are drawn from document analysis and an exploration of the semi-structured interviews. The final section of this chapter yields four critical themes that explore notions of professional knowledge.

Chapter Seven which is the last case study, focuses on the second industrial site, namely Prometheus Petroleum Industrial Refining plant. Here too, a history of the site is first provided which is then followed by four participant narratives. Representation and analysis of the data are limited to the first level of analysis. Finally, I extract four crucial themes linked to professional knowledge.

Chapter Eight is a cross-case study of academic and industry conceptions of professional knowledge. It is divided into four sections. The first section is devoted to exploring the conceptions of soft skills across industry and academia. In section two, work-integrated learning is the lens through which I explore academic and industrial conceptions while in section three, I show how professional identity is linked to conceptions of professional knowledge. In section four, I portray the influence of regulatory bodies on conceptions of professional knowledge. In each section, three levels of analysis predominate. At the first level, comparisons are drawn across the hierarchy for each case study. This is followed by comparisons across the two Universities of Technology. At the third level, comparisons are drawn across the two sectors, namely academia and industry.

Chapter Nine provides a conceptual level of analysis of the data exploring different notions of professionalism at play. This chapter seeks to identify a phronetic regulatory framework that best responds to the challenges of chemical engineering education in the sites selected, namely the two universities of technology and the two organisations. In section one, I discuss regulatory professionalism showing how it influences notions of professional knowledge in both academia and industry. In section two, I compare this notion to a phronetic understanding of professionalism. Here I focus on a more agentic professionalism strongly evident in academia. In section three, I argue for a combination of these notions: a regulatory phronetic professionalism which accepts the reality of regulation but equally responds to the practical and moral dimensions of chemical engineering work.

Chapter Ten is the thesis chapter in which I offer the notion of migratory professional knowledge as my contribution to the body of knowledge on this phenomenon. The findings are presented as responses to the theme of the transfer of knowledge within the two contexts studied. I conclude this section by looking at the characteristics of a migrant professionalism. In the next section, I explore the significance of the study. These aspects include the theoretical implications, the methodological implications as well as the contextual implications. Finally, I present the limitations of the study which looks at some of the reasons why the study was constrained. Section Four deals the directions for future research while the last section, presents the concluding thoughts.

Synthesis

This chapter firstly positions the study by outlining its contextual background and discussion of the researcher's stance. This is followed by the critical questions which provides a useful frame to undergird the project. The significance of the study and its usefulness is highlighted in the second section in which I offer the rationale and potential beneficiaries of the study. In conclusion, I provide an overview of the structure of the study.

CHAPTER TWO

SHIFTING CONCEPTIONS OF PROFESSIONAL KNOWLEDGE: TOWARDS A THEORETICAL LENS

Orientation

In the previous chapter, I provided a rationale for exploring conceptions of professional knowledge in academia and industry, highlighting the key research questions that directed the project. In this chapter, I explore the paradigmatic shifts in how professional knowledge has been conceived over time. I start with the classical period, focusing on Aristotle's notions of episteme, techne and phronesis and showing how the current crop of theorists draws on these concepts as the emphasis on knowledge shifts with regards to the phenomenon of professional knowledge. Three competing conceptions of professional knowledge vie for dominance in the current theoretical landscape, namely, the rational scientific view; constructionist notions of professional knowledge, which emerged in the past fifty years as a very useful tool to explore how knowledge is created, shared and evaluated (Alvesson & Sköldberg, 2009); and the realist conception of professional knowledge which has currency today.

Of the three models, the technical model has enjoyed dominance for the longest period and is strongly embedded in the scientific tradition. However, over time, theorists observed that the scientific method could not adequately explain complex phenomena, particularly in the social sciences. Critics of the technical rational model held that it did not respond to the complexities of the real world (Eraut, 1994). For Schön (1983), technical rationality did not provide a comprehensive account of the complexity of everyday practice. Social realism emerged in the past twenty years inspired by the work of Bernstein (2000). Realists view the shift in focus from theoretical knowledge to practical knowledge as problematic and contend that emphasis should be placed on theoretical knowledge as it provides a basis for innovative thinking.

This chapter is made up of six sections. In section one, I discuss the classical period, invoking Aristotle and his notions of episteme, techne and phronesis and showing how these concepts still have relevance today. In section two, I explore professional knowledge through a technical rational lens while the third section focuses on conceptions of professional knowledge from a socio-constructivist perspective. Section four traces the emergence of social realist notions of professional knowledge and in section five, I show how conceptions of self and professional identity are inextricably linked with notions of professional knowledge. Finally, in section six, I craft a lens through which to probe notions of professional knowledge in the field of chemical engineering in higher education.

2.1 Section One: The classical model of professional knowledge

Aristotle's work has recently stimulated interest amongst various theorists across diverse disciplines (Kinsella, 2012; Kinsella & Pitman, 2012; Kemmis; 2012), with a focus on episteme, techne and phronesis. Phronesis, in particular, has been the subject of critical attention among contemporary theorists of professional knowledge. In this thesis, I show how all three forms of knowledge need to be integrated to constitute professional knowledge. (See Figure 2 below).

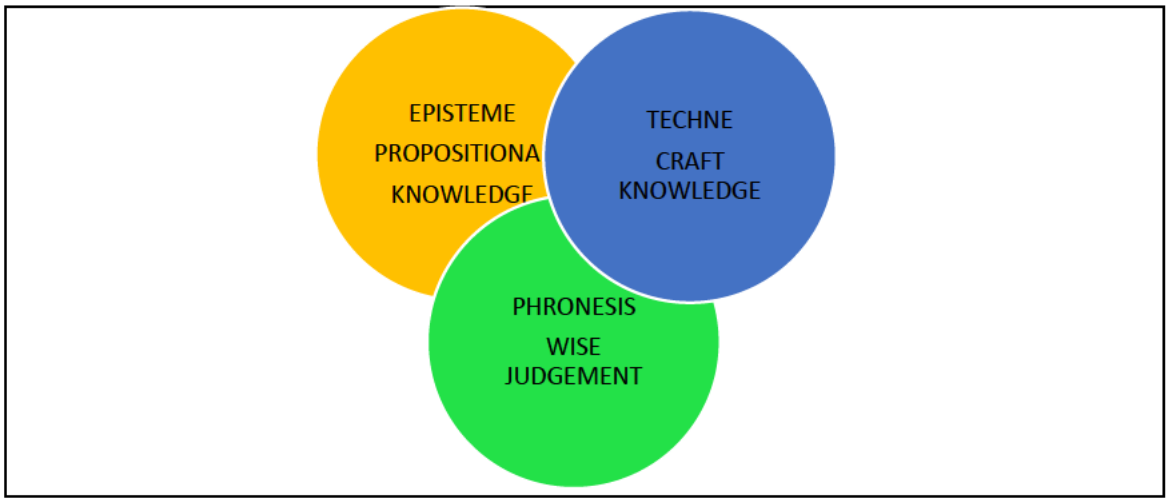

Figure 2*: Professional knowledge*

I start by offering definitions for each of these terms before showing how they relate to each other in Aristotle's work. Next, I demonstrate their relevance to today's workplace and finally I examine how they could be used to integrate various types of knowledge and enhance the way in which curricula work in the workplace and university.

In the translation of Aristotle's founding text *Nicomachian Ethics,* as interpreted by Peter (1893), Aristotle identifies three different forms of knowledge, terming them as *episteme, techne* and *phronesis*. For Aristotle, *episteme* is associated with theoretical or abstract knowledge, while *techne* relates to practice or craft knowledge (Peters, 1893, p.188). *Phronesis* on the other hand, is understood as wise, practical judgement involving ethics (Peters, 1893, p.203). Aristotle did not view these concepts in isolation. In fact, he posited that each presents a different challenge to man in seeking and gaining the most perfect knowledge known as *Sophia* (Dunne, 1993, p.238). In chapter six of Aristotle's *Nicomachian Ethics*, he highlights the different ways in which these concepts relate to each other. While *episteme* for Aristotle was theoretical and an aloof kind of knowledge, he viewed both *techne* and *phronesis* as being two different modes of practice. *Techne* is associated with the knowledge of the principles (*logoi*) a person has for creating artefacts while *phronesis* relates to how one conducts oneself

in relation to others (Dunne, 1993, p.246). Theorists like Eikeland (2008) interpret *phronesis* as prudent knowledge in action linked to one's identify.

In the *Nicomachian Ethics*, Aristotle uses the image of a young man to illustrate the difference between *episteme* and *phronesis*:

> A young man may become proficient in geometry and mathematics and be wise in these matters, but cannot possibly, it is thought become prudent. The reason for this is that prudence deals with particular facts, with which experience alone can familiarise us.
> (as translated by Peters, 1893, p.194).

While episteme is associated with facts that are based on permanent principles, prudence or phronesis is associated with the maturing mind's experiential knowledge. Episteme is associated with theoretical or abstract knowledge. According to Flyvbjerg (2001), it refers to knowledge that is context-independent. Such knowledge is regarded as certain and truthful, and will not change. It can be applied in various contexts. Techné refers to the know-how of a particular practice or craft and it is context-dependent (Massingham, 2019) while phronesis points to ethical action based on wisdom. For Kinsella and Pitman (2012), phronesis involves much reflection and deliberate pragmatic action. It appears that in practice, one needs to integrate all three aspects of knowledge. In order to solve problems at the workplace, an engineer will need to use a combination of specialist theoretical knowledge and practice knowledge. However, this process is not as simple as it seems. The practitioner will need to reflect deeply on whether the problem experienced is familiar to her/him. Thereafter, s/he needs to establish how the particular problem was dealt with in the past. This experience is often tacit and comes with practice. Sometimes the problem is unfamiliar, and the practitioner will need to research it. Once the engineer has decided on a course of action, s/he will need to reflect on whether the solution will adversely affect the company and society. While it may save money for the company, the effects of the company's action on the surrounding community need to be taken into account. Such judgements are based on the practitioner's past experience, knowledge and understanding. Thus, phronesis is informed wisdom.

2.1.1 Integration of knowledge forms for practice

In pursuing professional ways of enacting practice, practitioners may use a variety of knowledge forms that can meet their objectives in the field. This often involves merging different knowledge forms. The ways in which episteme (theoretical knowledge), techne (applied knowledge) and phronesis (wisdom) are linked depend on the exigencies that exist at the time of the action required. Thus, practice

knowledge not only depends on the range of professional knowledges available, but also needs to take into account a number of other factors that will impinge on the practice situation.

These factors include the prevailing contextual conditions that may make learning possible or limit it. Before engaging with the forces (Samuel, 2008) that may influence the practice situation, I explore how the different forms of knowledge need to come together. It should be noted that they do not function in a vacuum and will be subject to various pressures that shape them, as well as the praxis process. According to Kemmis (2012), professional practice involves knowledge that is activated in the doing of practice. He posits that it is embodied in the practitioner's relationship not only to the practice but also to others involved in and affected by it. Kemmis (2012) believes that in today's world that is characterised by rampant materialism and erosion of morals, the notion of phronesis needs to be reactivated in order to address gaps in professional practice situations. In this sense, phronesis comes to mean wisdom or prudence.

2.1.2 Phronesis

Phronesis has been the subject of robust scholarship in the recent past as theorists begin to seek wisdom from the classical period (Kinsella, 2012; Costello, 2019; Massingham, 2019; Higgs, 2019; Ellett, 2012; Kemmis, 2012). This Aristotelian notion has been widely acknowledged in a number of disciplines (Kinsella, 2012; Costello, 2019), but has gained major significance in the sociology of education (Wheelahan, 2015; Kemmis, 2012) as it contributes to deep epistemological understandings of professional knowledge.

Aristotle viewed phronesis as embodying both action and reasoning, which guide the individual towards the common good (Jenkins, Kinsella & DeLuca, 2019). Theorists in the field of health care draw attention to the ways in which economic agendas, growing technological advancement and managerialism have tended to erode caring relationships and moral reasoning. They postulate that these forces induce tensions within health care workers between what they should do morally and the demands of a profit making context. Jenkins, Kinsella and DeLuca (2019) expand the notion of phronesis to include embodiment, open-mindedness and reflexivity which enables them to draw on phronesis to address conflicting challenges in health care in a more moral manner.

Jenkins, Kinsella & DeLuca's (2019) study provokes a number of questions regarding the field of professional education. One major issue worth exploring is the usefulness of phronetic ways of thinking in examining whether professional knowledge can act as a bulwark against the rising tide of marketisation and rampant capitalism. A related issue is whether professionals in the field of engineering education experience the same tensions as health workers. A third area of investigation is

the differences between *phronesis, episteme* and *techne*, and the implications for conceptions of professional knowledge in the field of engineering education.

Phronesis has been defined by theorists as wisdom or prudence in executing practice (Kinsella, 2012). They add that this is a useful notion to explore conceptions of professional knowledge. Phronesis has come to be associated with the actions of a professional who is expected to make wise judgements and ensure that her/his actions protect both humankind and the environment. This thesis explores how these tensions play out in the world of the professional in both academia and industry and how new configurations of professional knowledge find expression as ways of dealing with increasing marketisation, managerialism, and globalisation. This is in sharp contrast to the world of Aristotle, who perhaps had the leisure to ponder on the mysteries of phronesis without the interference of forces such as marketisation, globalisation or regulatory agencies, or different workplace contexts. In order to deepen insight into varied contexts of workplace learning, theorists who deploy Aristotle's notions of techne, techne and phronesis or any of the other virtues generally expand them for contemporary relevance.

A case in point is the work of Gamble (2010), Jenkins, Kinsella and DeLuca (2019), and Kemmis, (2012) who have expanded this notion in the field of social science research. This study aimed to explore whether the same disciplinary fields interpret phronesis in varied spaces in vantaged ways. In particular, I examined whether academia and industry's notions of phronesis with regard to Chemical Engineering have divergent or similar hallmarks. Probing conceptions of phronesis across different "spaces" offers insight into the reasons for the prejudices that characterise their interpretation of each other's worldviews and practices.

Phronesis involves morally informed action based on reflection in order to do what is considered good for humankind (Kemmis, 2012). I explore the different aspects of phronesis, expanding its definition to investigate how conceptions of professional knowledge converge or diverge amongst academics and industry professionals.

This section briefly outlined the ways in which professional knowledge was conceived in the Classical Period. I invoked the concept of phronesis to show how knowledge forms were used by Aristotle and his followers to theorise everyday practical knowledge but also to highlight the higher purposes for which knowledge could be used, for example, to provide wisdom to action as well as impart a moral dimension to the practices in which we engage. This concept has significance for this study as I use it to highlight the role of moral action and wisdom in professionals' elucidation of professional knowledge.

The following section focuses on the technical rational model of professional knowledge which currently dominates the scientific world view. I trace its genesis in the Industrial Age and provide a brief description of its major influences and theorists. While the Industrial Age was a period in which various forms of knowledge making like folklore were banished, the Classical Period was in many ways an idealistic period of leisure and scholarly pursuit. Understanding the ways in which shifts in conceptions occurred at the micro levels of society allows for a richer understanding of current practices of the theory.

2.2 Section Two: The technical rational model of professional knowledge

The previous section explored Aristotle's notions of episteme, techne and phronesis to shed light on how these concepts could be used to deepen understanding of professional knowledge. This section focuses on the technical rational model of professional knowledge, also known as positivism. Positivism has been variously labelled by theorists and philosophers as technicism, technical rationality, dualism and instrumentalism, with finer gradations of meaning developed within each definition (Kinsella, 2012; Schön, 2002; Eraut, 1998; St. Pierre, 2012).

The evolution of the technical rational theory shows that it invokes a particular kind of knowledge and renders invisible other kinds of knowledge. For example, discussion of artistic or imaginative knowledge is missing as the theory arose in response to the needs of the Industrial Age of mechanisation and experimentation. In the world of scientific discovery there was no place for imaginative prose, poetry or magical incantations as sources of knowledge. I also discuss Auguste Compte and the Vienna Circle as this shows that theory construction is not the sole province of a single individual but is a collective effort and representation of thinking in a given period. Finally, Schön's comments on technical rationality conclude this section, with contemporary insights into the theory. I probe whether current practice and thinking bear the hallmarks of technical rational ways of thinking, particularly in the sciences. I first provide an overview of the roots of positivist thought and then explore its impact on learning and professionalism.

The following principles outline the classic tenets of positivism: embeddedness in empiricism; belief in an objective reality; belief in the certainty of facts based on observation and prediction; and an understanding that scientific progress can be accomplished in a linear and uncomplicated way, and that access to knowledge can only be achieved through tried and tested scientific methods (Schön, 2002; Kinsella, 2012; Eraut, 1998; St. Pierre, 2012). While many theorists view positivism as emerging from the work of Auguste Compte, Fred Eidlin (2013) traces its origins to European social and political

thought. In these traditions, Galilean and Newtonian influences on science served as inspiration for early empiricists, Hobbes and Francis Bacon and later for Locke, Berkeley, and Hume. For Eidlin (2013), the common definition which still holds sway today is that positivism is a scientific world view, and a belief in the autonomy of science.

Two important notions have been linked with positivism, namely, empiricism and rationalism. While empiricists hold that knowledge is only acquired through the senses through observation and experience, rationalists see its acquisition as intuitive (Hjørland, 2005). Positivists regard the world as a closed system in which cause and effect relations can be easily viewed. In contrast, the post-modernist position is that the world is socially constructed (Sousa, 2010). The current study explored the extent to which these conceptions of a technical rationalist worldview still hold sway in universities and workplaces and how they impact the way in which professionals enact practice. There are obvious tensions between the ways in which positivists and constructivists view the issue of professional knowledge (see further discussion on the constructivist worldview below). It is perhaps due to the divergent ways in which professional knowledge is conceived that the issue of transfer of knowledge from university to workplace is regarded as problematic. This study explored academia and industry's conceptions of professional knowledge in order to better understand the tensions in how knowledge is viewed by these two sectors.

Do academia and industry share similar or divergent views that may be paradigmatically linked to an empirical or a constructivist worldview? One perhaps needs to consider if this is what explains the divergences and disregard both contexts hold with respect to each other's operations. I argue that differing conceptions of professional knowledge activate different understandings of learning and hence different ways of teaching students who need to be prepared for the world of work and beyond. Divergences in the way the world of work and academia view knowledge may widen the existing gap between them.

2.2.1 Influences on Positivism: Auguste Compte and the Vienna Circle

Amongst the various principles that Auguste Compte outlined in his doctrine of positivism, his law of three phases has received critical attention in the form of affirmation, denial or opposition (Schmaus, Pickering & Bourdeau, 2018; Lorenz, 2015; St. Pierre, 2012). These laws charted the history of the intellectual thought of the day (Sanduk, 2012). Comte categorised the first law as the theological stage. Here all knowledge was attributed to the God-ordained universe. The second law described knowledge as emanating from an abstract rather than a supernatural source, while the third law viewed all knowledge as emanating from scientific principles (Sanduk, 2012). These laws reveal the shift from

dominant religious ways of thinking to more scientific thinking. Compte turned away from individualism to understand science as a social product (Schmaus, Pickering & Bourdeau, 2018). Despite the fact that Compte's positivism is touted as a focus on detached, objectified and empirical forms of knowledge (Sousa, 2010; Dunne, 2005, Eidlin, 2013), his social view of science was that it was rooted in its context (Schmaus, Pickering & Bourdeau, 2018).

In this section, I argue that the characteristics of positivism with its emphasis on rational thinking, experimentation, prediction and observation (Kincheloe & Tobin, 2009), can be traced to the impact of new technology made possible by the industrial revolution at the turn of the eighteenth century. Positivism emerged as a strong reaction to the religious dogmatic thinking of the pre-industrial era that was characterised by faith and magic (Schön, 1983). With the advent of new technology, during the first and second industrial revolutions, religious thinking was replaced by a new faith in the scientific methods of the day. Of course, this period was one in which science, technology and religion would intersect (O'Brien & Noy, 2015) and thinking would change gradually. The shift in epistemology from the religious dogma of the conservative period (controlled by religious authorities) to the scientific codified bodies of knowledge of the Enlightenment occurred over time. This shift was supported by a rapid industrialisation and a strong move celebrating the ascendance of individualism (a liberal agenda). (Barnett & Bengtsen, 2017)

Comte is regarded by many as the father of positivism (Koops & Kessel, 2017). Through a brief biographical exploration, I highlight his contribution to the classification of the disciplines, and track his impact on current understandings of professional knowledge. While the mapping and ordering of knowledge in the ancient world is best exemplified in the work of Aristotle (Ambrosio, 2016), in the nineteenth century, this task fell to Comte and his peers who sought to discover and capture knowledge by observing natural phenomena in everyday life. They aimed to classify what they considered to be fundamental knowledge for study. Comte's classification of the sciences in the *Plan des travaux* (Schmaus, Pickering & Bourdeau, 2018) outlined his way of organising his philosophy of science. Subjects like Mathematics, Physics, Chemistry, and Astronomy were prioritised as they were regarded as the fundamental sciences (Tripathi, 2017). I argue that the core subjects for the engineering sciences in higher education are still reflected by their nomenclature – Mathematics, Chemistry and Physics – although their content may have changed over time.

Comte's work enabled me to gain insight into not only the contours of positivist thought, but also how epistemological shifts can be attributed to personal, social and technological change. These contextual influences on conceptions of professional knowledge were explored in the study. In their study on the disorder of things, Cale and Craciun (2011) trace the origins and history of the traditional disciplines of

science, locating them at the turn of the nineteenth century. They infer that the scientific revolution infused empirical rigour into these disciplines. Comte's key role in the configuration of these disciplines is reflected in the fact that of all the classification systems of the day, Comte's law of classification is generally considered to be the most popular (Bourdieu, 2015). I thus contend that the form and order of these disciplines owe their early genesis to Comtean thinking. According to Kincheloe & Tobin (2009), Comtean thought can be discerned in work by scholars such as Charles Sanders Pierce, William James and John Dewey.

The subjects were then organised from the general to the particular and from the simple to the complex. Comte viewed the sciences as a way of understanding society and human behaviour (Corry, Porter & McKenna, 2018). His classification was adopted in the university curriculum in France and other institutions and endured for about a decade (Lorenz, 2015). Comte posited that knowledge claims could only be made if they were based on the observation of phenomena (Shapiro, 2017). In adopting this scientific approach, he rejected the theological and metaphysical doctrines of the day (Lorenz, 2015). What circumstances impelled such a paradigm-like shift (Kuhn, 1970) in worldviews? This could be due to Comte reacting to the tensions of a world fragmented by social, theological and economic upheaval, or perhaps he was responding to the rapid technological changes post the industrial era.

Was there a need to evolve news ways of ordering engineering knowledge (Ambrosio, 2016), given the new technologies that were being constructed and their ensuing knowledge footprints? Or was it simply personal trauma? Was his life like the steam engine which was invented in the first quarter of the nineteenth century and was starting to transform rural landscapes, while in urban spaces, cotton mills were bellowing smoke into the European sky (Bekar & Lipsey, 2004). Perhaps it was an amalgam of all these forces that caused the seismic shift in thinking from a naturalistic/theological standpoint to a positivist outlook. Vickers & Ziebarth (2019, p. 6) summarise it best when they articulate that the Industrial Revolution was less about the steam engine and more about 'changes encompassing an entire engineering culture, including physics and chemistry'.

Comte's Utopia

While we acknowledge the debt current curriculum specialists owe to Comte as well as his seminal influence on positivist thought, his relevance today is also reflected in understandings of the intersections between technology, science and religion. In this regard, Quill (2016) reconstructs Comte's dilemma by bringing him into an unusual comparison with Silicone Valley thinkers to highlight how epistemological changes recreate the worlds we inhabit. Both Comte and the current crop of thinkers viewed technology as a way of making the world a better place. In order to execute his mandate of recreating the world, Comte called for the emergence of an elite who believed in the power

of science as a spiritual basis for a new social order. For these disciples of technology, the old, failed metaphysical and theological systems needed to be replaced by a new techno-religion (Quill, 2016) based on observable science.

These positivist impulses find resonance in the work of Noah Yuvall Harari, best-selling author of *Sapiens: A brief history of mankind*. It is in his ideas about technology and religion that his links with Comtean thought become evident. Harari (2015) suggests that religion will become obsolete and will be replaced by a data religion. By this he means that the notion of liberalism and individualism will cease as humankind is understood as an amalgamation of biochemical algorithms. The intersections of religion, science and technology will produce a data religion where moral authority is in the hands of an external source (Harari, 2015). This could be a computer which will hold total knowledge of people, from their likes and dislikes, to reading preferences, lifestyle choices and a host of other issues.

By examining google behaviour, and using predictive tools, the computer will invade every facet of humankind's life. People will rely less on their feelings and instead allow the computer to make decisions as it holds statistics relating to millions of people (Harari, 2015). There is a striking parallel with the Comtean world in which increasing technological inventiveness caused a shift from a God-centred universe. It is not surprising, therefore, that the key values in this world would be certainty of knowledge and the ability to predict; the cornerstones of positivist thinking and the principles of the new techno-religion.

Resurgence of science and the dominance of positivist thought and neoliberalism

Many scholars assert that the tenets of positivism still prevail in Western culture, academia and education (Kincheloe & Tobin, 2009; Hall, 2019; Cruikshank & Abbinnett, 2019). They regard positivism as a highly negative influence, blaming it for a rise in neo-conservative values. They also see its influence in growing standardisation of pedagogy and curriculum which they proclaim de-professionalises teaching (Kincheloe & Tobin, 2009). Higher education is characterised by increasing neoliberalism, fostering econometric discourses and a new logic of return on investment. Indeed, its influence is felt beyond the educational sphere and extends to the socio-political landscape.

Given the vestiges of positivist ways of thinking and producing knowledge (Kincheloe & Tobin, 2009), it is not surprising that there has been a resurgence in technical rationality on the heels of the 4th Industrial Revolution (Gleason, 2018). This is most evident in the performativity culture instituted by the neo-liberal tendencies of marketisation and accountability (Olssen & Peters, 2005), and in the wide ranging technological advancement of the digital age in the form of artificial intelligence (Vickers & Ziebarth, 2019). The question that this thesis poses is: What new forms of knowledge will these twin

monsters spawn, and what lens is best suited to explore these hybrids? My exploration of paradigmatic shifts in epistemology using a socio-cultural lens may lead to new insights regarding the intersections and challenges of new technology, neoliberalism, and commodification facing early career engineers and academics who find themselves traversing new spaces of precarity (Holmwood & Sevos, 2019).

2.2.2 Positivism and its resurgence in the South African context

While Waghid (1999) was of the view that the demise of positivism was caused by technological and global development, paradoxically, technological advancement is linked to the resurgence in technical rationality (Harari, 2015). In this section, I chart some of the criticisms of technical rationality. Writing twenty years after the New Sociology of Education (NSOE) movement, Waghid (1999) draws on Young (1989) to support his advocacy of constructivism. Young's revolutionary fervour is clearly articulated when he calls for the emancipation of institutions shackled by technicist thinking and complete transformation, from the ways in which administration of education occurs to pedagogical relationships in the classroom. He asserts that epistemological discourses between educator and learner need to change and lambastes traditional education based on technical rationality as ahistorical and lacking in reflexivity (1989, p. 89).

Waghid (1999) suggests that positivism lacks value judgements. In other words, it tends to ignore ethical and political considerations. Furthermore, he argues that technicist accounts tend to produce knowledge that promote control of human and non-human actors (p. 124). In his discussion on the ways in which positivist thought is embedded in Engineering education, Waghid (1999) explores the positivist conception of the material world. He maintains that, for the positivist, the world as we experience it is out there, external and objective reality and independent of human beings (p. 125). The same applies to knowledge; it is objective, factual, empirical and reliable. Positivists use the deductive-nomological formula to explain phenomena as true and based on logic and empirical testing. Waghid (1999) criticises positivism on the basis that one cannot explain Engineering education theory based on a causal relationship between only two variables.

Waghid (1999) describes Engineering curricula as too rigid and reliant on technical subjects. He contends that such rigidity discourages creativity and problem solving, two key skills required in the engineering sector. Furthermore, he notes that the obsessive focus on core engineering subjects like Mathematics, Basic Sciences and others tends to obscure the importance of other lesser disciplines in the social and economic fields. Waghid (1999) argues that, internationally, Engineering education has come under pressure to change and to include a more diverse set of subjects to humanise the engineer. According to Waghid (1999), some South African universities have sought to diversify their curricula by introducing subjects like entrepreneurship, financial management and systems thinking. Waghid

(1999) suggests that a rigid curriculum presupposes an absolute theory of engineering education. He warns against the propensity to rely on the instrumental probability of outcomes of human action through the element of prediction. According to him, humans are not objects where predictions can be made about cause and effect. Instead, they are part of complex processes and are capable of self-reflection. This enables them to behave in ways that may defy logic and predictability. Waghid (1999) recommends that South African universities include subjects in their curricula which invoke metaphysical value judgement. He also calls for flexibility in designing the curriculum to include students who fare poorly in Mathematics and other Science subjects. He asserts that the curriculum should not act as a gate-keeping exercise where those that had access to better school education are granted access to higher education, while poverty conspires to exclude marginalised students from quality higher education and opportunities to participate in the economy.

As a model of knowledge, technical rationality has been shown to be inadequate in addressing the dilemmas of higher education. It seems preoccupied with theoretical knowledge to the detriment of practice knowledge. It is thus an inappropriate means of exploring the gap between theory and practice specific to the needs of chemical engineering in the two study contexts. In the next section, I investigate the contours of socio-constructivism and evaluate its efficacy in addressing the generation, circulation and activation of professional knowledge in academia and the workplace.

Debates on conceptions of professional knowledge and engineering education

In this section, I review some of the debates about conceptions of professional knowledge using studies drawn from the engineering sector that are specifically empirical in nature. These studies provide deep insights into the relationships between the world of academia and work and how some of the disconnections can be addressed. Although the studies are drawn from an American context, they still bear a great deal of relevance for engineering education internationally since many engineering curricula globally tend to draw from this western worldview. Representations of studies related to the interconnection between engineering, engineering identity and engineering work are presented below.

In the first study by Stevens, Johri and O'Connor on *Understandings of Engineering work*, the writers attempt to trace the relevance of conceptions of engineering to engineering education (2015,p.161). By drawing attention to the dearth of studies in engineering education, and engineering in general, they question if engineering educators hold accurate representations of what goes on in engineering work contexts given that many engineering educators have never been in the engineering sector. Moreover, representations or images of engineers and their practices are not very common in the research literature or general public media. A major gap they identify is the disconnect between engineering education within acamdia and the practices in the engineering field in the workplace. This finding is critical to

my study as I intend to interrogate a similar disconnect between the UoTs understanding of engineering practice and the actual practices in industry.

The work of Roth (2015) enhances the debates about representations of engineering knowledge in a unique study. Roth (2015) drawing on his studies on engineering knowledge explores how images, graphs, tables, drawings and diagrams domainte in the depiction of what constitutes engineering knowledge. Ross suggests that the inscriptions attached to these visual representations of engineering knowledge allow one to theorise the collaborative nature of engineering work where both the constructor (code sender) and the decoder (code receiver) co-establish the meaning of the texts with which they engage.. Further, he argues the inscriptions provide a means of enculturation of new engineers as the symbols are presented, represented and interpreted . Participants in a engineeromg design session, for example, have a tangible (visual symbolic) basis for their theorisation of the perceived problems. He describes the process as follows: firstly, there is enlisting and gathering of collaborators, then focus their attention to a joint object to construct a visual symbolic text, and thereafter, the collaborators organise the pragmatics of the joint project. Roth (2015) calls this process as conscription which demonstrates the social aspect of engineering (p.104).

A second major theme that is explored in the study is the need to disrupt traditional notions of technical rational conceptions of engineering and to advance a more *socio-technical engineering education* conception. Roth *(ibid*.) accuses engineering education of firstly, being a bastion of technical rationality (2015, p.176) and secondly, of being fixated on two issues: namely corporate profits and financial security. The relevance of these ideas to my study is that I also use an epistemological and ethical lens beyond simply an econometric basis to probe the paradigmatic changes in knowledge conceptions as a framework to interrogate current notions of professional knowledge conceptions in the domains of work and education. Using the conception of *heterogeneous engineering*, Roth (2015) advances the notion of an *ethics of care* in engineering education and practice.

Problem-solving and engineering identity

In a study, which attempted to understand the kinds of work that engineers valued, Anderson et al., 2010), found that problem solving was viewed as the skill set that identified them as engineers. This is consistent with the extant literature which argues that problem solving is regarded as the key activity in which engineers engage. Other skills that were valued were communication skills - found to be indispensable for disciplinary and interdisciplinary work as well as managerial skills which highlighted the need to manage projects in an economic way (2010, p.15). A more elaborate discussion of communication and other soft skills appears in the next section.

In this study of undergraduate perceptions and needs, the overwhelming need was to include more hands-on work, which suggested 'a greater connection to practice' (2010, p.15). In their extensive literature review, three seminal books on engineering practice are held up for review. The first book entitled: *What Engineers know and how they know it,* Anderson et al., (2015) draw attention to the writer's constructivist's leanings. Like Schon, Vincenti the author, refers to practice knowledge as an art, describing problem-solving as uncertain and messy (Anderson et al., 2015, p.5). In the second book, the work of Dominique Vinck is held up to illustrate the social nature of engineering knowledge. Anderson et al., (2015) also highlighted the role of communication in the study. Engineering in their worldview is a social practice involving interaction and dialogue amongst its various partners within the discipline of engineering itself, as well as outside the disciplinary field with non-engineering interlocutors in the general public, including clients, governance structures, policymakers and the wider community.

The third book held up for review is *Thinking like an Engineer* by Michael Davis (1991). While using an ethical lens to interrogate definitions of engineering, it also reveals the embeddedness of engineering work. Engineering is considered to be an interlocked multidisciplinary field which drew in the expertise and worldviews of a range of interlinked partners: including architects, builders, and landscapers. This study suggests that professional engineering education should be directed towards developing the quality of the identity of the prospective engineer to negotiate their presence in their spatial discourse community.

The next study takes up the challenge of presenting a comparison between workplace and engineering education by holding up how the two sectors differ in terms of problem-solving. In his study, Jonassen (2015) argues that in order to better prepare graduate students, it is vital to articulate the differences in how the two domains of engineering practice and academia view problem-solving. While textbook problems for Jonassen are contrived and have ready-made solutions, workplace problems are messy and unpredictable (2015, p.151). In the study, Jonassen highlights the importance of the situated context on problem-solving. Furthermore, he identifies the distributed nature of problem-solving knowledge among team members as key to solving problems in engineering contexts. He suggests that solutions to problems are never the work of individuals but emerges through various partnerships.

The authors recommend that learners need to construct multiple understandings of the system in which they will operate. In addition to knowledge of the domain, the graduate will need to construct knowledge about general theories and principles on which the system was designed. Knowing how the systems are put together and how knowledge flows in the system will aid the learner in coming to better solutions. He advises strongly that engineering education adopt a problem-solving method of pedagogy. A key insight that Johanness (*ibid*.) offers on the situated context is that it is constrained and enabled by

cultural, socio-political and organisational factors. Problem-solving methods are ill-structured because they present multiple belief systems embedded in the context (p.145).

Tension between theoretical and practice knowledge and engineering education

While the tensions between theoretical and practice knowledge have been explored in a wide range of studies, the study by Gainsburg et al., (2010), address this tension by creating a knowledge profile for the engineering occupations under review. In their study of a structuring engineering environment, they charted the number of times certain knowledge types were used by engineers and categorised them. These categories included design instrumentalities, appropriate structural elements, engineering actors, and fundamental design concepts. As the writers observed engineers at work, they noted the type of knowledge type used. These were then converted to categories. The writers hoped in portraying engineering knowledge in this accurate and authentic way, they would attract a broader range of clients at universities.

Students in turn would benefit by being better prepared for the workplace since they had an accurate profile of knowledge types that the work and project entailed. Morever, it could be argued that the particular kinds of categories of specialist knowledges was considered to be unique but interrelated in the sub-disciplinary fields of engineering, like chemical engineering, or electrical engineering or any other such sub-category. Learning the specific signatures of the categories of the sub-disciplines of engineering also constitutes a form of special engineering knowledge. It begs the question about whether there is a singular universalist notion of "engineering", or whether national, regional and/or institutional differentiations might also exist. These above concerns constitute the focus of my study: does the uniqueness of each contextual space generate specific signature conceptions of professional engineering knowledge? My quest reinforces debates beyond just the conventionalised disciplinary definitions of engineering knowledge to expand into the social nature of engineering knowledge.

Communication, soft skills and the 4th industrial revolution

Although problem solving has traditionally been viewed as a core engineering skill, other soft skills like communication have been recognised more recently as critical to engineers (Case et al., 2016; Nudelman, 2020; Fenwick, 2014) Given the rise of new technologies in the 4th industrial revolution, together with the impact of COVID, communication across a range of web-based platforms has become the new working order. The shift in focus from purely technical report writing to engaging in communicating via increasingly sophisticated visual and graphical means entails greater expertise in the 'rhetoric of data presentation and visual communication (Poe, Lerner & Craig, 2010). Engaging with multiple stakeholders like clients, other engineers, managers and government officials in large projects simultaneously has become possible through online platforms and has resulted in a growing

need to cultivate communication expertise in this field. Such multimodal challenges coupled with the growing calls from industry that graduate engineers are unable to write, present, manage interpersonal relationships, and function adequately in teams has prompted universities to rethink the way in which curricula is constructed or taught (Paretti, McNair & Leydens, 2015).

Epistemological swings of the pendulum in the 4th Industrial Revolution

John Reaves (2019, p.7), in writing about the new skills needed in the 4th Industrial revolution, highlights the relevance of academic curricula to real-world jobs. He draws attention to how continuous rapid changes in mutating epistemologies have challenged educational institutions to relook at how they codify new knowledge. He suggests that fluidity and flexibility should characterise the new norm. Reaves *(ibid*.) comes close to suggesting that typologies of knowledge too come under pressure to change. Moreover, practice knowledge and theoretical knowledge may occur almost at the same time. This suggests that students may need to explore the workplace context (for example, the industrial workplace) by operating in its discourse setting as soon as possible. At the same time they should have acquired domain-specific knowledge from the cloud, and adjusted to changes in the field as their knowledge increases. This challenges the notion of learning and curriculum design following an applied science model, which presents firstly, theoretical knowledge, which is then translated and tested in practice. Instead, both theory and practice ought to co-exist more reflectively and dialogically.

This signals a break from previous studies that emerged in the past thirty years. Since the 1970s, positivism has waned in the face of growing constructivist influence (Waghid, 1999). Where previous studies on engineering education emphasised the personal, political and social, the current slew of studies foregrounds the significance of episteme in addressing issues of practice and theory. These studies explore the theory-practice divide from a range of vantage points, including the curriculum, pedagogy, WIL, professionalism and regulation (Wolff, 2017; Brodie & Sunni, 2014; Nudelman, 2020; Walker, 2012; Winberg, 2013).

In this section, I draw briefly on these studies, focusing on how they expand our understanding of professional knowledge. Wolff (2017) provides illuminating insights by problematising the issue of the theory/practice divide in engineering contexts in South Africa. She approaches this debate by showing how attempts to shift the curriculum from a focus on basic sciences, and applied sciences have not improved the retention rates nor the graduation rate. Instead, she observes that employer complaints about graduate's abilities still predominate (Wolff, 2017). She advocates that engineering education should focus attention on the processes involved when practitioners switch codes in enacting practice; in other words, what are the dynamics involved when theoretical knowledge merges with situational

knowledge in enacting practice. In the engineering context, this is usually the practice of problem solving (Wolff, 2017, p.850).

Another key insight that Wolff (2017) articulates is on the usefulness of project work to develop responsive engineers by exposing them to real world problems. However, she warns that there should be better alignment between what students are taught and what is expected of them in the workplace. In her exploration of technicians' responses to problem solving in two case studies involving different contexts, Wolff's study has revealed that conceptual thinking increases when disciplinary subjects are foregrounded. However, Wolff (2020) embraces the significance of contextual knowledge when she invokes the role of industry stakeholders in the learning process. She calls for a reconfigured relationship between academia and industry by suggesting the use of case studies or mentorship roles in which industry staff can be deployed to share real world problems in an academic context.

While Wolff (2017) feels that bolstering disciplinary knowledge would promote students' problem-solving skills, Sheppard, Colby, Macatangay, & Sullivan, (2006) approach to problem-solving is far more complex. They acknowledge the role of technological advancement in influencing the ways in which problem analysis and solving occur. Whereas previously, problem-solving occurred in a neutral, objective and linear fashion, Sheppard, Colby, Macatangay, & Sullivan, (2006) highlight new intermeshed, networked methods. They also draw attention to the importance of factors such as sustainability, and the impact of economic and social issues.

The current study probed and extended these insights to determine how conceptions are impacted by these factors. Sheppard, Colby, Macatangay, & Sullivan's, (2006) central thesis is that since the engineering profession has evolved in terms of technological advancement, so too should engineering education and training. I probed the extent to which this disjuncture exists within the South African engineering education landscape.

2.3 Section Three: Socio-constructivist model of professional knowledge

The previous section outlined the contours of technical rationality, a model of professional knowledge. It highlighted its critical role in establishing current discursive structures at universities and other places of learning. However, it is limited in explaining complex phenomena in the workplace; hence the need for a new form of theory. I explore the socio-constructivist model of professional knowledge as an alternative to explain how knowledge is acquired and deployed in professional practice. It seeks to understand the knowledge journey of a novice from naiveté to competence as s/he migrates from one learning context to another – the journey from university to the workplace.

Socio-constructivism emerged in the 1970s in response to positivism's dominance in the sociology of education (Wheelahan, 2015). It directed its barbs at the lack of progress in Britain and other Western countries' education systems in countering the effects of class on the ability of the poor to transition from inequality (Moore, 2013). The NSOE movement mobilised knowledge as the centrepiece of its struggle and linked the ways in which knowledge was organised and deployed and the ensuing broader relationships of inequality and power (Moore, 2013, p. 335). Its paradigm essentially invoked the issue of social inequality; as a result, it attracted a range of other movements like multiculturalism, feminism and anti-racism that found a natural home in the constructivist camp. Given the variety of ideological stances taken by these movements, it becomes problematic to define constructivism. Any definition will lack specificity and will be generic.

Moore (2013) affords us a few basic tenets of constructivism. The first idea he identifies as constructivist is the notion that all knowledge is socially constructed and emerges from the historical and political contexts of its birth. Moore (2013) explains that to privilege particular knowledge is to privilege a particular type of knower. In contrast to the hegemonic model of knowledge as certain and disinterested, it is seen as ideological and political and as situated and embodied. Knowledge in the dominant conception is viewed as a detached, disembodied, disinterested observer of external reality. It is socially and historically decontextualised and presented as absolute, real and universal (Foundationalism). Knowledge understood in this way has been variously labelled as bourgeois, positivist, objectivist and absolutist.

In his review of constructivism, Philips (1987) humorously links this model of knowledge to religion with its many sects with each one wary of the other. I would argue that this suspicious nature is absent among proponents of this theory, but can be found in the vitriol of the realists who at every turn have turned on the constructivists about the intellectual turn in theory. I borrow Philips' (1987) typology in classifying the range of constructivist positions. He identifies at least three broad axes along which constructivism is stratified. The first type is individual psychology versus the public disciple type. Along this continuum of the way in which constructivists construct knowledge, at one end of the spectrum are learners who construct knowledge from an individual point of view, while at the other end there is a focus on how communities have built bodies of knowledge which we term disciplines. The first continuum is represented in Figure 3 below.

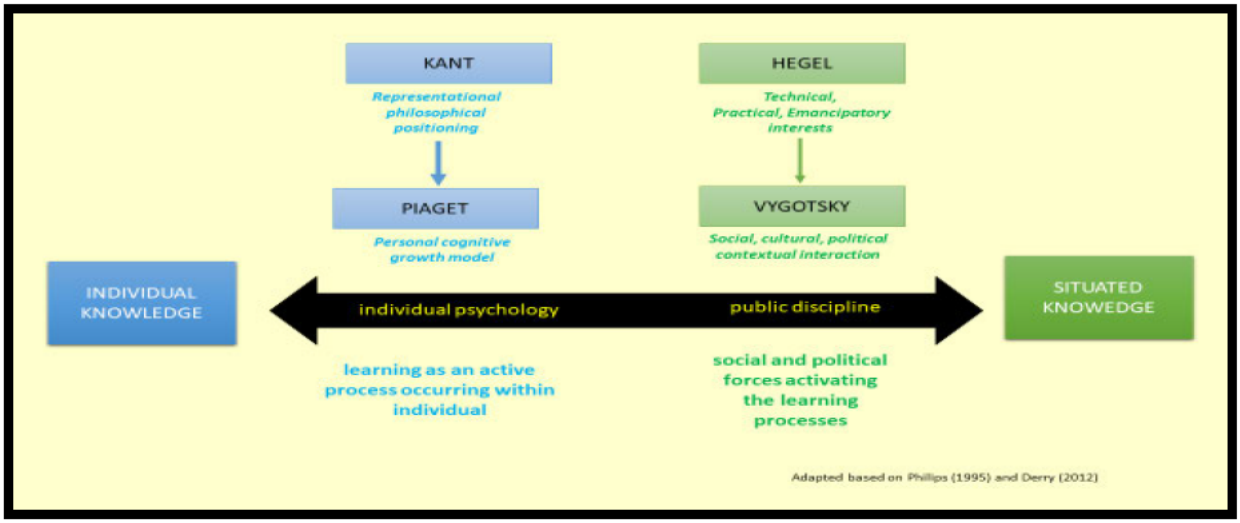

Figure 3: Continuum of constructivist positions

In this section, I seek to evaluate and critique various constructivist positions mooted by Philips (1995) in his seminal paper, *The Good, The Bad and the Ugly: The many faces of constructivism*. This is followed by exploring the work of Jan Derry (2012) with respect to the contributions of Vygotsky, Kant, Hegel and Piaget to constructivist thought.

Philip's three-dimensional model of constructivism accounts for the stances of various sects within the constructivist camp. A key distinction that Philip draws between two major sects is the emphasis each one places on the way in which knowledge is constructed. While cognitive constructivists view *learning as an active process occurring within individuals*, social constructivists emphasize the importance *of social and political forces in the learning processes*. Philips contends that each strand of constructivist is highly complex, is distinct, but are not mutually exclusive. Philip uses three dimensions or continua to present the relations of each constructivist according to specific themes.

In this section, I limit my discussion to the first continuum. In the first continuum, Philips (1995) uses the notions of individual *psychology* versus *public discipline* to show how constructivists differ along the continuum. While some theorists focus on how the individual learner constructs knowledge according to his/her cognitive apparatus, others show less concern with the individual and focus more on the construction of knowledge generally within social, cultural, political and economic settings (Philips, 1995, p.7). Central to this continuum are the figures of Piaget and Vygotsky on opposite sides of this continuum.

The lack of clarity by Philips with regard to the influences and positionality of figures like Kant and Hegel along the continuum prompts me to revise his framework. Figure 3 below highlights the influence of Kant on Piaget's theoretical positioning, and Hegel on Vygotsky's theoretical positioning. In doing so, I draw on Derry's (2012) insights into the Piaget/ Vygotsky divide. According to Derry (*ibid.)*,

Kant's representationalist philosophy is clearly reflected in Piaget's work. Within the theoretical positioning of Kant, Derry argues that representational philosophy involves an emphasis on the role of individuals as agentic constructors of their own realities. One's internal thoughts are seen as merely a representation of reality. Therefore, each individual depicts that reality internally in unique personal ways. Piaget too primarily emphasises the role of the individual and their cognitive growth in establishing learning schematic patterns. By contrast, Derry (*ibid.*) argues that Vygotsky needs to be read through a Hegel lens since both emphasise the role of the social-historical domain in meaning-making. The contextual space constructs the interpretation.

In contrast to Piaget, John Dewey uses the metaphor of a football to describe the ways in which a learner constructs knowledge. One can be a spectator and learn passively by watching or one can learn organically by participating in the game and affecting its outcome. This is active participation in the learning process. Although this example may suggest that Dewey is highly individualistic (Philips, 1987), he also focused on the social nature of knowledge construction. While Piaget and Dewey seem to articulate a balanced position with regard to learning from an individual and social positions, there are many theorists that position themselves at the ends of the spectrum where knowledge construction is either viewed as an active process carried out within communities of practice or knowledge construction is viewed as highly individualistic (Nelson, 1993). This thesis will explore to what extent such views of knowledge prevail amongst the participants drawn from the various sites of the study.

2.3.1 Reflective practice and knowledge prioritisation

As a model of professional knowledge, Schön's notion of reflective practice (1987), still enjoys significant currency in higher education (Hebert, 2015; Roessger, 2015; Fox, Dodman & Holincheck, 2019; Kirkman & Brownhill, 2020) particularly, in the field of professional development. In this review of Schön's notion of reflective practice, I show how the theorist seeks to advance understanding of professional knowledge as it is practised in places of higher learning. According to Kemmis (2005), Schön's insights not only illuminate the constructivist underpinnings of his work, but throw light on the ways in which professional knowledge is conceived by universities. Kemmis (2005) postulates that certain types of knowledge are prioritised at universities while others are downplayed. He feels strongly that Schön (2002) calls for a new epistemology of practice in which all kinds of knowledge are democratised and re-prioritised.

Kinsella's (2012) exploration of Schön's work opens with a question on the implications of reflective practice for professions. She responds to this rhetorical question by suggesting that professional knowledge sits at the heart of Schön's notion of reflective practice. Kinsella highlights Schön's critique of technical rationality and traces the influence of various theorists on his work. Using the themes of

artistry, framing and reflection, I show how they constellate around the notion of professional knowledge. In order to mine Schön's theory for its constructivist underpinnings, I use Kinsella analysis as a broad framework.

2.3.2 Professional knowledge as artistry

In his work, Schön tries persuasively to argue that professional practice should be seen as artistry (Kinsella, 2012; Wagenheim, 2014; Cushman, 2014). For Schön, professional practice viewed through a technical rational lens provided a very reductive view of the professional. To rehabilitate the image of the professional as both competent and wise, Schön used the metaphor of artistry (Paterson, Wilcox & Higgs, 2006) to convey the kinds of skills, dispositions and creative imagination and practical wisdom that practitioners display in circumstances that are uncertain, unique, and conflicted (Kinsella, 2012). The professional in the field of practice will use artistry to handle difficult circumstances with ease and panache. This suggests that the professional in the field of practice may demonstrate both competence as well as good judgement or wisdom (Fook, 2015).

Kinsella describes an uncritical acceptance of the scientific paradigm as problematic as it obscures one's vision of professional practice as artistry. An even more critical issue that Kinsella raises is the extent to which acceptance of professional practice as artistry paradigmatically changes how one conceives of professional knowledge (2012, p. 9) as it is understood and contextualised in the curricula of professional schools.

In my study, I explored Schön's (1983) notion of artistry by interrogating notions of problem-solving in professional practice situations at the workplace. I also expanded the concept of phronesis as it is used by theorists like Kinsella (2012), Ellett (2012), and Frank (2012) to explore knowledge conceptions in two very divergent sectors, namely, academia and industry. Another theme that this thesis explores is whether the enacted engineering curriculum reflects or not the notion of workplace skills and employability in preparing the future engineer (Case & Marshall, 2016; Maton, 2013; Winberg, et al., 2020).

2.3.3 Framing the world of perceptions and beliefs as professional knowledge

Schön's constructivist ideas are clearly revealed in his understanding of the concept of world-making in his book, *Educating the reflective practitioner (1987).* I prefer to call this framing the world, as it suggests more deliberateness in constructing reality. Schön's notion of framing is particularly useful in understanding how engineering practitioners make sense of the world of engineering practice and the ways in which they problem solve. Kinsella (2006) highlights an example of this problem-solving phenomenon. She puts under the microscope a civil engineer's road-building exercise and notes that

while the civil engineer may see drainage and soil stability, they may not see the road's effect on the town's economy. It is through the acts of naming and framing that the practitioner selects certain things for attention and organises them (2006, p. 9). It is in these processes of selecting, organising and problem-solving that worlds are made and unmade. Professional knowledge therefore, does not exist as a body of knowledge waiting to be "poured" into the heads of students. Instead, it emerges as responses to the worlds created by a range of forces acting both internally and externally which comprise the lived experience of academia and the workplace.

2.3.4 Differences between propositional knowledge and knowledge in action

According to Kinsella (2007), Schön's (1983) distinction between "knowing that" and "knowing how" is drawn from the work of Gilbert Ryle (1949) and points to his focus on the difference between propositional knowledge and practice knowledge. Ryle (1949) seems to suggest that propositional knowledge may not be necessary for action to take place. Although he concedes that it is necessary at times, he points to practitioners' spontaneous behaviour and concludes that they reveal a different kind of knowledge from that found in textbooks. Using the example of the tightrope walker and the baseball player, Schön makes the point that in know-how, there is no time in their actions to think about rules or plans. Schön calls this "knowing-in-action", which is revealed in skilful execution of practice but cannot be explained (Kinsella, 2012, p. 12).

Perhaps it is this type of knowing that Schön calls "tacit knowledge". A major gap in our understanding of professional knowledge is the issue of tacit knowledge or knowledge in and of practice. This type of knowledge is difficult to pin down into codified forms and therefore needs the practice situation to master it (Liu, Jiang & Song, 2014; Tounkara, 2013). The current study explored this gap.

2.3.5 Limitations of the reflective practice model

Despite its resurgence in higher education, and other fields of practice, theorists identify a number of weaknesses in the theory. These include lack of conceptual clarity (Kinsella, 1983; Canning, 2008), the highly individual nature of the model and the absence of any discussion of issues of power (Sellars, 2013). A number of models have been created in which some of these concerns have been addressed: these include Gore and Zeichner (1991), Valli (1993) and Gibbs (1988). Building on the notion of reflective practice and Schön's model, these early frameworks in teacher education have outlined various phases of reflection in which they try to incorporate personal emotional, political and moral issues into teacher performance (Sellars, 2013).

In this study, I draw on Schön's critique of technical rationality, his notions of artistry, of reflection in and on practice as well as his insights into professional practice to deepen my understanding of practice

in the two contexts of teaching in academic and engineering workplaces. I turn to communities of practice theory to address the gaps in Schön's theory regarding its highly individualistic focus.

In this section, I first explored how constructivist thought emerged as a response to the dominant scientific rational model of knowledge that prevails in universities and colleges of higher learning as well as in industry and other workplaces. Secondly, I drew on Schön's theory of reflective practice as a way of exploring knowledge transfers in inter-professional encounters. In addition, I used Lave and Wenger's (1991) communities of practice notion, to explore how newcomers in workplaces become competent old-timers as they are socialised into the workplace.

The next section discusses the social realist model of professional knowledge, and its emergence in the early 1980s in response to constructivist influences in higher education.

2.4 Section Four: The social realist model of professional knowledge

In this section, I first outline the socio-realist perception of the differences between abstract and experiential knowledge. This is followed by an exploration of the notion of boundaries as a way of exploring realist views regarding the use of different forms of knowledge during student transfers from universities to industry. I use Bernstein's (2000) notion of recontextualisation to understand the way knowledge is packaged differently according to the context. I investigate how issues of power and social justice are implicated in the intended curriculum and finally, I draw comparisons between the instrumental, constructive and realist paradigms of knowledge in terms of their views on professional knowledge.

2.4.1 Circulation of knowledge in inter-professional contexts: problems

Social realists argue that mundane knowledge is intrinsically tied to the context of its production and it is therefore only understandable in that specific context (Wheelahan, 2015). The structure of such knowledge is 'segmented' (Bernstein, 2000), meaning that its interpretation is linked to its context. Such segmental knowledge is not easily transferable unless aspects of the context remain the same. Essentially, this suggests that the knowledge and skills acquired in one context may not be meaningful or relevant in another (Wheelahan, 2015). This kind of knowledge is described by Bernstein (2000) as oral, tacit and multi-layered. This has implications for learning across contexts, and may perhaps account for why students have difficulty translating action from university to workplace contexts.

2.4.2 Singulars, regions and generic modes of knowledge

It is important to distinguish between abstract knowledge and knowledge based on social experience. Social realists like Moore and Muller (2002) provide clear guidance on the difference between abstract and experiential knowledge. Sacred refers to abstract knowledge while the profane points to everyday experiential knowledge. Young and Muller (2010, pp. 121) add that sacred refers to an internally consistent world of concepts. In contrast, profane knowledge refers to a continuum of practices and procedures.

In drawing a distinction between sacred and profane knowledge, Young et al., (2002) claim that sacred knowledge can evoke deeper resonances and complexities which are not possible with profane procedures and practices which are always contradictory and in Schön's word, 'messy'. They believe that powerful and cumulative knowledge can be built over time and across time and space (2010, p. 122). Social realists posit that experiential knowledge is difficult to theorise and categorise because it is mostly tacit. Social realists regard theoretical knowledge as playing two critical roles in society via its identity as collective representations (Wheelahan, 2015). In the first role, it enables society to understand and develop knowledge about the nature of the natural and social worlds beyond that which is accessible through individual experience. It also allows societies to make sense of the world, to connect the past, present and future and to consider alternative futures (Bernstein, 2000).

In the second role, collective representations play a more self-empowering role in terms of how knowledge is perceived. For example, Bernstein argued that individuals have the right to the means of critical thinking and to be included socially, intellectually and personally (2000, p. 10). This is the way in which a society's values and norms are established and passed on. Wheelahan (2015) argues that students require theoretical knowledge as they will need to participate in debates about society, in the workplace and in their private worlds.

Globalisation and the increasing technological sophistication of the workplace have added to the urgency of the problem of access to knowledge. The nature of occupations is changing as the ways in which practice is enacted changes in the face of increasing artificial intelligence. Ethical issues and how practice can be developed in future also need to be considered (Wheelahan, 2015). According to Muller (2000), in order to participate in societal debates, a student needs to be aware of the rules that enable one to participate as well as the boundaries that govern the ambit of the debate. Muller (2000) uses the metaphor of a crossing to describe this aspect of theoretical knowledge. He speaks of crossing the inscribed line in the sand; to successfully negotiate the crossover, one needs to understand the power inscribed in the line as well as have knowledge of how and where to cross.

However, Muller (2000) has cautioned that one should guard against simplistic polarisations of professional knowledge into its discrete categories. He argues that the relationship between disciplinary and transdisciplinary knowledge, for example, is highly complex. This is well-articulated by Guile (2019) in his four conceptions of recontextualisation of professional knowledges. Shay (2013) further elaborates on this complexity by showing how disciplinary knowledge or codified knowledge in the workplace context undergoes a double recontextualisation. At the first level of recontextualisation, codified knowledge needs to be modified to suit the pedagogic agenda of the university classroom and it is mediated through the academic's understanding of what the student will need in the workplace. Once the learner is embedded in a practice context, reconstituted codified knowledges will need further reconfiguring to suit the nature and agenda of the workplace. It is at this point, that is, in its context of application, that a complex relationship between disciplinary and transciplinary knowledge emerges (Guile, 2019). Such application is thus a fluid interchange of multi-layered perspectives.

Students at work will need to access theoretical knowledge in their respective fields before they can engage in successful practice. However, according to Wheelahan (2015, p. 2015), this is not the same for all students. She adds that differential access to knowledge occurs among students at different tertiary institutions. For students in vocational training institutions, the focus is on learning how to do, which is craft knowledge, while a traditional research-based university will emphasise theoretical knowledge before engaging in practice. The question that Wheelahan raises is whether such differential access to knowledge enables students to fully participate in societal debates. She regards theoretical knowledge as powerful because it enables epistemic access to society although such knowledge is 'incomplete, fallible and revisable' (2015, p. 753).

2.4.3 Notions of reality, disembodied knowledge and situated knowledge

Social realism and its adherents, like Moore (2013) reject extreme forms of constructivism arguing against its central thesis of relativism (Wrigley, 2018, p.5). For social realists, reality and knowledge are external, objective and detached from the perceptions and experiences of the knower. For social constructivists, on the other hand, reality and knowledge are inseparable from the knower's experiences and understanding. Reality, therefore, for social constructivists is considered as constructed from the individual's standpoints (Zipin, 2015 p.9).

A key difference between how realism and constructivism view knowledge is evident in the notion of embodiment. For realists, theoretical knowledge is disembodied or abstract knowledge. However, constructivist understandings of knowledge locate knowledge in contexts of practice, as well as in practitioners' experience. Moore (2013) deploys two sets of concepts to differentiate between constructivism and social realism. He uses reductive a nd subjectivist as labels to describe

constructivism while emergentist and objectivist are used to describe social realism. Elucidation of these concepts provides useful insight into the distinction between social constructivism and social reality. Constructivism is reductive because it understands knowledge as emanating from the point of its origins in the social relations of power, while it is subjective because it views knowledge from the standpoint of those producing it (Moore, 2013). In contrast, realism can be regarded as emergentist because it locates knowledge within socio-cognitive networks, independent of subjective and individual experience. It assumes objectivity when these networks come to symbolically act as a means of independent evaluation of knowledge (Moore, 2013).

Wheelahan's (2012) criticism of constructivist theorisations of knowledge emerges from a vocational education perspective. Using Bernstein's concept of segmental pedagogy, she posits that constructivism is unable to theorise the relationship between theoretical knowledge and workplace practice in knowledge transfer contexts. She draws a distinction between knowledge which is 'decontextualized from its system of meaning in which it is embedded, and knowledge which is tied to its context' (p ref). She then concludes that students are unable to access the criteria they need to select knowledge and to use it in innovative ways as the knowledge is not in their control.

2.4.4 Power, social justice and the curriculum

Studies on social realism in the sociology of education are generally tied to debates around curriculum selection (Muller, 2006; Young & Gamble, 2006; Wheelahan, 2015). The seemingly benign question of what kinds of knowledge should be selected for inclusion in the curriculum and why, has been implicated in the paradigm wars over the years. More recently, social realists have drawn on the theme of social justice to justify the philosophical positions held with regard to knowledge selection. They tend to privilege disciplinary knowledge over everyday language. This is best exemplified by Young's (2008, p. 14) use of the notion of powerful knowledge. He contends that it is specialised knowledge which allows society to engage in political, moral and other kinds of debates. He further argues that access to abstract knowledge is clearly more powerful than the experiential knowledge that students bring to class. Muller (2000) draws a distinction between an insular and a hybrid curriculum. The former emphasises discipline knowledge while the latter collapses the distinctions between them. Realists contend that the curriculum has shifted abstract knowledge from the centre and has prioritised knowledge that is contextualised (Wheelahan, 2015).

Critics of social realism have used the themes of power and social justice to show up weaknesses in the realist debates. One of the critiques levelled against Social Realism is that it frames the return of powerful knowledge into the curriculum debate in a very narrow manner. Zipin (2015) posits that only one dimension of the curriculum is invoked in the social realist debate and that is the issue of

knowledge redistribution. He further argues that in order for the disenfranchised to deploy specialist knowledge effectively, the critically enabling forces of cultural capital need to be activated as well. He suggests that by broadening the debate on knowledge in this way, it addresses the social justice issue by enabling the poor to deploy such knowledge more effectively. Wrigley (2018) concurs that a socially just curriculum needs both vernacular as well canonical knowledge.

Another critique raised against the proponents of Social Realism is that they ignore the ethical dimension in the construction of the curriculum, and instead prioritise only the cognitive dimension of knowledge. Zipin (2015) calls for a reframing of the curriculum in which creative imagination and lived experience are used to mediate cognitive capacity in order to work for the common good by exploring complex understandings of ethical themes (2015 p.34).

Gail Edwards (2014) also takes issue with the notion of privileging facts since this invokes an aura of totality and enduring sense and as a consequence leaves no place for agency. Drawing on Vygotsky, she advocates that a dialectical transactional relation needs to exist between the world of everyday knowledge and abstract theoretical knowledge in a reflexive relationship. She postulates that such a relationship would allow standpoints to transcend and be transformed. She further contends that Social Realists who tend to simplify standpoint theory need to embrace dialectical ways of knowing and not view standpoint theory as relativist straw man conceptions of knowledge.

2.4.5 Positivism, constructivism and realism

Moore (2015) makes the case that the differences between constructivism and positivism are not as widely divergent as they are usually made out to be. He advances this argument by firstly presenting the attributes of a traditional and generic understanding of positivism in order to clarify the differences between realism and positivism. He then offers a brief description of the features of a positivist model of knowledge in which reality exists externally and can be represented as objective knowledge by a disembodied observer. Such knowledge is certain and universal. In contrast, the constructivist model of knowledge is viewed as embodied and embedded within experiential and social contexts. For Moore, the conventional description of positivism described above is problematic as he believes that it is no longer viewed in this mode.

Moore (2013) argues that from a realist perspective, positivism and constructivism form the two ends of the empiricist spectrum with the major differences emanating from differences of language. He suggests that these diverse models of knowledge have more in common than they differ. He adds that the lack of ontology is the major issue, as in both traditions, it reduces knowledge to the epistemology of the knowing subject (2013). Moore adds that the social constructivist understanding of positivism is

that it is a correspondence theory of truth. This suggests that a statement can be regarded as the truth if it corresponds to aspects of external reality. Moore concludes that constructivism conflates notions of science with positivism from NSOE to postmodern perspectives. This suggests that constructivist and its postmodern understandings of science may be seriously misconstrued.

2.5 Section Five: Professionalism

Through an exploration of changes in conceptions of professional knowledge in its diverse paradigmatic incarnations, this chapter argues for the creation of a new professionalism which seeks to account for the complexities and contradictions of professional practice in times of uncertainty, globalisation and marketisation. In this section, I explore how paradigmatic shifts in conceptions of professional knowledge have signalled a crisis in the professions.

Professionalism has come under threat from the growing influence of marketisation and managerialism (Hall, 2019; Cruikshank & Abbinett, 2019) which have infiltrated the university and professional culture. The much-vaunted adage by Hoyle & Wallace (2005) that autonomy has given way to accountability, captures the conundrum facing higher education today. The suggested loss of power by universities to determine their own destinies (Evans, 2008) has caused many to speculate on how such a loss can be overcome. Professionalism has been seen as a form of avatar to ward off the evils of marketisation and managerialism which have encroached on the autonomy of professions. However, some claim that professionalism has capitulated to market forces with regulation being imposed from above (Evans, 2008).

2.5.1 Defining professionalism

What exactly do we mean by professionalism? Evetts (2018) points to two major themes. The first involves improving the quality of practitioner practice, while the other relates to capitulating to external control of the profession. When professionalism is viewed as an occupational value, it is associated with improvement in the quality of the practice that the professional enacts. When it is linked to organisational forms, it is viewed as imposition by external forces. A traditional view has been to regard professionalism attitudinally from an individual perspective as one's attitudes and behaviour towards one's profession. (Evans, 2008). In contrast, Ozga (1995) regards professionalism as the services of a profession that pander to those in power.

The influence of managerialism is not only complex but also multi-layered and multi-dimensional (Evetts, 2018). Although management is used to control, and sometimes limit, the work of practitioners in organisations, it is also used by practitioners and professional associations as a strategy in both the career development of practitioners and in order to improve the status of and respect for a professional

occupation (Evetts, 2018). According to Evetts (2018) professional occupations have been infiltrated by 'organizational principles, strategies and methods which have altered transforming their identities, structures and practices' (2018, p.49). The transformation of occupational professionalism to managerial professionalism has brought about changes in practice as well as the hierarchical structures of professions. However, this new form of professionalism is not only characterised by change as many elements of the old professionalism are retained (Evetts, 2008).

In many quarters, such changes have been regarded as an 'assault on professionalism' (Beck & Young, 2005). In response to growing threats to professional autonomy, Beck & Young (2005) posit that a new kind of professionalism has emerged that has stronger ties with the world of practice and weaker links with the acquisition and production of knowledge in higher education. Beck & Young (2005) also bemoan the fact that these changes emanate from within the ranks of academia, suggesting that managers have been complicit in adopting the mantra of auditing and performativity. It is surprising that the potential for new forms of academic identity has been muted. Instead, the loss of a fundamentalist, pure form of professionalism with its roots linked to vertical forms of knowledge is bemoaned. Moreover, a false association is conveyed in associating notions of genericism, trainability and competency-based education with socio-constructivist notions of professionalism.

2.5.2 Collaborative notions of professionalism

This study sought to develop a collaborative notion of professionalism (Adler, Kwon & Heckscher, 2008) as its ambit of study traversed two distinct fields of practice. These fields of practice integrate in the space of the WIL programme which offers a potentially rich site to study emergent forms of collaborations between academia and industry. In describing the nature of these collaborations, Barrett, Oborn & Racko (2017) characterise the structure of the envisaged partnerships as non-hierarchical with each partner retaining its own distinct identity. This study framed a collaborative form of professionalism through engaging with diverse forms of professional knowledge evident in inter-professional encounters.

2.6 Section Six: Crafting a lens for the study

This study employed a socio-cultural lens of the appropriateness and relevance of professional education and induction into the world of work to explore notions of professional knowledge across academia and industry. In order to construct my lens, I deployed constructs from a range of theorists. Aristotle's notions of episteme, techne and phronesis provided the theoretical undergirding of the study. These concepts, particularly phronesis were expanded to address the challenges and gaps identified in the ways in which engineering education is enacted across the two domains of academia and industry. Phronesis was used to interrogate notions of wisdom and moral action as understood in the two worlds.

In order to understand how knowledge circulates from the world of the university to the world of work, I use the insights provided by Schön and Eraut. While these theorists offer ways of exploring the differences between theoretical and practice knowledge, Lave and Wenger provide useful insights into how newcomers become old timers (see section below). The model below (Figure 4) represents this arrangement schematically to show the journey of the novice from novice to expert, to become a fully-fledged member of the community of practice within the organisations concerned. Four vantage points were used to explore varied conceptions of professional knowledge and compare conceptions across levels as well as industries. This was in response to the failure of previous research to include marginalised voices. While novices and managers appear to be well represented in the few studies that include an exploration of industry voices, the views of middle managers and senior academic staff are generally not well represented in comparative studies.

The positioning of each conception in the diagram below reflects the intersection between the varying individuals (within academia and the workplace) and their theoretical worldviews. Neither the individual themselves, nor the theories/ models are static, essential categories. They are fluid and flexible, mutating responsively to each other and their theoretical, social, political, organisational cultural contexts. The dotted lines and bidirectional arrows depict this fluidity. Starting from the periphery of the diagram outlining the theoretical models, is the first representation on the left side: the *Classical conception* of knowledge which represents one potential worldview of participants. The second outlines the *technical rational* notions which potentially could also be part of the worldview of individual participants.

This third representation of a theoretical model highlights *the constructivist* position, another potential framing worldview. The last representation constitutes the *social realist* conceptions which could be drawn on by individuals at different points in their reflections on professional growth trajectory of students under their mentorship. The dotted lines framing each conception emphasise the fluidity, reflexivity and dialogicality across individuals and models.

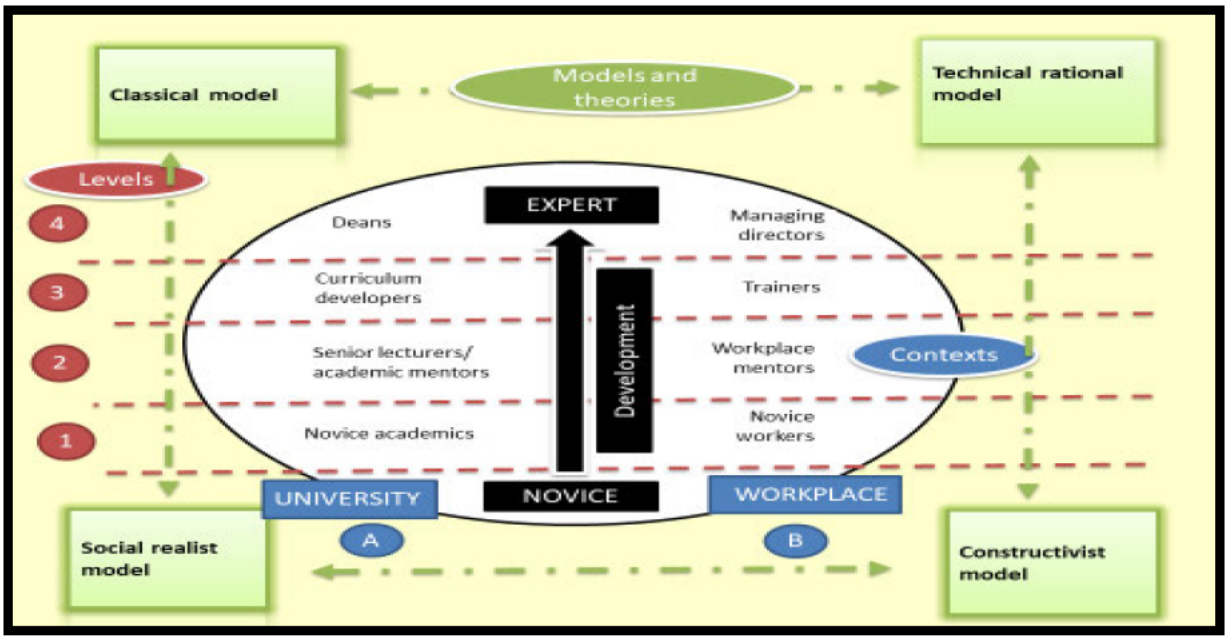

Figure 4: ***Conceptual framework***

2.6.1 Communities of practice framework

Lave and Wenger's (1991) COP theory provides a useful lens to explore how professional knowledge practices at the university and the workplace come to embody professional knowledge and the ways in which early professional identity is created. A COP refers to a group of people who share common interests, have a passion for something and whose interactions deepen their knowledge (Wenger, 2002). Examples range from tribes foraging for food in the Amazon jungle, to professors at a conference and accountants learning how to dance. In their mutual engagements, these communities build a repertoire of practices which come to embody their knowledge.

Members occupy different positions in these groups that are contingent on their familiarity with their knowledge of the community's goals and discourses. Those who are experts will occupy the centre while novices will tend to gather at the periphery. According to Wenger (2010), COPs reflect the collective learning of a community over time. By participating in these communities, members negotiate and define what constitutes competence as they interact with one another on a daily basis. According to Wenger, competence encapsulates three aspects, namely, understanding the collective responsibility of the group and its enterprise and contributing to it; being accepted in the group through joint sharing of ideas and practices in a mutually symbiotic relationship; and deploying the shared repertoires of the community's resources like language, artefacts, tools and stories (2010, p. 229).

In the current study, the world of academia represented by academics from UoTs can be a regarded as a COP, as can the world of industry. These worlds of practice were explored in detail for their potential to inform and transform the novice engineer. In as much as we focus on communities, it is the individual's journey through these communities that will signify that learning has taken place (Sofia Nyström, 2009). Lave and Wenger (*ibid*) deploy an interesting notion called "legitimate peripheral participation". This refers to the continuum of practice where the novice assimilates knowledge in a context of multi-COPs to become an expert. The process is "legitimate" because it is widely recognised that in order to become part of a community one needs certain "qualifications" and in this instance, practical experience is required. The term "peripheral" describes the newcomer as one who sits on the margins of the community doing all kinds of less important tasks. Thus, "participation" refers to the newcomer's active engagement in tasks that are initially marginal to the group activity, but once they are successfully mastered, s/he is welcome to participate in the core practices of the community.

The participants in this study were drawn from different hierarchical positions within the selected organisations and ranged from novices in their fields to those who after many years of experience and qualifications become experts in their areas of specialisation. Using the lens of legitimate peripheral participation, I analysed how each group conceptualises professional knowledge along different points on the career trajectory of an engineer.

2.6.2 Eraut's learning trajectories and knowledge transfer models

I drew on Eraut's (1984) taxonomy of knowledges to understand the different types of knowledge conceptions at play in the world of work. For Eraut (2004), professional knowledge is a combination of three types of knowledge, namely, *Process knowledge* as skills, *personal knowledge* which includes personal impressions and experiential interpretations, and *propositional knowledge* which consists of theories, concepts and propositions.

While Lave and Wenger (1991) set out the broad structural processes of socialisation and acculturation of novices into the workplace, Eraut fills the gap in understanding the internal details of knowledge creation and exchange within the workplace. Eraut's (2004) comprehensive analysis of the nature of professional knowledge enables one to focus on practical knowledge which he termed "knowledge in action" or "craft knowledge". The metaphor of an iceberg, as used by the MUSTER project (Samuel, 1998), effectively conveys Eraut's notion of craft knowledge that is not overtly visible. This knowledge remains hidden below the surface of the iceberg. It is gained while enacting knowledge during practice and is used to engage with work routines. Tacit knowledge is imbibed rather than explicitly taught. This suggests that academic knowledge is limited if it does not include a strong practical component so that students can benefit from engaging with workplace practices. Universities of Technology are ideally

positioned to take advantage of WIL programmes which consist of a period of practical training before students graduate. Traditional universities which have had a strong research focus can benefit from exploring how UoTs have implemented their WIL programmes.

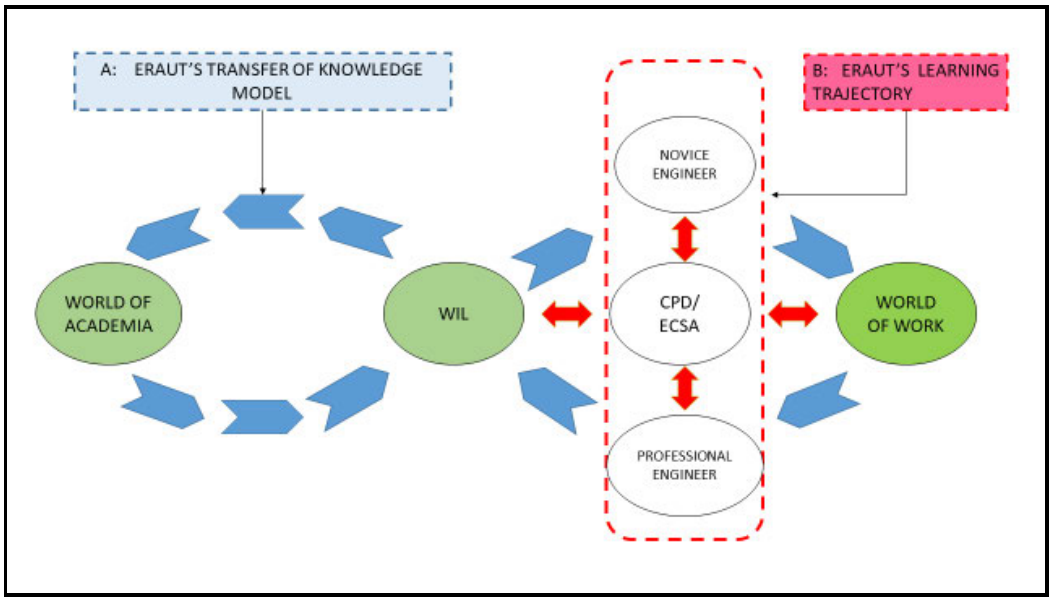

Figure 5: Eraut's model of knowledge transfer and professional development

Eraut (2009) uses two powerful models to deepen insight into issues of learning at the workplace. These models are graphically represented as A and B in the above figure. The first he terms the knowledge transfer model while the second is called a learning trajectory model. I use a lemniscate figure to represent these frameworks as they effectively convey the ways in which knowledge circulates through the different domains in the world of academia and the workplace. The infinity lemniscate figure encapsulates two separate worlds but they operate as a single entity when the novice is expected to engage in WIL. The blue arrows point in the direction in which the knowledge flows in a continuous stream. The second framework of professional development is represented by the red dashes. Here the movement is within the discipline of engineering where the novice is expected to progress through various stages to become proficient; this entails a period of registration with ECSA.

Eraut's (2009) insights into how novices migrate from university to the workplace address an important gap in the extant literature on the ways knowledge is conceived across two very different sectors of the economy. I drew on this framework to understand the epistemological challenges facing novices as they journey from UoTs to industry. Eraut provides very detailed mapping of the different processes that unfold in the novice's journey and the different types of knowledge that are activated along the

way. More specifically, this study aimed to make visible novices' learning trajectories as they journey from UoTs to the chemical engineering workplace.

Eraut's second framework was used to understand the process of professionalising novice workers. Here, Eraut draws our attention to the different roles played by various people and circumstances in the workplace in producing the professional. However, this model does not address the key role played by regulatory agencies in shaping novices' learning experiences in becoming professionals. Furthermore, he does not consider how structural forces like globalisation or massification account for changes in the ways in which learning is influenced. These include the internal cultural conditions of learning and teaching that occur at the workplace as well as the role of regulatory agencies in professionalising processes.

Eraut's (1998) contribution to this study lies in his penetrating insights into how the workplace is stratified into different levels of workers and the knowledge repertoires each engages in during practice encounters. These insights guided my understanding of how to view managers, middle managers and novices' encounters in the learning processes.

Synthesis

This chapter detailed the paradigmatic shifts in the way professional knowledge has been viewed over the past few centuries. The first section examined how Aristotle conceived of knowledge in the classical period. Section two focused on technical rational conceptions of knowledge that played a prominent role and are still embedded in ways of thinking about knowledge. In section three, I focused on contributions from socio-constructivists whose debates on the importance of context are central to this section. In section four, I explored the work of social realists while section five covered the theme of self and knowledge.

CHAPTER THREE
CONSTRUCTING THE RESEARCH DESIGN

Orientation

Chapter Two focused on the conceptual framework for this study that emerged from a critique of three models of professional knowledge, namely, the technicist, constructivist and social realist models. I showed how these models draw from Aristotle's notions of techne, theoria and phronesis and gave these concepts contemporary relevance. The new lens that I created extends the notion of phronesis and explores the relationship between self and professional knowledge.

This chapter presents the methodology employed to conduct the study. It comprises four sections. In section one, I set out the rationale for using an interpretive research approach, present the research design and justify the use of multiple cases within a case study design. The sampling procedures are discussed, including the criteria employed to select participants from within academia and industry. I end the section by briefly sketching the context in which the data were generated. In section two, I justify the use of a multi-method approach to generate data and show that semi-structured interviews, transect walks and document analysis were critical to the research design. A substantial portion of this section is devoted to the transect walk methodology as it is innovative and hence requires explication.

Section three describes the steps taken to ensure the rigour and quality of the research project. These measures were designed to build trustworthiness. I conclude by discussing the study's limitations and the ethical issues taken into account. Finally, section four describes the data analysis process.

3.1 Section One: Study design

3.1.1 Interpretive paradigm

The interpretive paradigm emerged in the aftermath of the paradigm wars (Denzin & Lincoln, 2011). Conflict over epistemological approaches to research led to an 'Interpretive Turn' in the 1980s which marked a shift away from research that was positivist in nature (Dean, 2018). A more socially constructive orientation gained currency over objective, scientific and detached approaches to social research. As Howe elucidates, 'Over the last several decades, positivist-behaviourist approaches to social and educational research have been on the decline, whereas interpretivist approaches have been on the rise' (1998, p. 13).

For positivists, external reality exists as objective while for interpretivists, experience of the world is subjective (Guba & Lincoln, 1994). Reality is experienced as the meaning people ascribe to things in the world. In other words, each person's experience of reality is fundamentality different (Cohen, Manion & Morrison, 2007). This paradigm was appropriate to explore conceptions of professional knowledge among academics and industry personnel because they are rooted in existing social, cultural and economic conditions.

3.1.2 Qualitative case study design

According to Yin (1984), a case study answers why, and how questions. It is a useful methodology to understand a phenomenon in its everyday context. In this study, the case is industry and academia's understandings of professional knowledge, and the multiple cases embedded in it are the contexts in which conceptions of professional knowledge are rendered, namely, the UoTs and industry sites (Prometheus Petroleum Industrial Refining (PPIR) and Atlantis Purification Industrial Plant (APIP)[2]) . The multiple cases allowed me to compare and contrast results within and between cases. The matter of fact and unproblematic description of a case study above belies its contested nature (Yazan, 2015). According to theorists, there are multiple ways to define, design and implement a case study (Yazan, 2015; Miles, 2015; Thomas, 2013). By exploring various theoretical conceptions of the case study design, I show its usefulness as well as limitations in studying the phenomenon of professional knowledge in academia and industry.

3.1.2.1 Definitions

According to Simons (2008), a case study is highly complex and provides a contextualised real life description of institutions and the many manifestations of academic culture. Harrison, Birks, Franklin, & Mills (2017) consider case studies as agnostic because they do not subscribe to a single world view, and can accommodate both qualitative and quantitative research methods. Luckett et al., (2006) state that case studies span paradigms because they have the potential to embrace a variety of philosophical approaches, while Denzin and Lincoln (2011) describe case studies as fluid as they are able to accommodate different ontologies, epistemologies, and methods. According to Stake (2005, p. 443), case studies involve the analysis of persons, events, decisions, periods, projects, policies, and institutions. However, Stake (2005) regards the openness of a case study as a flaw as 'anything can be regarded as case study research'. Miles (2015) asserts that case studies are very useful in educational research as they enable readers to make connections between the case and their experiences.

[2] All the names of the institutions and industries, and their personnel are pseudonyms in order to ensure anonymity.

It is important to set out my own philosophical position as this epistemic orientation impacted on the perspectives I drew on in adopting the research methods and design. Although I drew on Yin, I am a constructivist at heart, and I see the world as constructed and multidimensional. I viewed my purpose in this study as exploring emergent conceptions of professional knowledge: do they arise from theoretical notions taught at universities or do they emerge from situated understandings of practice in academia and industry as these milieus evolve and change to meet the demands of a globalised era?

3.1.2.2 Comparative cross-case research

I chose to conduct a cross-sectoral, cross-case study as I believe that relationships between professions embedded in different traditions need to be explored through comparison. In this thesis, I compare the world of academia to that of industry in terms of the professional knowledge conceptions held by staff within each sector. I regarded the case study as an ideal tool to achieve this objective. Perhaps there is space to learn from one another as professions experience a crisis.

My rationale for selecting a case study with multiple cases rather than an in-depth study of a single case was that I believed that exploring conceptions of professional knowledge across economic sectors would yield deeper insights into the nature of the relationship between academia and industry. Deciding whether to opt for a single case study or one with multiple sites was challenging. However, it seemed that the decision on whether to go for scope or depth (Krehl & Weck, 2019) was already embedded in my topic. Since the topic was comparative in nature, I was compelled to identify possible sites across the two professional sectors selected for the study.

The study was also doable as it comprised four research sites which meant that depth did not have to be sacrificed. In addition, I chose to go for scope rather than depth as singular studies of depth have been repeatedly undertaken. While I concur that undertaking a cross-case study can promote depth, I felt that a focus on multiple sites of research could make a significant contribution to understanding the links between academia and industry in terms of professional knowledge.

3.1.2.3 Advantages and disadvantages

A major strength of a case study in the field of education is its focus on authentic learning contexts. This is because case studies acknowledge that practitioners, both novices and experts, learn through rich and varied textures of experience in practice encounters in the workplace (Thomas, 2013). By locating learning in the field of practice, the case study is particularly suited to an investigation of tertiary education and industry sites. The multiple cases enabled me to gain deep insight into the way professional knowledge is enacted and has illuminated workplace cultures and their affordances.

However, the extant literature notes that one of the weakness of case studies is their lack of generalisability (Krehl & Weck, 2019; Miles, 2015). According to Flyvbjerg (2006, p. 21), case studies often draw on narratives which reflect the 'complexities and contradictions of real life'. He adds that it may be difficult to summarise these narratives into general propositions and that critics often see this as a disadvantage of using case studies. However, he maintains that a thick and difficult narrative is evidence that the researcher has uncovered a potentially rich site of research.

3.1.3 Sampling

The sample for this study was drawn from the worlds of work and academia. Within the world of work, I selected one company from the petrochemical industry, and the other from the water sector. Prometheus Petroleum Industrial Refining is located in the south Durban industrial basin, a highly polluted area, while Atlantis Purification Industrial Plant is located in Overport, an urban centre in Durban. Both companies are large enough for the kind of sample I required.

I selected participants who occupy different hierarchical positions in these companies. This yielded richer data as I was able to mine information along different points in the participants' career trajectories. The positions ranged from manager, to trainer, WIL representative and newly qualified graduate. From these different vantage points, I gleaned how participants conceived of professional knowledge. I used years of experience as an important criterion to distinguish between participants; for example, the newly qualified graduate had less than five years' work experience, while the mentor had about ten. Ten years was set as a yardstick to select participants as I believed that the insights I would gain would be richer. This proved to be the case. A total of eight participants from industry were interviewed.

I used the same sampling pattern at the UoTs. Here, I drew from different levels in the organisation. I chose members from different career points because I felt that this would provide rich data. This proved advantageous as experiences of professional knowledge and practices were varied. The sample consisted of a range of staff members from different units and levels at the university. The positions ranged from Deans, to curriculum designers, mentors (WIL representatives) and academics. The academics and mentors were drawn from the Chemical Engineering department. I chose this department because it housed a range of scientists from novices to senior chemists. Given that I aimed to elicit their experiences of their career trajectories, I chose a bigger department with staff with diverse field experience. Four participants were selected from each UOT, making a total of eight from this sector.

In order to answer the research question on the sources of academics and industry personnel's definitions of professional knowledge, I surveyed the curricula, policy documents and departmental reports that guide academics and engineers' practice. I also explored ECSA, the CHE and DHET's

websites as these regulatory bodies guide professionals in universities on the what and how of their disciplines. Engaging with the research sites meant reading any relevant literature found at these sites. The texts were analysed using content analysis to understand the conceptions of professional knowledge implicit in them.

Answering the question on why professional knowledge was conceived in the way it was and the pressures that shaped its contours involved tracking who or what influenced or shaped understandings of professional knowledge. In terms of the transect walk design, each walk involved two participants and the researcher. There were thus two walks per site, or four in each sector, making a total of eight walks. I ensured that I included participants from all four levels within the UoTs as well as industry. This configuration is reflected in the table below:

Table 1

Number of transect walks: sites and participants

Sector	Site	Participants				Walks
1. Industry	**1. Atlantis Purification Industrial Plant (APIP)**	**NQG**	**Trainer**	**Mentor**	**Manager**	**2**
	2. Prometheus Petroleum Industrial Refining (PPIR)	**NQG**	**Trainer**	**Mentor**	**Manager**	**2**
2. University	**3. Sharrukh University of Technology (SUT)**	**Academic**	**Curriculum Designer**	**Mentor/WIL representative**	**Dean**	**2**
	4. Amir University of Technology (AUT)	**Academic**	**Curriculum Designer**	**Mentor/WIL representative**	**Dean**	**2**
	Total				**Total**	**8**

Note. NQG = Newly Qualified Graduate

3.1.4 Research Context

Data for the study was drawn from two domains, namely, the world of the university and the world of work. The first focused on two institutions in Durban both of which are former technikons that are now known as UoTs. They have changed their governance structures to reflect more formal research type institutions. Although the study is embedded in the city of Durban, I used two very different locations.

Amir University of Technology is located in the city centre while Sharrukh University of Technology is located in Umlazi, an African township 20 minutes to the south of Durban.

Sharrukh University of Technology has made dramatic changes to its vision in the past five years since its management transformation. It has experienced tremendous pressure to become a traditional university, that is, a formal research type institution. This meant relooking at all its academic offerings and research orientation. The university caters for the poor and serves the mainly rural areas of north and south KwaZulu-Natal. Amir University of Technology is the product of a merger between two former technikons in 2002 as a result of the streamlining of higher education in South Africa. Located in the city centre, it has a diverse student population and, like other former technikons, has strong links with industry. With its new status as a UOT, staff have come under pressure to pursue a more rigorous research agenda.

My choice of institutions in Durban was influenced by the fact that the kinds of sites that I wished to compare were only located in this city. To the best of my knowledge, SUT is the only institution that was not part of a merger and chose to remain independent. Amir University of Technology is a merged entity. As I intended to interrogate competing constructions of professional knowledge, I believed that a major process like a merger would have played a significant role in shaping the discourse of professional knowledge amongst affected staff. Equally, not being part of a merger and being isolationist would have impacted on staff understandings.

The other site of data production was the world of work, where I selected PPIR, a company in the petrochemical sector, and APIP, a water parastatal. Thus, one is privately owned and the other is linked to the state. I selected these sites because students from both the UoTs are attached to them for experiential training, and they have historically had strong links with these institutions. Selecting companies in different sectors yielded rich data for comparative purposes. Both companies are leaders in their respective fields. Within the water sector, APIP is a visionary company that ensures that water is equitably distributed to all communities within the Ethekwini region. Prometheus Petroleum Industrial Refining is a petrochemical company that specialises in producing fuel.

Since both companies are the largest in their fields[3], they offer benefits that attract and retain employees. My motivation in choosing these companies was that I aimed to identify employees whose career trajectories were sufficiently varied as well as those that had transitioned from novice to expert. Hence

[3] Atlantis Purification Industrial Plant is a state-owned company which is the largest supplier of bulk potable water in South Africa
Prometheus Petroleum Industrial Refining is the largest crude oil company in South Africa accounting for 35% of all fuel consumed

my choice of subjects, each of whom represented a different point in the career trajectory which spanned the novice to the expert and included management personnel. In addition, I selected the chemical engineering field because I felt that the environment was most sensitive to pollutants produced within this industry. I sought to understand whether academia and industry's understanding of professional knowledge includes notions of environmental sensitivity since central Durban and the south Durban industrial basin, where they are located, are regarded as the most polluted space in South Africa. Related to this are social justice issues which I explored by investigating the kinds of issues and knowledge that are rendered invisible or prioritised by academia and industry.

3.2 Section Two: Data generation

Data generation occurred in two phases. In phase one, I conducted individual semi-structured interviews, and document analysis. Phase two employed the virtual transect walk interviews. While all these methods were broadly designed to provide illuminating insights into the phenomenon of professional knowledge, in the main, each sought to respond to a different key question. Semi-structured interviews were employed to answer the first question on academics and industry personnel's conceptions of professional knowledge. The second question on sources of professional knowledge and its activation was explored through transect walks. Document analysis was also used to throw more light on the sources of professional knowledge. The insights drawn from all three methods enabled me to explore why professional knowledge is shaped in the way it is. The table below reflects the relationship of each data generation method to the key questions.

Table 2
Summary of data generation methods

	KEY QUESTIONS	Semi-structured Interviews	Document Analysis	Transect Walks
1	**What are academia and industry's conceptions of professional knowledge?**			
2.1	**What are the sources of professional knowledge?**	✓	✓	✓
2.2	**How is professional knowledge activated?**		✓	
3	**Why is professional knowledge shaped the way it is?**	✓	✓	✓

3.2.1 Semi-structured Interviews

The purpose of semi-structured interviews is to probe for information on phenomena by using a set of questions guided by identified themes to steer the conversation towards uncovering information that is

deemed significant to the area of interest to the researchers (Qu & Dumay, 2011). The semi-structured interview is regarded as a highly effective tool with which to reveal 'hidden facets of human and organisational behaviour' (Qu & Dumay, 2011). I conducted a total of sixteen such interviews divided equally between two universities and two industry sites. Each interview lasted for approximately an hour. At each site, interviews were conducted with participants who occupied different positions along the hierarchy. These levels consisted of either the Dean or manager, a trainer or curriculum developer, a mentor and a novice. I started the interview by asking the participants to tell me their story from the time they entered school, through university and work to their current position. This was my grand tour question. During their narrative, I interrupted as little as possible, only intervening where I needed clarification or if I was interested in any special phenomenon that they described. Here, I probed further into the area of interest. I tried to create a friendly atmosphere rather than a formal question and answer interrogation. I concur with Kvale (1984) that by showing genuine interest, one can generate a great deal of information that would not be forthcoming if the atmosphere of trust and friendliness was absent.

The interviews were structured in three parts. The pre-interview phase involved establishing trust between the interviewee and myself as the interviewer. This involved sharing information about myself, the purpose of the interview and the possible leakage of private information provided in the interview. I assured each participant of confidentiality in writing, and sought consent to conduct and record the interview. The second phase of the interview involved the participant providing their narrative. I noted points of interest that I wished to probe later and did so in the second half of this phase while also posing a few questions relevant to the phenomenon. In the third stage, I thanked the participants for the interview, assured them of confidentiality and promised to make the transcripts available to them should they wish to review the documents. This enabled us to check the accuracy of the transcriptions. Table 3 below sets out the distribution of the semi-structured interviews across the research sites and across ranks along the hierarchy.

Table 3

Semi-structured interviews across sites and ranks

	ACADEMIA			INDUSTRY		
	UoT1	UoT2		Industry 1	Industry 2	TOTAL
Ranks			Ranks			
Dean	1	1	Manager	1	1	4
Curriculum Designers	1	1	Trainer PDP Unit	1	1	4
Discipline Mentors	1	1	WIL Rep Mentors	1	1	4

Lecturers	**1**	**1**	**Newly Qualified Graduate**	**1**	**1**	**4**
No. of interviews	**4**	**4**		**4**	**4**	**16**

3.2.2 Transect walks

A transect walk is a guided tour of a local environment (Flatau et al., 2014). In this method, participants were expected to take me on a guided tour of the site, highlighting spaces, textual objects and signs that they considered significant. The aim was to establish what they considered as important and how they conceived of professional knowledge. A transect walk shifts the power differential into the hands of the participants (Van der Riet & Boettiger, 2009). Sadly, I was informed by one of the managers of a particular site chosen for the transect walk that a physical tour would not be possible as the site was regarded as sensitive and important to the security of the state.

Sitting in the foyer of the manager's office, I noticed an aerial photograph of the site that had been enlarged and covered a whole wall. This inspired me to consider a virtual walk through the site by asking participants to provide a tour using the picture. I replicated this idea at the three other research sites but since these sites did not have pictures, I asked the participants to map onto an A4 piece of paper the significant pathways that they would follow in their transect walks and to highlight what they considered as spaces where knowledge is activated, transferred and used.

I also asked the participants to relate the history of the site during their narratives and to focus on changes over the years. I hoped to understand the reasons for any change and how the participants felt about it. These discussions led to conversations about the effects of globalisation on how learning took place at the site.

I followed the convention of the transect walk methodology where the experts are the people that are domiciled in the context. Those who guided me became the power brokers in the relationship. In this way they were freer to talk and although there was a question and answer session during the virtual walk, it was done via a transect map that the participants drew which enabled them to provide richer input. As the facilitator, I listened carefully, observed and identified different spaces, signs and objects which were mapped on a transect diagram that I used for analysis.

While the data provided by the virtual transect walk was adequate to allow for significant insights into the key questions, a true transect walk would have provided more authentic experiences of the site and learning spaces. The participants would have been more relaxed in their natural surroundings and would perhaps have offered richer data.

3.2.2.1 Transect Walk: research sites and participants

Transect walk participants were drawn from the four sites under investigation. The table below shows the participants that participated in this exercise at each site.

Table 4

Transect walk: teams

SECTOR	SITE	PARTICIPANTS		INTERVIEWS
		Team 1	Team 2	
1. Industry	1. Atlantis Purification Industrial Plant (APIP)	NQG/Trainer	Mentor/Manager	2
	2. Prometheus Petroleum Industrial Refining (PPIR)	NQG/Trainer	Mentor/Manager	2
		Team 1	Team 2	
2. University	3. Sharrukh University of Technology (SUT)	Academic/Curriculum Designer	Mentor/WIL representative	2
	4. Amir University of Technology (AUT)	Academic/Curriculum Designer	Mentor/WIL representative	2
			Total no. of interviews	8

Note. NQG = Newly qualified graduate

3.2.3 Document Analysis

Document analysis is a research method that analyses the content of written documents, both printed and electronic, in a systematic and rigorous manner (Bowen, 2009; Wach, 2013). The text can be drawn from company reports, agendas, blogs, diaries and brochures, amongst other kinds. I opted to analyse a range of texts, including company websites, brochures and reports, blogs and departmental curriculum documents. A full inventory of these items is set out in Table 5 below. These texts provided physical, social and economic background on the research sites. They also provided deep insights into the practices and products of the institutions and organisations under study.

3.2.4 Method of Analysis

The analysis of the range of texts consisted of three stages. In the first, I read through the documents, then attached various codes to the segmented texts. Categories were then used to cluster the codes. Finally, I put the codes together to generate a summarising code or precis of the material. This method allowed me to triangulate my findings (Denzin & Lincoln, 2011). The document analysis enabled me to access data that the participants had forgotten or did not think of at the time of the interviews (Bowen, 2009). I disagree with Bowen when she describes this method as easier than other research methods as it involves selection of data instead of data collection. Obtaining the data was an arduous process. Many participants were also reluctant to provide documents as they felt that this might flout institutional or company regulations. As a consequence, I had to be content with documents in the public domain.

Table 5

Types of documents consulted

Academia	**Industry**	**Regulatory Agencies**
UOT 1: SUT	**Industry 1: APIP**	**CHE/ECSA**
SUT :Faculty of Engineering Prospectus 2016 SUT Annual Report 2016	APIP Annual report -2016	**CHE** Syllabus: General Policy for Technikon Instructional Programmes- NATED Report 150. WIL Policy: Work integrated learning: good practice guide
UOT 2: AUT	**Industry 2: PPIR**	**ECSA:**
AUT : Chemical Engineering Handbook AUT Annual Report 2016	PPIR Annual Report -2016	Policy on Registration in Professional Categories Policy for the accreditation of technology programmes in engineering

3.3 Section Three: Measures to ensure quality

In his discussion of trustworthiness in qualitative research, Shenton (2004) invokes the difficulties positivists experience with establishing validity and reliability in naturistic data. He contends that although locating strategies to ensure trustworthiness is very tricky in qualitative studies, there have

been many attempts to do so. One such response has been Lincoln and Guba's (1985) whose constructs of credibility, transferability, dependability and confirmability, are currently used by qualitative researchers to establish trustworthiness. This study will draw on these constructs as well.

Trustworthiness

3.3.1. Credibility

Credibility in qualitative research involves measures to instil confidence and veracity in the findings. Its corollary in quantitative research is internal validity which is concerned with trustworthiness of the findings and it is associated with truth-value (Kortjens & Moser, 2018). Although there are several strategies to ensure credibility in qualitative research, I have limited this study to using the following measures: prolonged engagement and observation, triangulation, and member checking.

Prolonged engagement and observation

Prolonged engagement refers to the time spent in the research in order to become familiar with the context (Kortjens & Moser, 2018; Amin et al., 2020; Lincoln & Guba, 1985). The purpose of persistent observation is to focus in depth on those aspects in the research context that are most relevant and which impinge on the phenomenon being researched (According to Lincoln & Guba, 1985). Amin et al., (2020) highlight the distinction between prolonged engagement and persistent observation; they observe that prolonged engagement provides scope while persistent observation provides depth. Where prolonged engagement functions to identify a range of influences, persistent observation allows for the identification of elements that are important to the phenomenon under scrutiny.

A caveat which Shenton (2004) provides regarding prolonged engagement is when too many demands are proposed by the investigator before the researcher can establish trust with his/her participants. This may create suspicion among the gatekeepers and participants which may then have the effect of jeopardising the study. One of the methods, I propose to augment one's understanding of the context is to use the organisation's website as a way of thoroughly familiarising oneself with the culture of the organisation. Since the sites chosen for study were large enough to be prominent, they had a well-developed web presence. This enabled me to gain deep insights about the sites ranging from physical infrastructure, staff demographics, philosophy, mission and vision. Annual reports and other media texts provided an incredible range of information.

In order to build sufficient rapport with the participants, I spent enough time in the field to gain deep insights into not only the context, culture and phenomenon under investigation but also to observe those elements that influence and shape events and understandings. I believe that this enabled me to rise above

my preconceptions and avoid any distortions that may have arisen in interpreting the data by co-constructing meaning. The codes assigned to the transcripts were explored thoroughly and the categories were refined so that theories emerged after constant attention to the characteristics of the categories (Kortjens & Moser, 2018).

Triangulation

Triangulation refers to the process of using several methods to enhance the credibility and dependability of a study (Lemon & Hayes, 2020). Approaches to triangulation generally describe either multiple methods used in the collection of data, triangulation of data sources or theory triangulation (Lemon & Hayes, 2020; Kortjens & Moser, 2020, Shenton, 2004). It is very possible to use all three methods to triangulate the data.

In my study, data was generated from a number of sources, including semi-structured interviews, document analysis and the transect walks. I have also used a diverse group of participants drawn from four different sites and from four hierarchical levels. I also used different theories to mine the data. I am satisfied therefore that a range of approaches were used to triangulate the studies. From the divergent methods used, common categories and concepts emerged, suggesting consistency in the findings. I also checked for consistency within the same method by exploring data at different times and with different participants holding divergent views. I mined the data to check for results that contradicted the findings. There were many instances of contradiction and outliers in the data which allowed for a broader discussion and analysis.

Member checking

Guba and Lincoln (1985) regard this method as critical for establishing validity. I collaborated with the participants with regard to checking if the data reflected what they had said, as well as whether the interpretations of the data analysis were accurate.

3.3.1.2 Confirmability

Confirmability refers to the notion that the way in which the study's data is interpreted emerges from the data rather than the researcher's imagination (Korstjens & Moser, 2018). In order to ensure that bias did not creep into the study, I kept a reflective journal and left an audit trail.

Audit trail

A record of all the research steps from the commencement of the study to the analysis of the data was kept and safely stored. This included all the documentation involved from the raw data to notes, as well as drafts and the final research instruments.

Reflexivity

By reflecting on the research process, I became aware of my own positionality and bias. I kept a reflective journal in which I recorded my feelings and beliefs regarding the methods that I used to conduct research. By engaging with myself in this way, I was able to gain an understanding of how my own position and feelings affected the way I interpreted the data.

3.3.1.3 Transferability

An important part of any study is the question of whether the results can be transferred or applied to other contexts or respondents. Measures to strengthen such transferability include the use of thick description (Lincoln & Guba, 1985). Ideally, the researcher should write while immersed in the culture of the participants, soaking up the atmosphere, tensions and the general ambiance and by noting in detail the actions and behaviours of the participants within the specific research context (Geertz, 1973).

Thick description

I ensured that I provided a thick description of the phenomenon under scrutiny by ensuring sufficient scope and depth to the analysis. This included providing clear details about the research sites chosen, the number of participants within each site and the roles played within these research contexts. I was particularly sensitive to the ways in which participants responded to their work environments and their peers. I also made notes about the atmosphere that prevailed in the context in which I found the participants.

3.3.1.4 Dependability

Dependability in any qualitative study seeks to establish consistency by ensuring that the analysis process follows acceptable conventions and standards for the kind of research design followed in the study (Korstjens & Moser, 2018). It is therefore important to ensure that records of the raw data, coding sheets and analysis and journal reflections be made available to ensure transparency. The audit trail also establishes the dependability of the study.

3.3.2 Ethical Issues

Protecting the privacy of participants is paramount in any research project. This process is complex and several steps are required to ensure that both organisations and their employees are fully protected. Ethics pertains to how the researcher protects the privacy of people and institutions (Cresswell & Cresswell, 2018). In this qualitative study, I took various steps to ensure that the rights of participants were respected and not violated in any way. I explained to the participants their rights as it pertains to ethical principles and I ensured that these rights were strictly adhered to in this study. The research

proposal was submitted to the Faculty Ethics Committee for approval (Ramrathan, Le Grange & Shawa, 2017).

I also sought gatekeepers' permission from the four research sites. A gatekeeper is the individual who enables access to an institution or an organisation (Singh & Wassenaar, 2016). Before the commencement of interviews, I sought the participants' permission, both written and oral, to proceed with the research. I also sought informed consent. Here I was guided by the need for participants to fully understand the nature of the research project. The document was hence couched in accessible language and was free of any coercion (Manti & Licari, 2018).

3.4 Section Four: Limitations of the study

3.4.1 Limited range of participants and sites

This study focused on four research sites. It was limited in the number and range of the universities chosen as well as the industrial sites selected as they were from a single sector. A more diverse range of sites would have enriched the study.

A longitudinal study or sometimes referred to as a tracer study would also have been beneficial as this would have enabled shifts in the way professional knowledge is conceptualised to be tracked, providing more depth. Samuel (2012) notes that tracer studies provide a way of observing shifts in conceptions over time. Although the study focused on comparing conceptions of professional knowledge across sectors and levels of power, the treatment of each level tended to be limited.

3.4.2 Messiness in the collection of data and implementation of data generation method

In this section, I resist the urge to sanitise my data and instead set out the problems I experienced at the commencement of the research process and in the methods and collection of data. The first problem was obtaining gatekeeper's permission to conduct the research at the various sites chosen. Industry and the UoTs' reluctance to provide these letters was disconcerting as I expected the process to be smooth sailing. This served to open my eyes to potential problems that might lie ahead. Not surprisingly, the data collection process was problematic. Of the two industry sites chosen, the public entity was far more amenable in terms of acquiring a gatekeeper's letter. I was pleased that I could go ahead at one company. It took several months of negotiations and cajoling before I was provided with a letter to proceed with the research at the privately owned company. Problems also arose in securing a letter from one of the UoTs. There was a great deal of red tape as it was new to the process of generating research. After several weeks of delays, I opted to conduct the research at the sites where I had received permission. Before doing so, I conducted pilot studies and in the process of setting these up, I was alerted to the myriad issues that would pose potential hazards to the research process.

The choice of participants became an issue at the privately owned company as the managers selected were reluctant to participate. Another manager was willing to stand in as a replacement but did not have the requisite qualifications for a manager with engineering experience. It is possible that this might have compromised the data in some ways as a manager with engineering experience would have provided in-depth insights into the nature of hybrid professionals in the chemical engineering field. Being denied permission to conduct a transect walk at one of the industry sites was another setback. While I opted for a virtual walk, an actual one might have provided deeper insight into the issue of knowledge circulation, deployment, and conception. Nonetheless, I believe that the virtual transect walk provided sufficient data.

3.5 Section Five: Data Analysis

Cresswell and Cresswell (2018) employ a useful metaphor to describe the data analysis process; they describe it as unpeeling layers of an onion and then returning the layers to their original position. This highlights the complexity of the meaning-making arising out of the data analysis process. It also points to the active role played by the researcher in constructing meaning through the process of unpeeling and re-peeling layers of the data.

I employed a constructivist grounded approach to analyse the data. This choice was based on its robustness and detailed analysis of the data at different levels. In constructivist grounded theory, coding of the data occurs in three stages, namely, open coding, axial coding and selective coding (Volstedt & Rezat, 2019). I explored the data by means of constant comparison, comparing interpretations and then translating them into codes and categories (Mills et al., 2006). However, nothing prepared me for the sheer volume of the data generated through the four case studies. I felt overwhelmed but immersed myself in it (Korstjens & Moser, 2018). By reading through the data a number of times, I hoped to elicit key issues raised by the participants. Not only was the process very circuitous and iterative but it was also messy.

3.5.1 Open coding

The first phase of coding involved thorough reading of the interview transcripts for their overall sense. Since this data was voluminous, it involved winnowing it (Cresswell & Cresswell, 2018). Each interview transcript was read carefully, line by line, and the margins of the transcript were annotated. This included stating what was going on in the chunks of transcript, who was involved and the setting. The first step involved breaking dialogue into small workable units, using codes to describe the main idea in each unit. These units were analysed deeply and each was assigned a concept which consisted of either a summary of the data in the fragment or a comment on the people or actions involved, or the

context of the fragment. The second step in open coding involved categorising the concepts assigned to each unit of dialogue. Assigning a category denoted a higher level of conceptualisation of the data. Similar codes or concepts were grouped together to produce a category. These categories possessed aspects that could be described. An example from my transcript regarding concepts and categories is presented below.

Nemo, a manager at one of the industry sites describes his upbringing in Austerville in Merebank, a suburb in the south of Durban. He recounts his high school experience and the fact that he had to catch two buses to reach it. A concept that I assigned to describe this experience was the effects of apartheid on the life of a young scholar. Later on, Nemo describes his early career in a chemical engineering company and his commitment to uplift the life of Ayanda and young black women. The category that I created after linking the two concepts was mentoring and later on professional development. In this way, I created concepts which ended up as categories as they linked with similar themes in the transcript. I used Strauss and Corbin's (1990) "wh" questions to sensitise me to the data by focusing on the phenomenon. The "what, "where"and "why" enabled me to identity the phenomenon, the context of its enactment and the causal relations between different phenomenon.

3.5.2 Axial coding

The next phase of the coding involved probing the categories and the links between the categories that I created. The framework provided by Corbin and Strauss (2015) assisted in generating ideas about the causes, conditions, and consequences of the categories constructed. An example of this kind of category and its dimensions is illustrated from my data below:

Category: Mentoring

Causes: Good experience of previous mentors set an example to Nemo to continue the same practice.

Conditions: The workplace and Nemo's position as manager allowed him to informally mentor the young disadvantaged workers to experience different parts of their career trajectory.

Consequences: This allowed professional growth of the workers involved. It also gave Nemo a sense of personal satisfaction at assisting in promoting and developing staff. It is quite obvious from Nemo's personal commitment to uplifting the African workers in his company that he values the ideals of democracy and social justice. My construction of Nemo's motives in this instance was guided by Charmaz's (2000) observation that in seeking meaning, researchers need to identify the values, beliefs, and ideologies that emerge tacitly in the data.

3.5.3 Selective Coding

In the next phase of coding, I listed all the categories and looked for a common thread running through all of them. This involved some expanding and refining of categories. The final outcome that I was

seeking was to establish a core category to which all my other categories could be related in some way. This involved creating a schematic diagram in which I tried to link each category to the central point. The process entailed drawing the links together and telling a story. By yoking the categories, I was able to produce a coherent narrative. The subcategories and their links to the main category are listed in Figure 6 below:

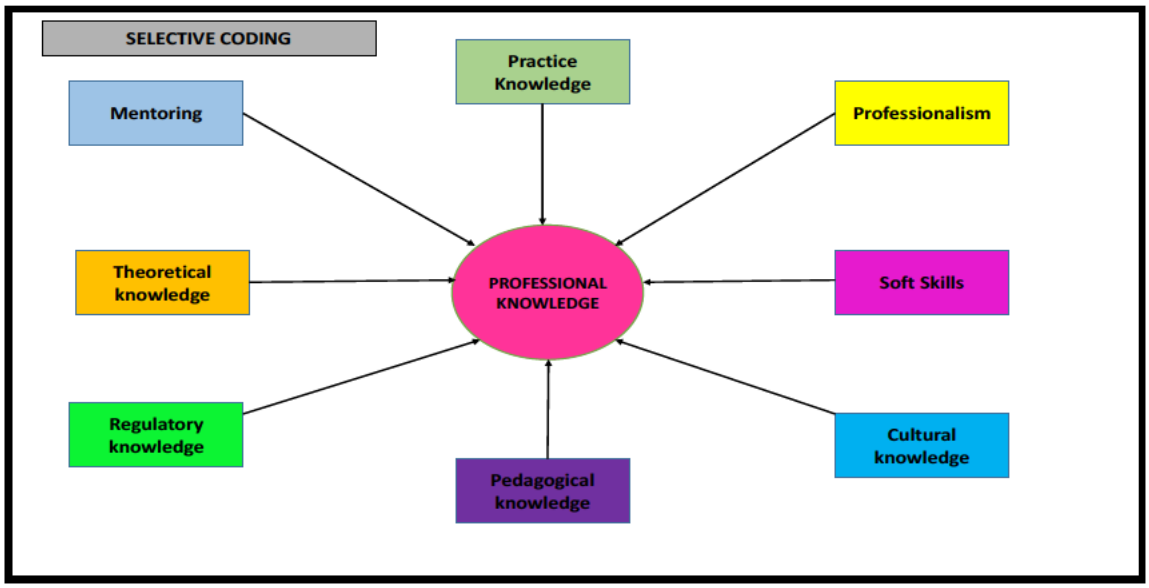

Figure 6: Selective coding into relevant themes

When coding selectively, I used three types of coding to analyse the data, namely, open, axial and selective coding. This enabled deep exploration of the data. Because the process was iterative, I gained a comprehensive, in-depth understanding of the contours of the data generated. The initial process involved using various concepts to identify issues in general and I then combined similar themes that were reflected in different parts of the transcripts. These formed categories which were further refined. Finally, I distilled nine categories and arising from this distillation process, I crystallised the notion of professional knowledge, which formed the core category. I now had the ingredients of my story or theory.

3.5.4 Representing the data

I have represented the data generated by dedicating a chapter to each of the four research sites. Within each chapter, the data unfolds in three parts. In the first, I describe the background and context of the research site. The second part of the chapter is devoted to four participant narratives while the third engages with the major themes that emanated from each participant narrative as they related to the theme of professional knowledge and learning.

I replicate this structure across the four chapters so that richer data is yielded through the comparative analysis in Chapter Eight. As this chapter is a cross-case study of academia and industry's conceptions of professional knowledge, I highlight how four major conceptions differ or are similar across industry and academia. I also explore these themes as they differ across hierarchical levels within and across the research sites. By placing the chapters within Part Two of the thesis, I was able to glean important insights into the phenomenon of professional knowledge by juxtaposing each site against one another.

Synthesis

This chapter presented the methodology employed to conduct this research study. It discussed the research design within an interpretive framework and the appropriateness of the case study method. The multiple methods employed to generate data were discussed, as well as the measures adopted to ensure quality. Finally, I set out the data analysis process using various forms of coding.

PART TWO: DATA EXPLORATION

The data presented in this section is narrated in four case studies drawn from the world of academia as well as chemical engineering industries. The case studies commence with a brief context of the site. This is followed by participant narratives in which I reconstruct their career trajectories and lived experiences of their work contexts. These personalised narratives are probed for key themes that relate to the phenomenon of professional knowledge. Finally, I compare the results of the four participants surveyed to identify instances of convergence or dissonance. Replication of this pattern in each case study enables comparison within the academic and industry sectors as well as across these occupational sectors.

Chapter Four presents the data from Sharrukh University of Technology (SUT), a higher education institution located in a peri-urban centre in Durban. Participants were drawn from a range of positions within the university, namely the Dean, and a curriculum designer, mentor and novice. Chapter Five presents data from Amir University of Technology (AUT). This UoT is located in an urban centre and is the product of a merger between two former Technikons. Participants were drawn from the same positions as SUT, providing a basis for comparison.

Chapters Six and Seven present case studies of organisations within the chemical engineering sector, namely, Atlantis Purification Industrial Plant (APIP), a water purification company, and one in the petro-chemical industry, Prometheus Petroleum Industrial Refining (PPIR). Comparisons across these sectors offer rich data as one is a service industry and the other a profit-making company.

In Chapter Eight, I present a cross-case study of academia and industry's conceptions of professional knowledge. I explore the convergences and divergences of conceptions as they pertain to the sites and sectors chosen for study. Comparisons are drawn not only across the hierarchical levels within each research site and sector but also across sectors.

CHAPTER FOUR

A CASE STUDY OF SHARRUKH UNIVERSITY OF TECHNOLOGY (SUT)

Orientation

The previous chapter presented the study's research design, justified the use of the case study method and set out the sampling procedures used to identify the participants. It also described the methods employed to promote rigour and trustworthiness.

Sharrukh University of Technology (SUT) was one of two university sites selected for this study. It is located in an African township in the city of Durban and is the only University of Technology (UoT) in South Africa in such a location. The participants were drawn from the diverse community teaching at this institution and included three African males, one of whom is from the Democratic Republic of Congo and one South African Indian female. All the participants teach in the Chemical Engineering department. Their narratives draw on a rich tapestry of experience in the chemical engineering field to 'provide a story of the subject from the inside'. Major themes that emerged from the analysis include professional knowledge, work-integrated learning (WIL), soft skills, and regulation.

Section one presents the findings from this case study, with analysis and representation at the first level of abstraction. The contextual background of the site is presented as well as a brief history based on document analysis. Section two presents the four participant narratives, with each representing a different position in the organisational hierarchy. The narratives were crafted from the transcriptions of the semi-structured interviews as well as those of the transect walk. Finally, section three presents the four major themes that emerged from the analysis.

4.1 Section One: The context of SUT: The evolution of a hybrid

Sharrukh University of Technology is a relatively young institution, at barely 40 years old. It opened its doors in 1979 with an intake of 15 students (Mbali et al., 2014) and was designed to serve the mainly African population in Umlazi, a township 20 kilometres from the city centre. Consistent with the apartheid policy of separate development, the African population was assigned its own Technikon to train technicians for industries in the Durban South Industrial Basin and elsewhere.

The idea of creating such an institution was first mooted by the Chief Minister of the then KwaZulu 'homeland' Dr Mangosuthu Buthelezi in 1974. Concerned that African people did not have access to higher education, he proposed the establishment of an institution that would afford them the chance of

becoming technicians and perhaps engineers at a later stage. The South Africa Labour and Development Research Unit (SALDRU) at the University of Cape Town was commissioned to conduct research on the feasibility of training more technicians to serve the labour market. By establishing a new institution for African students, 2 000 skilled workers could be added (Mbali et al., 2014). The Oppenheimer family donated R5 million towards the establishment of the Technikon and other sponsors like Mobil Oil, AICL and the SA Sugar Millers' Association helped establish the Chemical Engineering Department. Over time, various other sponsors assisted the Technikon to expand.

The institution is located in close proximity to major industries in KwaZulu-Natal and has historically enjoyed a very strong relationship with industry. The first lecturers were sourced from industry and this seems to have created a precedent over the years, with industrial experience prioritised in terms of staff recruitment. For many years, a possible effect of such prioritisation of industrial expertise over qualifications resulted in the low level of qualifications held by many members of staff. Only in the past five years has this situation changed with many staff members graduating with M.A. degrees. The university has embarked on encouraging members to complete their PhDs.

Transformation to a University

In 2008, the then Minister of Higher Education, Naledi Pandor introduced a Bill in Parliament which transformed SUT into a UOT. While this affected the University in a number of ways, I focus briefly on its impact on SUT's academic offerings. Previously, the Technikon followed a common curriculum shared by all Technikons. A Convenor Technikon co-ordinated this function. With the demise of the Central Technikon, institutions could alter their curriculum as long as they registered their programmes with SAQA. A useful feature of the Technikon programmes was the historical link with industries.

Many Technikons were also merged with other institutions of higher learning and lost their separate identities. However, SUT chose to remain outside the merger process and thus retained much of its old structure. With the transition to a university, the institution came under pressure to rethink its offerings. Many departments had to overhaul their syllabi. The University was also audited by the Council on Higher Education (CHE) and placed under curatorship due to management problems. A new Rector was appointed to oversee the changes suggested by the CHE.

Currently the University houses three faculties. The Engineering Faculty is comprised of the Departments of Chemical, Electrical, Mechanical, Civil, Surveying and Construction Engineering. The Chemical Engineering Department offers a B.Tech in Chemical Engineering, which is a postgraduate qualification. The other two faculties, namely Management Sciences and Natural Sciences offer a variety of diploma programmes. Recently some departments have started offering Masters programmes.

The shift to offering postgraduate qualifications is in line with the changes in the higher education landscape. The University has a student population of 10 000, and 306 academic staff. Students that are attracted to SUT are usually those that do not gain admission to other institutions of higher learning as the University has lower entrance requirements. Many staff members have recently embarked on Masters and Doctoral programmes, as the minimum requirement for a lecturer is a Master's degree. As noted previously, since its inception, SUT has employed staff with experience from industry.

4.2 Section Two: Participant narratives

4.2.1 RAHUL – The poetic engineer

Rahul is in his sixties and will be retiring soon. He is the Dean of his Faculty and he notes that he has 'travelled quite a long path with many detours'. Rahul's political activism during the dark days of apartheid were responsible for many of these detours. His story mirrors the lives of many who sacrificed their careers in the fight for freedom. Rahul was one of the lucky few who survived and carved out a niche in academia. But his story is a long one.

As a young man, Rahul attended St Francis College in Mariannhill, Pinetown – one of the few elite high schools for African students. He notes that it brought together the best minds from all the provinces and in particular, students who were expelled from schools during the Soweto uprisings. It was the mid-seventies, and the school was ablaze with ideas, with students forming various organisations to discuss the politics of the day. The principal was very strict and did not allow students to be politically involved, with the result that Rahul was expelled from high school. However, he was allowed to write the Junior Certificate examination which he passed with distinction.

He then moved to Emezi, a school in Umlazi township in Durban. Here he started 'newspaper reading sessions'. At first the teacher was impressed but when the teacher realised the seditious nature of the activity, Rahul was reported to the principal who expelled him. He joined the Open School which was run by the South African Institute of Race Relations. Many student activists from the Medical School at the then University of Natal provided tuition at the Open School and they offered the young Rahul the kind of political discourse for which he yearned.

Ephraim Mogale, the president of the Congress of South African Students (COSAS) was impressed with Rahul and was keen to open branches of COSAS in Natal. When Mogale was arrested, the burden of organising fell on Rahul. He could not devote much time to his matric studies and received an average pass. Rahul joined the labour market and found employment in a number of factories. He worked as a sweeper, operator and builder. He completed a diploma with UNISA and found a job at the South African post office. A scholarship from Shell and BP enabled him to registered for a BSc degree

in 1984. This was a time of student uprising and Rahul was once again roped in to organise students. He was detained for 10 days without being charged, lost his bursary and had to turn to the labour market. He did a brief stint as a technician at Lever Brothers and then joined Ohio Computer Systems in Pinetown.

A chance encounter with a Mr Kruger, a senior lecturer and later Dean gave Rahul the chance to teach at the Technikon where he graduated with a diploma. In 1995, Rahul started as a technician at the Technikon and was also given a full teaching load. He was later appointed as a lecturer and then senior lecturer. Rahul was also awarded a scholarship to study in America where he completed an MSc degree. He graduated with a PhD in 2014. He would have graduated earlier but was tasked with providing leadership and managing the Faculty of Engineering as Dean.

Disciplined artistic sensibility

For Rahul, a professional is a person who is disciplined and conscientious and whose work must be meticulous and free from careless errors. One should also display ethical behaviour. He also believes that one should not be rigid in the field of engineering. He says that others looked at him as if he was mentally unstable for suggesting this. He believes that for one to be more rounded as a person, one needs to have a broader outlook. Interestingly, he believes that an engineer should be educated in philosophy and the arts as this encourages creativity and an open mind.

Although he is an engineer, Rahul confesses to having an artistic sensibility. He is a published writer and a painter. He cites his mentors, famous authors like Mafika Pascal Gwala, Ben Langa and others as people who guided him. These influences can still be traced in his life as a Dean. In 2015, he organised an Arts Festival at the University with a keynote address on The Art of Science and the Science of Art: The symbiotic relationship between the two. A second conference on Africa Engineering Week included guest speakers from across the African continent. Local residents and employers who were not familiar with the institution were very impressed and changed their perceptions of Umlazi.

In 2009, Rahul convened a conference of educators and practitioners to examine what industry requires of students. It was unanimously agreed that leadership skills are more important than disciplinary skills and the use of technology. He comments that, ‘maybe our focus should be on how we develop our students as leaders before we look at disciplinary knowledge’. Within the leadership role, he sees communication and attitude as key. Another key aspect is teaching critical thinking skills. He confesses that it is not easy to change the way people have been doing things for a long time and suggests that change will be steered by the younger crop of lecturers who are in a position to rethink the course structure and teach critical thinking skills.

Rahul feels that staff at universities and in industry need training as teachers. He states that 'most times, we take someone from the factory floor and say, come teach our students, however, they have not been trained on the methods to use and do not know how to manage a class, or to assess or moderate.' As far as industry personnel are concerned, Rahul believes that they need to know how to interact with students and to be trained to mentor and coach trainees. He cites the example of a good engineer who is anti-social and cannot get on with anyone. This will affect his/her performance as well as that of those he/she trains. They thus need to be equipped with emotional intelligence.

Impact of institutional mergers

With regard to the mergers that took place between institutions of higher learning, Rahul is clear that the country needed more institutions rather than less. He notes that, while the process reduced the number of universities from 36 to 21, he believes that SUT would have benefitted from merging with other bigger institutions in the province. The decision not to merge affected the quality of output from the university. A major disadvantage was the lack of cross pollination of ideas. It appears that the university looked to industry to bolster partnerships rather than other institutions of higher learning. Arrangements were made with Eskom to collaborate with the University in staff exchange programmes. A budget was put in place and the plans were at an advanced state when strikes occurred and it was abandoned. There is currently a move to resuscitate the programme.

Scale of Instrumentation

Rahul is of the view that the WIL programme benefits students as well as staff. Many staff have not worked in industry for some years. During their supervisory visits, they are able to catch up with the latest trends in industry. For students, one of greatest benefits is the use of equipment. At the University, the scale of the instrumentation is much smaller. Although the emphasis is on practical work in labs, funding seems to be a problem. Rahul feels that there are differences between UoTs and traditional universities in terms of the ratio of theory to practice. At the former, the ratio is 40 to 60, while at the latter, it is 80 to 20.

Rahul feels that a major disadvantage of the WIL programme is the fact that it depends on the state of the economy. 'The state of the economy will determine its success or failure'. This suggests that when companies are growing they will see the need to accommodate more students. Rahul adds that as an institution, they have no control over the assessment process or the choice of the mentor appointed at industry level. While the institution's students are at diploma level, supervisors may be artisan. Even though the artisan might be very experienced, this is not ideal. He comments that, this 'makes it difficult

for us to assess the training'. In general, Rahul feels that the system needs to be modified to make articulation possible across all levels from artisan, to technician, technologist and engineer.

ECSA and Ethics

Rahul regards ECSA as a statutory body that operates in a manner similar to the Public Protector. It ensures that students' training enables them to find employment and to create quality jobs. Rahul adds that they should not endanger the public when undertaking these responsibilities. ECSA requires that an ethics component be included in programmes and the University has included this in the curriculum..

4.2.2 FREDDY – When an elderly man in Africa dies……a library burns

Senior lecturer in the Department of Chemical Engineering at SUT, Freddy Khambatta is in his mid-forties and was born in the Democratic Republic of Congo (DRC). He completed his undergraduate degree at the University of Lubumbashi in the DRC. The civil war made it impossible for him to continue his postgraduate studies as eminent professors left the country. Freddy decided to study in neighbouring Zambia. However, funding was a challenge and he taught science and mathematics at a private school before deciding to take up postgraduate studies in South Africa. He graduated with a Master's degree in Chemical Engineering, secured a job as a lecturer, and registered for a PhD.

Freddy worked in the scientific unit of a radio station in the DRC where his job centred on making scientific news accessible to the public. This set the stage for later deployment as an educator. In terms of industrial experience, Freddy worked for a year in a mineral processing plant, where he was involved in research and development in the laboratory. His job also entailed interacting with members of the public. He says that this experience taught him that, even though people might not be formally educated, they still possess knowledge. Freddy's engagement in research resulted in many advantages. Publishing articles brought him recognition amongst his peers and opened up many opportunities. He was able to project a positive image of himself and made friends internationally. As a consequence, he was appointed as editor of a journal in Chemical Engineering.

Good theoretical background

For Freddy, professional knowledge is a combination of practical know how and a strong theoretical background. He refers to a gap between 'cases that we deal with in lecture rooms and what is it you know, the practical know-how'. He defines a professional as someone who can solve problems. He believes that engineering should be about making everyday life better and that it includes know how, including the way one interacts with other people and the environment. He notes that international

curricula include a course on how to safeguard the environment. He opines that although this is not a subject per se in UoTs, but each design problem given to students to solve must include 'an environment impact assessment'.

Freddy believes that for an engineer to problem solve, he/she needs to have a 'good theoretical background'. Equally, he/she should have practical experience. He states that one can be the smartest student when one graduates, but 'you cannot be put in a chemical plant and start running it…with just what you learned at university'. There is a need to build on knowledge from university and knowledge from work in the form of practical experience. Freddy feels that the use of chemical engineering software should be part of classroom practice so that students learn to design processes on a computer. One advantage of this new trend is that students will be able to find employment in consultancy firms where there is currently a dearth of students from the UoT sector.

You must be a communicator

'Contrary to popular belief, you must be a communicator', is how Freddy describes the importance of soft skills to an engineer. He adds that 'every time you do something in a company, you have to compile a report'. Engineers are required to keep a written record of every problem that occurs in the company so that future engineers can trace the history of problems that recur. Freddy equates good communication skills with a company's financial well-being. He notes that if one is not clear, the company can lose millions. He regards dissemination of information as equally important as general communication with peers. Freddy identifies certain attitudes that he feels are problematic among students. The first is lack of perseverance. He cites the example of a student searching for information who becomes easily frustrated when they cannot find it as they expect it to be provided on 'a silver platter'.

The second issue he raises is students' lack of respect. He recalls incidents in class when a female arrives late and males whistle and misbehave. He shares how he stopped this bad habit by scolding the students a few times. He mentions that although it is viewed as insignificant, it has a big impact on how people regard one. He advocates teaching students to respect one another and laments the fact that in South Africa and elsewhere on the continent, respect for the elderly is diminishing.

Sources of knowledge

Freddy identifies the lecturer and the textbook as initial sources of information. Peers are also viewed as sources as much information is not written. Freddy uses a useful metaphor to describe the elderly's vast store of knowledge and experience. He says that when an elderly man in Africa dies, 'it is a library

which is burning'. He adds that sometimes one seeks information which may be quite elusive, but can be provided by someone with experience. Therefore, he suggests that one needs to maintain good relations with others. Other sources of knowledge identified by Freddy are log books and YouTube. Company log books are a record of all problems that occurred on site and how they were resolved. He also suggests using Google scholar to review papers to keep abreast of latest trends in one's field.

Practical know how

Freddy believes that it is very important to serve an internship to complement what is learnt in class. He also believes that the period is too short. He compares his UOT with the University of KwaZulu-Natal (UKZN), whose students serve an internship of 14 weeks which is broken up into different times during their degree programme. At the UOT, WIL only takes place at S4 level when one has completed one's studies. In his undergraduate programme in the DRC, Freddy completed his WIL in two parts – one in second year and the other in third year. He confesses that he found the final year WIL visit far more useful as by then he had covered a lot of theory. He feels that this is better than the current system at the UOT.

A further problem that Freddy identifies is the fact that the jobs students secure do not always match the experience gained during WIL. For example, a student might get a job with a company that manufactures paint, but his/her WIL experience is in the petro-chemical sector. It then takes a few months before he/she can work independently. Another problem is that the Chemical Engineering programme is too broad and includes very little theoretical knowledge. This seems to contradict what he said earlier: 'you only use a small part of what you studied at university. … you have to forget everything except what you are using'.

In view of the above, Freddy believes that UoTs need to increase the contact time students spend in industry. Another important suggestion is for universities to upgrade their equipment so that students become familiar with the basic types of equipment used in industry. Freddy notes that changing the curriculum is a complex process as the department has to comply with the breakdown of subjects stipulated by the Engineering Council.

Pedagogy

Freddy feels that as a lecturer, one needs to constantly update one's knowledge. Content should be modified as new knowledge emerges. Chemical Engineering is a dynamic field, where things change constantly. He cites the example of computer software. Although people may not be trained to use the latest software, they can still get by using their old knowledge to learn the new. However, he says that if one is trained it can save time and money. If lecturers do not update their knowledge, students will

not keep up with the latest trends. He also sees the need for lecturers to be trained how to teach. Interestingly, he said that one of the roles played by academics should be to inform industry about new information and techniques.

4.2.3 JUNGLI BILLI: The fundamentals

Jungli Billi is a young woman in her mid-thirties. She graduated from the Durban Institute of Technology with a B.Tech degree in Chemical Engineering. She was employed at GUD Filters and thereafter moved to Eskom as a technologist for five years before returning home to Durban for personal reasons. While at Eskom, she completed a Master's Degree in Chemical Engineering.

Analytical and systematic thinking

Jungli Billi describes professional knowledge as 'the fundamentals of chemical engineering'. For her, this entails understanding the basic concepts of chemical engineering and 'applying them in real life situations'. She notes that knowledge learnt in class is well defined, but applying it is challenging for students. She cautions that professional knowledge may mean something else to a person in industry. She supports this by stating that 'professional knowledge be linked to the environment'. For example, for an environmental engineer, professional knowledge means knowledge of the water regulations in South Africa or understanding the 'international laws that we have to abide by'. For a safety officer, it 'has to be interpreted per situation'.

In terms of requisite professional skills, Jungli Billi cites applying 'analytical thinking and systematic thinking to a situation…to be able to come to a conclusion based on facts and logical information'. She includes 'skill sets' in her understanding of engineering knowledge and maintains 'that this knowledge needs to be factual'. She contends that, as an engineer, one must be able to interpret information and yet, be critical of this information. Furthermore, one must have practical understanding. She also refers to the need to be able to be articulate, which entails being able to explain what one is doing and to 'describe the problem to someone else'.

According to Jungli Billi, students confront a range of challenges in the workplace including 'how a company is run and how they run their environment'. Here, she describes both management processes and the nature of the context in which the student will find him/herself. She identifies the institution as an important source of knowledge as it 'provides you with sufficient knowledge and background'. Jungli Billi also draws attention to the importance of a person's character in determining how prepared they are to work in a given environment: 'I think it is very individualistic in that it is up to the individual, their character that determines how prepared they are'. She adds that different skills sets are required in

different environments – ‘if you go into a research, consulting and design environment it is very different from a production environment’. In a production environment the skills set includes making decisions on the spot; being hands on and able to work under pressure, and being capable of coming up with a solution in a shorter period than in other engineering environments.

Jungli Billi uses diverse work experience to explain the differences among knowledge processes. Using the simile of a power plant, she explains that the fundamentals of knowledge remain the same, but the processes change. The simile she uses is the new Medupi Power plant. She explains that the last one was built 40 years ago. At the new Medupi plant, the boiler boils at much higher pressure which enables greater equipment proficiency. She states that ‘the fundamental operation has not changed; the principles of operation have changed’. With regard to keeping abreast of new knowledge, Jungli Billi says that in her classroom practice, she needs to keep students updated with regard to how ‘plant operation has changed’. For example, when new regulations are promulgated. This means that, one needs to ‘look at new processes that will assist in meeting new regulations’.

Semesters are too short

Jungli Billi believes that you ‘need to know the theory of the subject matter you are teaching’. She also mentions that ‘practical knowledge helps’. She suggests that using practical knowledge allows students to visualise the problem, enabling learning. She feels that academics should have sound theoretical knowledge when teaching. She asks, ‘How can you teach someone’, without this knowledge?

She also says that students require a range of soft skills. These include report-writing, verbal communication and self-confidence. She adds that one way of improving these skills is for the lecturer to provide opportunities for students to practice them: ‘Communication, whether it is written or verbal comes with practice’. She also notes that teaching of these skills is clustered in the first semester and should be shifted to the third semester. In addition, it ‘needs to be continuously driven’. Jungli Billi feels that, as a lecturer, one needs to explain rather than read. Lecturers should learn and employ a range of teaching methodologies, especially if they do not have a background in teaching or academia. She elaborates that this includes people who come straight out of industry or who have no knowledge of teaching methodology. Jungli Billi identifies time and space as a problem for students as well as lecturers. She says that ‘a significant amount of material is to be taught in ten weeks and it is to be examined in a three-hour examination. She complains that semesters are too short.

Work-integrated learning (WIL)

She considers WIL as very important to the graduate as it provides them with a 'realistic view of what a manufacturing environment is or an engineering environment'. Students are exposed to pictures as there is a dearth of suitable equipment in the laboratories. Jungli Billi says that they can now physically see the site and have a better understanding of concept and size. She considers the WIL programme valuable when the training provided to students is structured and meets specific requirements set by the University. In this respect, she advocates that industry should work closely with the University. Students use the knowledge they gain from the WIL programme to fulfil the outcomes listed by the University

Ethics

Jungli Billi feels very strongly about ethics. She defines it as students not copying other students' work and presenting it as their own. She makes it a point to educate students about the dangers of plagiarism: 'On the first day of lectures, this is the only ethical discussion I have with them'. She adds that she is very strict in marking reports. With regard to other ethical issues, she states that the course is too intensive and there is hardly any time in a ten-week period to discuss anything else. Presented with a hypothetical scenario in which a chemical engineer has to decide whether or not to dump effluent into a nearby river, she says that her teaching materials do not cover social responsibility in chemical engineering. However, she notes that as an engineer registered with ECSA, she is ethically bound not to 'discharge effluent into the river'. She adds that in addition to ECSA's ethical code of conduct, which one needs to sign, government regulations protect the environment. Jungli Billi also feels that ethics should be linked to professional knowledge. She cites the examples of an environmental engineer and a safety officer discussed earlier and posits that, for the former, knowledge of water regulations is critical, whereas for the latter, professional knowledge relates to the immediate context.

Jungli Billi reports that, in order to practice, technologists must be registered with ECSA. The council is involved from day one in guiding the curriculum structure and the knowledge areas that the curriculum needs to cover. Finally, she states that ECSA decides who can practice engineering. Potential engineers or technologists also have to accept ECSA's ethical codes of conduct when registering.

4.2.4 DON: I didn't jump

In discussing his career trajectory, Don was immensely proud of his journey thus far. With pride, he spoke about going through the various stages of being an academic and not jumping any stage. He says: 'I did not jump and become a lecturer'. Rather, his experience and qualifications enabled him to succeed. He mentioned that he graduated with a diploma in Chemical Engineering from the same university where he currently lectures. He then completed a B.Tech degree in Chemical Engineering.

Don believes that he is fortunate to have come up through the ranks, initially as a tutor, and then as lab demonstrator. This was an invaluable training ground for his career as a lecturer. During his stint as a tutor and demonstrator, he gained first-hand understanding of students' needs and how to craft the best ways to assist them. Not only did he assist with the theoretical aspects of the syllabus but also with the practical components of the course. As a lab demonstrator, for example, he ensured that students were afforded an opportunity to complete their practical work through familiarity with the use of equipment. After two years of interacting with staff and students at different levels, a vacancy arose for a part-time lecturer. Don believes that he was the automatic choice for the position because 'people saw my potential and contribution'. Four years later, he was appointed on a permanent basis.

In terms of his own development, Don sees the need to always learn more. He clarifies this by explaining that it is not knowledge of the discipline that he needs, but development and training in pedagogy. In terms of the discipline, he is satisfied that he is competent, but he admits that as a junior lecturer, he needs training in how to 'impart the course – to impart knowledge'. Don speaks of his experiences as a tutor and demonstrator as learning ways to 'interact with students, knowing their challenges, knowing how to solve them, to handle them'. Developing this personal knowledge seems to be a useful platform on which to build his further training as an academic.

Don sees his development from a tutor to an academic as a continuum. He is proud of the fact that he has basic experience not only of interacting and learning about students' needs, but he also has knowledge of teaching in the discipline as well as practical experience in the labs. This seems to suggest that he feels that he has a fullness of experience.

Expert in his discipline

Don believes that as a professional, one needs to be flexible, particularly when dealing with difficult people. He adds that one needs to be organised and contribute to society. An important concept introduced by Don is his notion of a professional. We first encounter this word when he describes graduate students who will need to perform at industry level by displaying various skills like presentation, meeting targets and report writing. He ties this notion to the idea of assessment when he says that 'you will be assessed in terms of the report writing skills'. He expands this argument with the idea that as a professional 'you should be able to demonstrate that skill' (referring to report writing). Don adds that professionals should be open to positive criticism and be able to apply their abilities and skills in different environments. Finally, he states that a professional must be an expert in his/her discipline.

Don feels that a graduate from a UOT should be able to use the knowledge gained to benefit him/herself and others, and to be able to think creatively and add value to people's lives. He also stresses the need to make a living. Don notes that graduates should be committed to their work and demonstrate dedication, particularly when it comes to projects. A weakness that he identifies is their ability to interact – by this, he means a lack of confidence in their presentation skills. A shortcoming that Don addresses is the teaching of soft skills, which he regards as crucial to the student's development as an engineer. He feels that students who are competent but lack these skills may not be successful in the workplace. He identifies the following skills as critical: oral presentation skills, time management and handling pressure. He suggests that students only have limited exposure to these skills as the curriculum is loaded and lecturers may not have time to teach the requisite skills in a sustained manner. He further complains that content that should span six months needs to be squeezed into barely three months. Finally, he suggests that the teaching of soft skills should be distributed across the curriculum from first to final year.

Practical Experience – Vessels, valves, plants, pipes and pumps

Don believes that practical experience is an important part of students' skills training. As novice technicians, they will need to 'demonstrate' their ability to get involved 'practically'. This entails familiarity with the 'components in a plant environment', including vessels, pipes and pumps. For Don, the practical sessions at the University afford the student an opportunity to become familiar with 'equipment and 'the real set up of the plant environment'. Together with the practical component, Don also views theory as important. He cites the example of a novice worker 'opening a valve' to 'see real production in a plant', as grasping this process involves theoretical understanding.

According to Don, the WIL programme varies widely from company to company. Ideally, it is a practicum that students follow for six months before they graduate. In the WIL programme, companies agree to take on students for a period of six months to enable them to gain practical work experience. This partnership between industry and the University has been ongoing since the birth of the institution. Lecturers act as mentors to guide and assess students. These assessments take different forms. In some programmes, students are expected to compile a portfolio for assessment, while, in others, they submit a report on their experiential learning during the practicum. According to Don, while some companies have a well-structured programme, others merely use students for menial work. He adds that companies with a fully structured programme have logbooks and clear objectives that students must meet. Don adds that not all supervisors are fully committed to students. Thus, the choice of supervisors is important. Experienced and knowledgeable supervisors who know how to assess students should be selected.

Don also remarks that students are often not assigned mentors. They perform the tasks of general workers and in their spare time, they try to complete the assignments and projects set by the institution. This suggests that he believes learning can improve through assessment and guidance. He refers to a 'standard' that needs to be met. Quizzed about the usefulness of the WIL programme, Don agrees that it is very useful as students 'gain a lot. … they are exposed to live time problems in a plant'. He adds that in companies where WIL is well structured, students are provided with opportunities to 'demonstrate their understanding, mathematical skills, presentation skills and report writing'. He identifies bigger companies as providers of these opportunities for students. A further important notion that he proposes is that these skills are engendered by 'doing' and 'interacting with different people'.

Don supports the WIL programme, as it offers a positive link between the institution and industry. However, he notes the need for 'strong monitoring'. Other benefits of WIL include the fact that students may ultimately be hired by the company and that some are afforded the opportunity of joining the main engineering stream programmes to become engineers in training. An important word that Don uses is 'early'. This seems to suggest that the pathway to becoming an engineer is indeed a long one for many students. The WIL programme can shorten this time by identifying potential students for the engineer in training programme.

Changing Technologies and Industry

Don feels that lecturers need to go into industry to keep abreast of changes in the plant environment as technology advances. He believes that academics need to remain relevant. This suggests the need for a match between what and how the University teaches and what is happening at industry level. He says that, 'as lecturers we need to get that exposure now and again in the industry to see their way of doing things'. He focuses on 'new technologies' and feels that in order to stay relevant 'our programmes must speak to … what people are doing in industry'.

Alongside this, he recommends that universities do not follow a generalist approach, as this will tend to make programmes irrelevant. They thus need to upgrade their technology. Presumably, this suggests that the equipment used in industry should be replicated on a smaller scale at universities' laboratories. He adds that links with industry should be strengthened and more visits undertaken.

While Don acknowledges that lecturers need to be more relevant in terms of their techno fit, he is reluctant to comment on learning approaches. This is understandable as he is a junior lecturer and is perhaps afraid of incurring the displeasure of his superiors. He skirts this issue and focuses on the need to update software, which is constantly changing. He advocates integrating technology in existing subjects instead of changing entire subjects.

Don invokes three conceptions of professional knowledge that are linked to his work as a tutor, lab demonstrator, and lecturer. He notes that, as a tutor, his work involved interacting with students and solving problems: 'as a tutor, you are more involved solving theoretical problems'. This suggests that theoretical knowledge is activated in the discipline of chemical engineering in the classroom via the lessons taught and the materials provided. As a demonstrator, his job entailed facilitating the use of equipment used in the discipline of chemical engineering and familiarising students with practical components in laboratory settings. This includes the use of a range of equipment and supervising students conducting experiments. Don shows a distinct preference for practical knowledge and practice knowledge. He states that the 'practical component is key'. Therefore, he regards practical sessions as critical to students' understanding of practice knowledge. This includes familiarity with and use of equipment in the chemistry laboratories.

In addition to the practical sessions at the University, Don also regards the six-month practicum known as WIL as crucial to students' success. He notes that during this period, students engage in real life problem solving in actual chemical plants. Much of this practice knowledge will, of course, depend on how the WIL programme is constructed at the company and the opportunities it affords students to engage in practical engagements, as well as the supervisor's level of commitment. He notes that some companies exploit students by using them to perform menial tasks. On the other hand, he believes that the WIL programme enables students to demonstrate their potential and some might be fortunate enough to be employed by the company or gain access to the engineer in training stream.

The third conception of professional knowledge that Don espouses is integration of theoretical and practical knowledge. In discussing students' preparation for industry, he suggests that industry trains students to combine the theoretical skills that they developed at university with the practical skills that they developed during practical sessions and during WIL in industry. He notes that, during the WIL programme 'you are expecting students to solve some related problems…obtained during the studies'.

Teaching and its regulation

For Don, being a professional means being an expert in theoretical knowledge. Moreover, this knowledge needs to benefit one, as well as the community. He also focuses on soft skills that graduates should develop like presentation skills and report writing skills. Specialised knowledge is also prioritised by Don. He seems to suggest that lecturers need to prepare students for the specific types of industry in KwaZulu-Natal. This would entail a more specialised curriculum. Don adds that lecturers need to keep abreast of developments in industry, particularly technological changes in chemical engineering. This will enable them to remain relevant. He also suggests that people in industry need to

learn assessment methods. In others words, both academics and industry personnel involved in training students for practice require pedagogical knowledge.

With regard to his own development, he feels that he still has much to learn in terms of delivering course content. However, he is happy with the experience that he now possesses as a result of working as a tutor and lab demonstrator. He says that this gave him insight into the ways in which students interact and how to handle them. Don is keenly aware of the need for specialist training for engineers as well as the different chemical engineering environments in KwaZulu-Natal. He notes that these include the sugar industry, the petrochemical industry and the pulp and paper industry. He suggests that students will probably end up working in one of these fields; therefore, universities should prepare them to meet the needs of these sectors. He feels that the curriculum is too general and needs to include specialised knowledge to facilitate learning for these different industries.

Don identifies ECSA as an important influence on teaching and the syllabus. He notes that ECSA ensures that UoTs meet certain standards by accrediting these institutions every five years He adds that ECSA's probes go 'deep down as to how we impart those skills'. This suggests that they are involved at a pedagogical level. He also confesses that he does not know their workings at the highest levels. This would presumably be at the level of senior management. Probed further about ECSA's role, Don displays nervousness and is reluctant to pursue the discussion.

4.3 Section Three: Constructions of professional knowledge

4.3.1 Soft skills

Both Don and Jungli Billi regard soft skills as critical to the development of students as future engineers. However, they felt that, rather than the teaching of such skills being clustered in the first year, they should be taught throughout the four semesters of the diploma. Both note that the curriculum does not devote sufficient time to soft skills. Furthermore, Jungli Billi believes that students need to be given more opportunities to practice these skills and that they should be continuously driven by lecturers.

Don is also of the view that students have limited exposure to soft skills. However, it is not clear whether he is referring to limitations imposed by time which he alludes to earlier or a lack of creativity on the part of lecturers. While Don identifies oral presentation skills, time management and handling pressure as critical skills, Jungli Billi agrees on speaking skills and adds report writing and confidence. Freddy also notes that report writing skills are vital in developing learning resources in a company. He adds that students need to learn to persevere as many expect to receive things 'on a silver platter'. Freddy notes that general communication skills contribute to the financial well-being of a company in the sense that breakdowns in communication amongst stakeholders can be costly. He is also saddened by

students' lack of respect for others. Rahul is a little more optimistic about the youth in our society. He believes that young academics will promote critical thinking skills because it is not easy for those that have been teaching for a long time to change their ways of teaching. He adds that leadership skills are the first priority; this includes communication skills as well as attitude.

4.3.2 Work-integrated learning

According to Don, student experience of the WIL programme differs widely depending on the nature of the engagement with the companies to which they are attached. Experiences range from doing menial work to taking part in a highly structured WIL programme where log books are kept and clear objectives are met. He notes that bigger companies offer better training opportunities. Don also comments on the quality of engagement with supervisors or mentors at the workplace. Some are more committed than others and in some companies, there are no mentors. He advocates for the need to be circumspect when choosing mentors and suggests using experienced mentors who are knowledgeable about assessment practices. Rahul notes that in some companies, artisans assess students. This is problematic because, while they are technically competent, they may not have knowledge of assessment procedures.

Don outlines several benefits of the WIL programme. Firstly, he states that it allows students to experience 'live' problems. It thus provides opportunities for students to demonstrate their learning and skills, as well as their soft skills. He suggests that skills are developed by students 'doing and interacting'. Overall, Don feels that there should be strong mentoring. Other benefits identified by Don include being hired by the company and being given an early start to join the engineering stream.
Freddy's experience of WIL extends beyond South Africa. He compares his WIL experience with that at UKZN and a university in the DRC. He states that WIL complements the theoretical knowledge developed in class. However, be believes that the period of practical experience is too short. Another problem that he identifies is that the chemical engineering programme is too broad in that one uses too little of the theoretical knowledge in the field in which one finally works. He adds that experience gained in the WIL programme in one sector of chemical engineering, for example, petro-chemical is 'lost' because the person finds work in another sector; for example, 'water.'

A related issue raised by Don that seriously hampers students' progress is the lack of equipment in the University's laboratories. He feels that students need to spend more time in industry, but also suggests that ECSA's regulation of the department's offerings makes it difficult to make changes. Rahul also expresses concern at the lack of equipment at SUT. He states that the scale of instrumentation at UoTs is much smaller than in industry. Despite the fact that UoTs focus on hands-on experience, the lack of appropriate instruments is a problem. Like Freddy, Rahul compares a UOT and a traditional university.

However, he focuses on the knowledge types and the divide between theory and practicals. He states that the proportion of theory to practice in a UOT is 40/60 while for a traditional university it is 60/40. Rahul also relates the success of the WIL programme to the state of the South African economy. When the economy is healthy, more companies are able to accommodate the WIL programme because they have the financial and human resources to do so. He suggests that universities should drive innovation rather than the other way round. In general, he feels that there should be greater articulation between artisan, technician and engineer.

4.3.3 Professionality and identities

Although she mentions practical understanding, Jungli Billi tends to link professional knowledge with logic and facts. It is not surprising therefore, that her definition of professional knowledge is the fundamentals of chemical engineering, and its application in real world situations. She focuses on the skills sets that engineers require in different situations and states that each sector in a particular industry may require a different set of skills.

Don's conception of professional knowledge is linked to the notion of expertise and demonstrated competence. Jungli Billi seems to share this understanding, as she is of the view that theoretical knowledge forms the bedrock of what constitutes professional knowledge. Freddy's understanding contrasts with Jungli Billi's in the sense that he prioritises the importance of practical knowledge as well as theoretical knowledge. Rahul's conceptions, on the other hand, are linked to notions of self-discipline and ethical behaviour.

For Rahul, being strictly discipline specific is highly restricting. He encourages the formation of well-rounded engineers. In order to become such, he believes that one must transcend the narrow boundaries of discipline specificity. Rahul's conception of ethical behaviour refers to both how one behaves on a personal level as well as how one reacts to the environment as an engineer in terms of social responsibility. This idea is linked to Freddy's concept of professional knowledge in that he defines it as everyday know how about people and caring for the environment. Don's conception extends to include social responsibility when he says that a professional is someone who cares for others and who adds value. Don also believes that one must be flexible when responding to people and the environment.
For Freddy, a professional is someone who is a problem solver. This concurs with Don's conception of a professional. One solves problems in the community and adds value. For Jungli Billi, the professional should be able to articulate a problem. This suggests identifying and understanding the issue and then communicating it to different stakeholders.

Pedagogical knowledge

The participants' conceptions of pedagogical knowledge include the need for self-development or the need for the development of industry personnel, or both in terms of a range of pedagogical approaches. For Don, pedagogical knowledge is important in order to understand how to deliver content. At the same time, he stresses the need to update his knowledge of technology as it pertains to industry. In this respect he feels that industry has been moving ahead while the University is lagging behind. Nonetheless, Don is aware of his advantage of having worked as a lab demonstrator and tutor, where he was able to build his personal knowledge of students and better understand their needs; hence, making him a more effective lecturer. With regard to industry personnel, he feels that they need to learn assessment methods as they mentor students engaged in experiential training.

The above concerns are also raised by the other three participants. Jungli Billi adds that academic staff who come from industry and have not trained as teachers should be encouraged to use a variety of teaching methodologies as part of their learning as teachers. She draws a distinction between explaining and reading and believes that students should be presented with a number of opportunities to practice their skills and thus enhance their learning. She laments the fact that the programme is so tightly organised that students have limited opportunities to practice.

Rahul shares Jungli Billi's concern that industry personnel that mentor students are not carefully selected. He notes that while they may be good engineers, they need to develop their emotional intelligence and be trained to mentor and coach students. Freddy concurs that some academics require pedagogical training. He notes that professional knowledge is constantly evolving; hence, the need for upskilling. He also links training to saving money and time. He views old knowledge as crucial in building new knowledge and in this respect he cites the need to improve computer skills. Finally, he feels that one of the roles of academics is to inform the world of industry of new information and techniques, rather than the other way round.

4.3.4 Regulation

For Rahul, the manager, the impact of ECSA in terms of education and development is very positive. He feels that at university level, it ensures programme relevance and ensures high standards and benchmarking so that graduates can find employment in a competitive environment. He also sees ECSA fostering a more ethically response workforce. Freddy, the curriculum developer sees ECSA's role as too prescriptive, particularly in its shaping of the curriculum.

Interestingly, the mentor sees ECSA in a gatekeeping role when the latter registers professionals. She feels that ECSA does not market itself suggesting a reluctance to open up to all and sundry thereby establishing engineering as elitist. She seems to suggest that ECSA exercises its power through its role in deciding who can practice engineering. She shares the manager's views about ECSA's role in accreditation and standards setting in higher education. Don, the novice, seems intimidated by ECSA evident in his nervousness to provide more information regarding its regulatory role. Like his colleagues, he shares their views regarding ECSA's role in shaping the chemical engineering curriculum.

Synthesis

This chapter briefly sketched the profile of Sharrukh University of Technology (SUT). This was followed by the narratives of four participants representing the four levels of the university hierarchy. These included narratives from the Dean, a curriculum designer, mentor and a newly qualified graduate. By exploring these narratives, I extracted conceptions of professional knowledge as experienced and understood by these participants. In the final section, I brought these conceptions into dialogue with one another across the four hierarchical levels occupied by the participants.

CHAPTER FIVE

A CASE STUDY OF AMIR UNIVERSITY OF TECHNOLOGY (AUT)

Orientation

The previous chapter described the findings drawn from the first research site, namely, SUT. This chapter begins with a brief sketch of the history of Amir University of Technology (AUT) before exploring four participant narratives. The remainder of the chapter focuses on the factors that drive conceptions of professional knowledge.

Amir University of Technology is located in an urban area of Durban, a coastal city in KwaZulu-Natal. As with the first site, participants were drawn from the four different levels in the institution's hierarchy. Their rich narratives provide unique perspectives into the ways in which chemical engineering teaching and learning takes place at the institution.

Section one presents a contextual background of the site and a brief history, based on document analysis. This is followed by four participant narratives from different vantage points in the organisation. The analysis and representation is at the first level of abstraction. The narratives were crafted from the transcriptions of the semi-structured interviews as well as those of the transect walk. Section three presents the four major themes that emerged from the analysis, namely, professional knowledge, regulatory bodies, soft skills and WIL.

5.1 Section One: The context of AUT: The merger

Lassi Technikon and Sherbet Technikon merged to form the Amir University of Technology on 1 April 2002. The merger was in line with changes to the academic landscape across South Africa under the leadership of the then Minister of Education, Professor Kader Asmal. The Universities Extension Act which was promulgated by the apartheid regime in 1959 provided for separate higher education institutions based on race and ethnicity (Asmal, 2002). The mergers sought to redress the iniquities of the past by granting access to previously disadvantaged communities and by sharing the institutional wealth of privileged entities. In KwaZulu-Natal, two Technikons situated in close proximity and similar in design and offerings, were earmarked for merger. A third Technikon, Sharrukh Technikon in Umlazi, sought to remain independent.

Lassi Technikon

Lassi Technikon was established with sponsorship of £100 000 pounds by Hajee Mulukmahomed Lappa Sultan in 1942 (AUT, 2008) With the passing of the Indian Advanced Technical Education Act, the institution became a college of advanced technical education in March 1959. The status of the

college changed to a Technikon in May 1979. In 1989, four faculties, namely, Arts, Engineering, Built Environment and Science and Commerce were established. The institution became popular among the Indian population and expanded throughout the 1980s and 1990s. The Technikon Act of 1993 enabled Technikons to offer degrees.

Sherbet Technikon

Founded in 1907 by Dr George Campbell, Sherbet Technikon was known at the time as the Sherbet Technical Institute (AUT, 2008). It was renamed Sherbet Technical College and was reserved for the white population. The Vocational Education Act of 1955 placed technical colleges in South Africa in the hands of the government. The institution continued to grow and celebrated 50 years of producing apprentices and providing higher education in the arts and the humanities in 1957. In 1979, it took on the title of Technikon and could produce higher diplomas. In the 1980s and 1990s, a campus was established in Pietermaritzburg. With the winds of change in the early 2000s, the campus appointed its first Black Rector.

5.2 Section Two: Participant narratives

5.2.1 SKAPI: Close alignments

Skapi completed his undergraduate studies at the University of Durban-Westville, a university created to serve the Indian population. He proceeded to complete a Master's degree in Chemical Engineering and was subsequently appointed a temporary lecturer in the Department of Chemical Engineering at a historically white institution of technology, then known as a Technikon. He applied for a lecturer's position at a sister institution which served a mainly Indian population. Upon completion of his Master's, he immediately registered for a PhD in Chemical Engineering. After three years, he was appointed as Head of Department and served for four years, until the institution merged with another Technikon.

At the merged institution, Skapi continued as Head of Department for a year before the post was rotated and he assumed the role of Senior Lecturer. The merger with a historically white institution was challenging for Skapi on a personal level. He states that he was intimidated, because he had not grown up interacting with White people due to apartheid. However, it was also an enjoyable experience. He mentions that he sat in Senate meetings where there were only two Indians present. He recalls his undergraduate years at a university reserved exclusively for Indians. When he started work, he looked up to Whites as superior. This was an intimidating experience, especially at meetings. Initially, he passively absorbed everything and later found the confidence to challenge. The members of staff he interacted with were 'a fantastic set of guys' who all worked towards the common purpose of taking the institution to a higher level. According to Skapi, merging the two institutions was a good idea.

Indeed, historically the Chemical Engineering Departments at both institutions had a very good working relationship. They shared resources, lecturers and practicals/projects. Skapi mentions that instead of competing with each other, it made sense to use their energies to grow the institution. In his view, the merger enabled transformation of the curriculum, as well as the opportunity to offer higher qualifications and better serve the needs of the province.

A hundred-page report

Skapi states that while it is very important for engineers to be competent in the core knowledge they require, they should also be to communicate effectively. He cites the example of an employee who writes a technical report and submits it to a supervisor who does not have the time to read a hundred-page document. He/she needs a concise summary in order to get a sense of the problem described. Hence, novices should develop the ability to orally summarise the most salient aspects of the report when submitting it to a supervisor. He notes that the supervisor first needs to be attracted to the work, then to understand its importance and finally to be persuaded to read its technical aspects.

Skapi reports that the department has spent much time trying to incorporate soft skills into the syllabus. He feels that this is the area that is lacking in the curriculum. Industry also complains about this issue, which is reflected in the poor communication skills of students in in-service training. However, he adds that industry personnel are happy with the technical skills displayed by students and to justify this, he mentions that his students occupy high positions in industry. Skapi also feels that while technical expertise is a prerequisite, the graduate will be required to interact with a range of different stakeholders. This includes 'working with juniors, colleagues and seniors'. He notes that the graduate is the liaison between all these stakeholders and he/she must ensure that everything is running smoothly.

Ethics

Skapi feels that as a professional engineer, one must be ethical. He qualifies this by stating that this should be the case whether it is one's personal ethics or the ethics practiced in the institution or industry. He points out that aspects of ethical behaviour in terms of being a student are taught as part of one of the courses that he is familiar with. Ethics refers to plagiarism, falsification of documents and copying. Questioned about ethics when it comes to the environment, Skapi reports that in some courses, a component of the syllabus is devoted to environment impact. This is formally taught. He adds that safety is the focus of the course, which includes a tour of the South Durban Basin. Students are exposed to the effects of pollution in this area and witness its effects first-hand. Thus, while they are exposed to various profitable and successful companies, attention is also drawn to the negative effects of their waste products.

Globalisation – 'turning valves'

Skapi feels that the changes that have taken place in industry are for the best, with specific reference to the dramatic changes wireless technology has made to old infrastructure. He cites the example of the newly built control rooms in engineering plants which control the entire plant from a single node. This is as a result of technological change brought about by globalisation and the transformation of industry by developed countries. He adds that, while students, lecturers and industry personnel have adopted wireless communication, this has not reduced the importance of the engineer in the plant. Technologists and technicians are quite active in floor operations and troubleshooting, while those in academia or in research and development are not as active.

Close Alignments: Relationship between Academia and Industry

Skapi feels that the relationship between academia and industry needs to be strengthened. He draws attention to the re-circularisation exercise currently underway that underscores the importance of engaging with industry. He adds that he is keenly aware that the University is producing graduates for industry. There is therefore, a need for close alignment with industry. The parties should inform each other of what they are doing and they should share information on the latest global developments. This will enable academics to keep up to date in their teaching.

Skapi notes that such interaction takes place at different levels, including advisory boards, lecturers visiting industries and contact between university staff in different units with industry personnel. An example is the University's relations with a company called TTT Refiners. This relationship is based on certain projects that are domiciled in industry but with close collaboration with academic staff. It enables staff members to interact with industry personnel and offers academics a unique glimpse into daily activities on the shop floor. Awareness of the problems confronting industry enriches their teaching.

ECSA

Skapi feels that ECSA needs to ensure that the product that the University is producing is at the required level that will satisfy the needs of not only South African industries but international requirements. He is of the view that, as an accreditation body, ECSA is critical in maintaining standards. He thus feels that departments that do not have an external accreditation body are lacking. While there is internal moderation, where fellow professionals evaluate the quality of a programme, external evaluation is critical.

One of Skapi's criticisms of the assessment process is that lecturers become too concerned with administrative issues. While he believes that ECSA goes in depth, sometimes there is too much focus

on less important issues. He feels that lecturers need to focus on the overall purpose which is to ensure the production of quality graduates. He notes that lecturers' preoccupation with keeping their files up to date and ensuring that study guides are drawn up in a uniform manner takes up too much time. Instead, he believes that quality time should be spent developing the course in such a way that it is better for students.

Hindering graduates

With regard to WIL, Skapi maintains that the University has an 'elaborate and supportive co-operative Education Department that assists with student placements'. However, he believes that the process of in-service training has 'gone too deep' and that it 'hinders graduates instead of promoting them'. He cites the example of a student who works as a full-time operator but is required to complete presentations, write technical reports and be assessed. The student is unable to 'achieve all the objectives' that the unit demands and hence is unable to pass. Assessment is another problem in relation to the WIL programme. Skapi notes that industry assesses whether they want to 'take a graduate on or not'. He feels that proper interviews should be conducted before a graduate is appointed. After appointing a candidate, the company should provide training, as it is its responsibility to ensure that the graduate can perform on the job.

Skapi describes chemical engineering as a vast field. Although someone may have qualified as a technician, experiences in a petro-chemical plant and a small blending firm can be quite diverse; hence, the need to train the graduate for a particular sector. He adds that the University should inculcate the requisite technical skills, educational requirements, theoretical requirements and practical knowledge, but the graduate needs training from the company for the particular niche area that it serves. Skapi states that the department used to offer specialisations, such as training for the sugar or water industries. However, given that chemical engineering is such a vast field, one will only use 20% of the knowledge that is produced in a sector. He adds that as a department they are preparing the student to work in any sector of the chemical engineering field. Industry has made input into the new suite of qualifications that ECSA has approved, where there is no requirement for in-service training. However, he concedes that there may be people in industry who are not on advisory boards, or part of SAICHE or ECSA who will not be aware of the latest developments. In this respect, the University is holding roadshows in which all stakeholders are being made aware of the new suite of qualifications.

In response to some of these problems, the department is introducing a new three-year degree where there is no in-service training. Linked to the question of new qualifications is the issue of identity. Skapi says that in the old dispensation, when the institution was a Technikon it had strong linkages with industry and that 'the training of students for industry was important'. However, the University is

becoming more aligned to a traditional university with a focus on research and development. 'And if it is being spent on research and development, then it is not training someone for industry.'

Furthermore, he believes that the traditional university produces engineers who work as engineers but technicians and technologists are being used as operators. This calls for a focus on actual physical operations and controls. The traditional engineering degree builds on first principles in theoretical equations. He concedes that theoretical knowledge will become more important when the University offers Honours and Masters programmes. Skapi feels that although there are some fine 'technical professionals in their field', he believes that 'they do not teach well'. He describes some of the courses that they need to attend, including 'research projects on engineering education'. He feels that academics are there to impart knowledge and that they should do it properly.

5.2.2 CHAKU: The Bologna experience

Chaku initially attended university but dropped out due to personal problems. He worked in industry and later completed the diploma in Chemical Engineering part-time. He continued with his studies and graduated with a Higher Diploma in Chemical Engineering. He subsequently did his Master's degree and is currently pursuing a PhD in Chemical Engineering. He started work in 1987 and four years later joined the M.L.Sultan Technikon. In the course of 26 years in academia, Chaku occupied a number of different positions, including lecturer, senior lecturer and Head of Department. He served as Head of Department in the merged university. As the position is rotational, he is currently a senior lecturer.
Chaku sits on a number of ECSA panels, both at UoTs and traditional universities. He has been a member of the Engineering Standards Generating Group (SGG) since its inception and is proud of the fact that he was part of the committee that drew up the outcomes-based qualifications currently on offer at UoTs. He is also the architect of the new suite of qualifications in Chemical Engineering.

Building Laboratories

Chaku is also immensely proud of the fact that he was part of the project which saw the building of laboratories at his institution. He claims that they were the best in the country such that other institutions like the then University of Natal were keen to use the facilities. He adds that over time, other universities managed to catch up with the standard set by his institution. This was a very rewarding project because he was able to use his Chemical Engineering knowledge to create this infrastructure. According to Chaku, the laboratories were built at pilot scale, with some of the equipment as big as a room. The objective was to give students 'a realistic feel for the types of things they would encounter in industry'.

European Union curriculum project

Another important milestone in Chaku's career was his participation in a European Union curriculum project called the Bologna Accord. The aim of the project was to harmonise curricula across European universities in order to facilitate student movement from one country to another. Chaku was involved with the project for nine years from 2005 to 2015. One of his responsibilities was to create a model for the Chemical Engineering qualifications that would be common to all European universities, and this involved the harmonisation of all the programmes. Chaku defines harmonisation as a minimum footprint for a Chemical Engineering qualification. In other words, subjects like Mathematics or Physics should reflect a certain type and level of knowledge.

Chaku says that insights from the Bologna experience informed the creation of the South African Engineering qualifications: 'that is the basis on which we developed it…we drew up a generic standard'. This standard was common to all the engineering courses that were taught, that is, for Chemical Engineering, Civil Engineering or Mechanical Engineering. The minimum footprint defined in this generic qualification was the prescribed content for each subject. Having defined the minimum content, the committee comprising of ten members sent it to relevant stakeholders for comment and based on the feedback received, they amended the standard for a diploma or a degree.

ECSA

An interesting insight offered by Chaku into ECSA is the fact that the council is audited by an international team of auditors: 'ECSA [is] … accredited by the international body, … the Engineering Alliance'. He notes that this is due to the fact that ECSA is a signatory to several accords. 'All the countries that are signatories to those accords … recognise [one another's] qualifications'. Thus, being a signatory to an accord means that 'our qualification has been accepted internationally'. There are two types of accords, one based on the qualification and the other on professional registration. The Washington Accord has been endorsed by about 50 countries from the Commonwealth, Europe, the United States of America, and Canada.

Chalk and Cheese

Based on his years of experience of auditing programmes across South Africa, Chaku describes engineering programmes at the country's universities as "chalk and cheese". He cites a number of historical reasons for such wide diversity. According to Chaku, in the past, some institutions received more financial support than others, making it difficult for the latter to catch up. He adds that he feels that institutional management plays a key role in determining how programmes develop and the role of Deans and HODs is critical as they are closest to the action on the ground.

Chaku believes that many staff are not familiar with the curriculum and that, 'teaching is not their primary objective'. He postulates that in the past decade, the shift in focus towards academic research has 'been detrimental to teaching'. Academic promotion depends on the number of papers produced rather than how well one teaches. He compares staff members in his department who are really dedicated to students to those who are focused on research. Chaku asserts that this is due to the Department of Higher Education and Training offering incentives for research productivity. In contrast, ECSA is focused on the programme and its delivery rather than a postgraduate qualification. He notes that as a member of ECSA, he is concerned about what is being done to train students and how well they are being trained.

Stuck in the system

According to Chaku, aspects of the new set of qualifications designed in the past ten years aim to 'humanise the engineer.' He notes that, as an ECSA council member, he receives many applications from institutions that want to offer the new qualifications. However, he finds that people are still stuck in the old system and that some academics do not want to move from their comfort zones and teach engineering knowledge in new ways. He expresses disappointment that academics are not exploiting the true potential of the new qualifications. He notes that in many reports to institutions, he observes that, 'The institution has not taken the opportunity to embrace the new qualification and address some of the regional needs'. For example, he cites cosmetic changes which some institutions adopt, such as changing the B.Tech degree to the Advanced Diploma.

While the new qualification is designed to address some of the shortcomings of the B.Tech degree, institutions have simply changed the name instead of using the opportunity to overhaul their offerings. Interestingly, he mentions that students who complete the B.Tech believe that they are engineers. However, he feels that they are not properly tested or evaluated at B.Tech level. Chaku feels that there is a disjuncture between the way students are taught in the diploma years and the methods employed in the B.Tech degree. He is of the view that, while a small number of students will cope with the stringent demands of the degree programme, the majority will find it hard to adjust. This is evident in the number of failures at this level. He also suggests that this qualification is becoming the minimum level that industry is willing to accept; hence increased enrolment for this degree. Complicating the issue is the pressure from government to improve throughput rates. As a consequence, students who should not pass are pushed through.

Failure of the system

Chaku feels strongly that, while the WIL programme has noble intentions, its current application has failed. He has been involved in the WIL programme for the past 20 years and has observed that industry

merely sees the student as an employee who needs to comply with what industry wants from him/her. Despite the fact that the University has an elaborate WIL manual which students use as a guide to complete a range of assessment tasks, according to Chaku, when they are questioned about the tasks given, they cannot complete the exercise as the information is not forthcoming from industry personnel. Chaku also explains why industry is unable to fulfil its training mandate. While ten engineers worked in a typical chemical engineering environment ten years ago, today there is one who must mentor a number of students. Given these structural changes, it has become difficult for industry to offer students adequate training. The WIL programme is not included in the new suite of programme offerings. Chaku is proud of the fact that he was instrumental in this decision. He cites two reasons for the move, namely, that students are treated as employees and that only 50% of students manage to secure in-service training. Doing away with the WIL programme ensures that all students are treated equally. He says that WIL can be included in postgraduate qualifications.

Boxes at the end of the line

Chaku is of the opinion that the university graduate is not prepared to hit the ground running. He feels that there should be an incubation period where graduates are trained for the specific jobs that they will do. He believes that students also need to play an active role in realigning their knowledge to the requirements of the sector in which they find themselves. Chaku reiterates that fear is a key factor that prevents students from making the connection. As long as they do not make the link they will remain push button employees, i.e., they will merely follow mechanical processes rather than engage in creative thinking.

Chaku notes that industry is focused on making a profit. He describes the process of work as making sure that so many boxes roll off the production line. This preoccupation with production has resulted in the loss of the 'social responsibility aspect'. He attributes this to the streamlining of labour and the role played by Government. He notes that when he was working in industry, tax incentives were offered for sponsoring or training students. However, the government scrapped these incentives. Chaku says that many believe that they should be reintroduced.

Graduate Attributes

Chaku feels that many students lack confidence. He attributes this to what he describes as subservient behaviour that is nurtured by the schooling system. He also bemoans the fact that students lack initiative. While the University teaches a student to be a good technician, they are unable to make the transition to a technologist or engineer. Implied in this statement is his criticism of the way in which lecturers teach: 'we train them so well to be a push-button type of person'. This raises the question of lecturers' training. Chaku refers to some academics as 'full time students' who undertake Master's and doctoral

studies and are then employed at the University. They have no industry experience. He adds that they teach in the way they were taught. He feels that organising workshops is not necessarily the solution as many of those who conduct these sessions have limited exposure to industry.

Chaku also highlights the need for lecturers to learn to improve their teaching methods. He notes that they should set various assessment tasks rather than relying on conventional tests and examinations and cites competencies and outcomes as the new language of the programmes. He emphasises that the lecturer's teaching practice should create the right environment for the student to become an active learner; lecturers cannot read from textbooks and expect students to be enthusiastic about the subject. Chaku states that the engineering knowledge that students require can be broken into two areas – 'those that directly affect engineering and those that will give the student a greater appreciation of the things around him/her'. He adds that previously, engineering was very technical and did not take people's well-being into account. The focus was on applying technology. However, there has been a shift to making the student a more responsible citizen. This should be evident not only in his/her engineering designs and knowledge, but also in his/her awareness of social issues. Chaku believes that broadening students' knowledge in this way will create better engineers.

5.2.3 CHAMELI: Industry should train graduates

Chameli is an Indian woman in her mid-forties. She started her undergraduate degree at the University of Durban-Westville. After working as a researcher for three years under the tutelage of Professor Judge she registered at Unisa to complete her degree. She then proceeded to complete a Master's in Chemical Engineering. While studying, she worked as a tutor, researcher and laboratory assistant. She was later appointed as an associate lecturer. Although this was a junior position, she taught final-year students. She was appointed on a permanent basis at her current institution, completed her PhD and is currently the Head of the Department of Chemical Engineering. She is supervising three Master's students who have been placed in industry.

Read a book, and walk into a plant

Given that Chameli came from a university background, when she moved to a UOT, she had to re-orient her approach to work in very practical settings, become accustomed to teaching for industry and learn about in-service training. She confesses that as an engineer she thought that she could do it all. She thought that she could 'read a book and simply walk into a plant and operate it'. She says that she never thought of applying herself to industry. She now feels that skills training is critical in creating a graduate who is fully independent. She defines the training period as applying theory 'in a practical environment'.

In order to perform successfully as an engineer in the workplace, one needs to master the basics of mathematics, physics and chemistry, and application of that knowledge. Chameli notes that another name for chemical engineering is process engineering. It is concerned with the conversion of raw materials that are useful for society. Thus, students need to be familiar with the conversion process and unit operations, which are a significant aspect of understanding and operating a plant. It is for this reason that heat and mass control are included in the second year of the diploma curriculum. Students also cover problem solving and application and are exposed to investigations in the design component of the NS3. This enables them to understand troubleshooting. For example, they are asked to investigate how to remove salt from water. They build a small unit to investigate and present their results.

In the third year, the student is part of industry and is equipped with basic science – the theory of unit operations and some soft skills. Chameli also highlights the importance of self-learning, noting that when students visit a plant and operate in the control room, they come to grips with technology. Much of the learning occurs during the monitoring process. She also distinguishes between the qualifications. At B.Tech level, the focus is more on unit operations, but at a higher level; for example, heat transfer. The focus then shifts to design implementation and thereafter one moves it up a notch.

She describes an example of the technique that she uses to teach the above. Students are expected to design something bigger, but it is open ended and not all the information is supplied. For example, they are given an assignment to grow algae from CO2 emitted from a refinery. The theoretical knowledge and skills required to undertake the process are provided by the University but as soon as the student goes to industry he/she has to apply his/her skills. If the company decides to place them in an Engineer-In-Training (EIT) programme, they will accumulate management, strategy and finance skills.

A Practical and Everyone's Place

Chameli says that there is scope for practicals in every subject. The University has extensive laboratories and mini-plants, including a steam plant and a distillation plant. An S3 student, that is, a student in the third semester completes approximately eight practicals per semester with four subjects. The same applies to S2 students. Students are limited to two practicals per subject. Practicals are emphasised from the first semester. The same pattern characterises the B.Tech programme.

Chameli believes that 'everybody has a place when they get to industry'. She compares the traditional university graduate with a UOT graduate. University graduates do three-month vacation training each year to get their practical training, while UoTs have one-year in-service training. On the other hand, big companies like Eskom and the refineries put students on a two-year programme. Chameli adds that, with regard to students from traditional universities, 'those who do not have bursaries and are

consequently not selected by industry, spend much of their time in operations doing finance and strategy and other jobs'. She comments that this is an example of the well-rounded training that students from traditional universities receive. In contrast, she believes that UoT students will not be able to 'walk through that door'. She adds that few UoT students become Engineers-in-Training and is quite proud of the fact that students who graduated with a B.Tech degree in Chemical Engineering were able to get into EIT programmes. Once the base qualification is received, students working in an operations environment can reach the same level. She feels that learning takes place in a day-to-day work situation as one makes money for the company. According to Chameli, the technician and technologist are stepping stones to becoming an engineer. She adds that learning is not about books, but about industry, the product and process control. Subjects like process safety and environmental waste management were previously small components of the course, but are now courses in themselves. Given that process safety is a significant aspect of industry, it is now a full course in the BEng. Tech. Academics have been able to make these changes to the curriculum because they have experience on advisory boards and are also active on other bodies, such as the South African Conference of Co-operative Education (SACCE).

Chameli is also very involved in the WIL programme at AUT. Indeed, she claims that she was responsible for creating much of the manual for WIL students. She takes the WIL programme very seriously and notes that it is an accredited subject. She points to a file in the office and draws my attention to its contents. These include assessment forms and portfolio requirements as well as the manual that directs students' activities. The subject is reviewed by supervisors. Like any other subject that will be audited, she analyses student surveys and ensures that the course is improved the following year. Supervisors from industry as well as from the University are required to complete surveys on the WIL programme and these form a basis for interviews in which it is critiqued for improvement the following year. Chameli says that this entails a lot of work and humorously calls it 'self-inflicted'.

Another innovation that Chameli has introduced is student workshops where WIL students are able to voice their feelings about the programme. This platform was created because she felt that there was too little interaction between students and their academic mentors. Chameli notes that the Department of Chemical Engineering takes responsibility for the placement of students in industry. Students are tasked with projects and are expected to achieve 12 outcomes during their time at the industrial site. Their manuals list a total of 17 outcomes and they are able to draw on diverse chemical engineering operations to achieve them. In this way, the department ensures that students placed in different chemical engineering environments are able to achieve the outcomes. For example, 'a student who is working in a waste water plant may not have access to a heat exchanger but instead could do a waste minimisation study'.

Students are provided with a mark sheet with a rubric so that they are clear about the criteria by which they will be assessed. Support is provided by academic mentors who are guided regarding their projects and written feedback is given. Chameli is proud of the fact that her institution is one of only a few in the country that assess in-service training. Interestingly, the entire WIL programme is written up as a learnership programme. This incentivises industry to contribute spaces and training for students. Chameli calls this a win-win situation where industry gets funding from The Chemical Industries Education & Training Authority (CHIETA) while the student receives training and is able to graduate.

Soft Skills and the Writing Centre

Chameli believes that her institution has come up with creative ways to address technical and creative skills. This involves constantly reviewing and realigning their programmes. They take into account the pass rate and guidance from industry. For example, supervisors report on students' weaknesses. Examples of soft skills include computers, report writing and presentation skills. Chameli notes that the Writing Centre housed in the library is used to improve students' writing skills. When a lecturer identifies a poorly written report, he/she submits the student's name to the Writing Centre, that assists the student on a one-on-one basis. While the lecturer provides clear feedback on where the student is lacking, the Writing Centre aims to address the student's shortcomings in terms of report writing.
Another way of being creative, according to Chameli is when lecturers try to make lessons interesting because there are many applications to produce the same product.

Globalisation and Ethics

According to Chameli, while we are South Africans located in the south, we need to conduct business as if we have a global office. Aside from the fact that the technology that we use is imported, the engineer needs to be aware of global trends in the commodity market as the cost of raw materials drives how things are produced. She cites the example of paper companies. Previously their main activity was producing paper, but they now see the need to produce lignin.

Environmental factors also come into play. Chameli notes that companies are now aiming for zero waste and looking at how they can take maximum advantage from their waste streams. For example, the sugar industry is producing food additives. Substantial funding is available for research in this area. Ethics is an important consideration when placing students for in-service training. Chameli insists that students need to be aware of environmental legislation with specific reference to the industry in which they are working. This is one of the core outcomes of the course. Students are asked to do a safety audit and to be aware of by-laws.

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Training

Chameli believes that, 'It is the moral responsibility of industry to train graduates'. She maintains that a three-month stint is insufficient as, 'you've got to understand industry'. She adds that a one-year in-service programme suits both industry and the University. From industry's perspective, this represents an opportunity to train the student for future employment. She also believes that one cannot simply expect graduates to be employed on the job from day one and 'make money'. They need to be trained at the plant for at least three months; according to industry, this requires significant resources. While funding is available for lecturers to also receive training in industry, none of the academics has taken advantage of this opportunity as most are involved in research. However, many academics are involved in industry projects. She also lists projects where students are involved in industry.

Being Professional– Meeting the 3 Ps (People, Planet and Profit)

For Chameli, being a professional means being registered with ECSA and meeting their requirements in terms of a qualification. She also believes that a professional should work ethically and morally. He/she should meet the three Ps – People, Planet and Profit – not one to the exclusion of another. Chameli insists that they strictly follow ECSA requirements, such as the 40% requirement in Mathematics for Chemical Engineering. She notes that ECSA sets standards which must be adhered to for accreditation.

5.2.4 RUNLI: I don't see the fire

Runli's story begins with loss and emotional pain. The loss of her mother early in her life made Runli very independent. She describes arriving at university and paying for herself. She set herself the target of finishing on time and did not allow anything to distract her. She completed her diploma in Chemical Engineering and then completed her in-service training as a research assistant. She subsequently completed her Master's degree and was employed as a technician in a laboratory at the University.

She left the University to do her engineering training (EIT) in the sugar industry. She completed the Aqua production course and expected to be given a permanent position. But an existing member of staff was redeployed in her position and she returned to the University as a junior lecturer in 2011. Five years later she was appointed to a lecturer position.

Runli's best memory of her undergraduate years is her Mathematics lecturer who inspired her to perform well. As a result, she passed *cum laude*. However, the effect of this achievement on industry staff was quite surprising. According to Runli, they believed that if someone performed well academically, it meant that they did not have what it takes when it came to industry. Runli experienced problems with her manager as he would have preferred someone from a traditional university. She proudly asserts that it was a panel that selected her as a result of her good performance and the manager did not have much

of a choice. However, he posed a challenge and claimed that although she was technically good she was not assertive enough. She reacted by saying that no matter what he did to her, she was not going to leave. Such determination enabled her to completed her EIT course.

Applying knowledge

Runli notes that knowledge needs to be applied, but that, in the first instance, one must know where to find it. She says that she does not fear challenges because she knows that knowledge on how to solve the problem is out there somewhere. Runli says that the report writing that she did at university was very helpful in industry. She was expected to write a report on completion of her project and found that the structure of the report which she was taught was very useful in organising her data. She also states that no one was willing to show her how to do it. Her technical report writing skills were mastered in the Chemistry 2 class.

We don't know how to marry it

A critical point that Runli makes is that academics are mainly interested in teaching and the student passing. Everything is treated in silos. Academics do not seek to understand the student's social life or what is affecting his/her performance. She feels that students need some form of 'therapy' in order to improve their social lives and enable them to focus on their studies. She provides the example of a hungry student who is unable to concentrate as he/she lacks energy. The academic is not interested in whether or not the student is hungry, but whether or not he/she has understood. But the student has no energy to understand. Runli suggests that institutions invite graduating psychologists to address problems that students are experiencing which originate outside the institution.

A related issue highlighted by Runli is how students define happiness. She notes that poor female students are vulnerable to rich men who seek sexual favours in exchange for money and luxuries. This is particularly rife around the campus. She is concerned that these students have a faulty understanding of where happiness comes from: 'they need to see that happiness comes from you, and not things, or other people'. One way in which Runli and her colleagues addressed the issue was to create a club for students which meets regularly and where they can discuss any issue. Issues range from pressure to personal social problems. One of the benefits of the club is to enable students to see that science is not only found in textbooks, but is part of everyday life. Convection and radiation do not only happen in the classroom, but also at home.

It is important to Runli that students are disciplined. For her, industry is about being serious and about making money. No one is going to baby sit the graduate and therefore he/she needs to become independent. Self-learning is very important as is time management. These qualities sum up what she

feels makes a perfect graduate. Despite the fact that she remembers her graduates visiting her after working for several years in industry, she feels that they lack fire. Students are unable to think or make assumptions. They regurgitate everything and expect to pass.

ECSA

Runli reports that ECSA has identified a shortage of engineers and technicians in South Africa. She believes that many graduates are sitting at home. Many engineers are not registered with ECSA and the registration process is not well marketed. Runli feels that the numbers cited by ECSA are not a true reflection of the number of engineers, technologists and technicians in South Africa. ECSA plays a pivotal role in designing syllabi: 'we develop the curriculum in terms of ECSA's requirements, but they also meet the DOE's requirements'.

Pedagogy

Runli notes that many academics studied at traditional universities and their teaching seems to focus on design rather than operations which is the focus of UoTs. She says that as academics, they do not know where to start and end. The boundaries are blurred. For example, as part of the syllabus, students design distillation columns and do calculations around them. She questions whether students should be taught such aspects rather than teaching them how to operate, adjust and install distillation columns. She believes that, while the course is challenging, it depends on how each individual student reacts. It teaches students about the other side of themselves – when they stop complaining, they will realise that they have the ability, but if they continue complaining, they will fail. Runli is of the view that students need to be independent learners because not everything is given to one in industry. She adds that she tries to convey this in her teaching through giving examples so that students get a sense of what it is like in industry.

Runli also feels that everything is taught in silos and that students are unable to see how each part relates to the others. This was evident when she merged all the processes that students were taught in an examination question. It was difficult for the students to break down each process that they were taught. An important aspect of Runli's teaching is making the connection between engineering and the real world. For example, she says that she makes her students aware that engineers have contributed to acid rain and the ozone problem. She urges them to be responsible when designing. She notes that ethics is only introduced at postgraduate level and feels that academics are neglecting this important issue. Issues relating to the environment will be addressed in the subject known as General Education in the new Bachelor of Engineering (B.Eng).

Finally, for Runli a professional is someone who knows everything. As a professional, one must able to deal with technical problems while doing the budgeting and designing. Costing must be kept in mind when designing and using new technology. A professional technician is someone who can save energy. This description of the ideal for students and lecturers stands in stark contrast to how students are treated when undergoing their compulsory in-service training programme in engineering companies. Runli says that, while she regards the WIL programme as critically important, she is saddened when she sees students making tea instead of being more gainfully occupied. She feels that huge expectations are placed on graduates when they enter the workplace and this can overwhelm them. Even though their might know their work, their performance suffers.

They are unfamiliar with the environment and the demands placed on them. In this regard, the WIL programme plays a crucial role in familiarising students with some of the types of pressure that exist in the workplace. She regards WIL as a transition space: 'you have seen some of the things so you are able to work through and it is not overwhelming'. The idea that the new suite of qualifications will not include a WIL programme alarms Runli. She retorts that it will create students of a sub-standard level who are not performers. She advises that universities which will offer the new B.Eng. should work very closely with industry to determine how WIL can be operationalised. It should be a requirement that students must complete an internship and that they must receive an allowance, which could serve as a bursary. Government incentives would encourage industry to enter into such arrangements. Once students complete the internship programme, they should qualify for a permanent position.

5.3 Section Three: Constructions of professional knowledge

5.3.1 Soft skills

With regard to soft skills, the participants agree that communication skills are important, particularly writing technical reports. However, they stress different aspects of the technical report. For example, for Skapi, the manager, it is important to be able to summarise as the report is often dense and lengthy and the supervisor needs to access the salient parts. Chameli highlights the importance the department places on report writing. She said that students that produce poorly written reports are referred to the Writing Centre for assistance. Runli confirms the usefulness of this exercise when she reports that writing a report in her second year stood her in good stead when she was working in industry and had to produce a report on a project.

Other soft skills identified by the participants include self-discipline and independence. Runli feels that these qualities are essential to grow the graduate. Chaku highlights the need for graduates to have a sense of confidence and to be able to take the initiative. He feels that students are being taught to simply

become compliant push button workers. Skapi and Chameli agree that students need to develop their oral skills as they will need to engage with a range of stakeholders in industry.

5.3.2 WIL

For both Skapi, the manager and Chaku, the curriculum developer, industry is responsible for training students. Chameli also notes that industry has a moral responsibility to train the graduate. Skapi feels that while the University provides technical, practical and theoretical knowledge, industry offers specialist training as the field of chemical engineering is very broad. Both these academics feel that WIL in its current formulation has failed. While they acknowledge that the programme has noble intentions, the way it is practised leaves little room for success as both students and academics are overwhelmed by the workload and red tape. Skapi also feels that while WIL is very comprehensive in terms of design, it has become too prescriptive.

Chaku is of the view that WIL has failed due to a conflict of interests between the University and industry. While the former expects students to achieve certain outcomes during their tenure at the workplace, the latter treats them as full time employees. This leaves students with very little time to focus on the projects and other work assigned to them by their University supervisors. He is also disappointed at the lack of cooperation from industry supervisors. The views expressed by the mentor and the novice differ significantly from those above. For Chameli and Runli, WIL is critical to graduates' success. Runli notes that, while the experience can be overwhelming, it allows students to familiarise themselves with the challenges in the workplace. However, she agrees with Chaku that industry should avoid using students as employees and tea makers. She adds that the experience should translate into a permanent position at the company.

Chameli who was the chief architect of the WIL manual and other WIL innovations, feels that there is much goodwill between the University and industry as they have a long association. Chameli also notes that the WIL programme is written up as a learnership and hence, industry is incentivised to take on students as they receive funding. Runli draws on the idea of partnerships between stakeholders as she believes that a tripartite partnership between government, universities and industry could yield great benefits for the student. She feels that the government should provide incentives to industry to offer students stipends and bursaries.

To summarise, while the manager and the curriculum developer seem concerned about the social justice issue of access and exploitation in relation to the way in which WIL is practised, Chameli emphasises the successful running of the learnership and its accreditation.

5.3.3 Professionality

There are clear divergences between managerial and junior staff at Sharrukh University of Technology with regard to the identity of a professional. These divergences relate to professional, registration, notions of professional competence and technical knowledge of chemical engineering operations.

Managers at SUT feel that a professional should be someone whose knowledge and sense of responsibility is not limited to just mastering technical and engineering knowledge but should also include the responsibilities of being a good citizen. This idea is expanded by Rahul when he views the professional as someone who is well-rounded and not purely knowledgeable about the engineering sciences. This suggests that the engineer should be competent in other fields of knowledge as well. Rahul adds that the professional should be exposed to philosophy and the arts. Freddy, the trainer recognises the role of the professional as someone whose engineering skills should be used to protect the environment. Both see the professional as an innovative, creative and problem solvers. Convergences between management and other staff occur at the level of the issue of ethical concern for the environment. All participants agreed professionals had to follow an ethical codes of practice. Mentors and novices tended to view the professional as someone who was registered with ECSA and who displayed technical competence by having a sound knowledge of the core subjects of engineering.

5.3.4 Regulation

While all the participants agree that ECSA is responsible for the maintenance and regulation of the standards of the programmes offered at universities, Skapi and Chaku focus on the need for students to be internationally competent and competitive. Runli and Chameli agree on the need to strictly follow ECSA regulations when designing the curriculum, while Skapi feels that too much attention to administrative issues can seriously distract from one's purpose which is to create a curriculum which benefits the student. Chaku feels that many academics are too comfortable teaching the way they do and are resistant to change, and thus unable to exploit the potential for change in the new suite of qualifications. Chameli supports the professionalisation of graduates through registration with ECSA while Runli feels that ECSA has not marketed this process successfully as many graduates are still sitting at home. Hence, she feels that the current statistics on the number of engineers and technicians are skewed.

Synthesis

This chapter outlined the context of Amir University of Technology (AUT). I then provided participant narratives from four different levels of the university hierarchy. They included narratives from the Dean, a curriculum designer, mentor and a newly qualified graduate. I then presented participant conceptions of professional knowledge. Finally, I compare these conceptions across the four hierarchical levels occupied by the participants.

CHAPTER SIX

A CASE STUDY OF ATLANTIS PURIFICATION INDUSTRIAL PLANT (APIP)

Orientation

The previous chapter highlighted the evolution of AUT, while the participant narratives provided a vivid portrayal of their roles and responsibilities in their institution and their insights into the nature of professional knowledge and the factors that drive these conceptions. This chapter explores the first industry research site, the Atlantis Purification Industrial Plant (APIP), a water treatment plant located in a peri-urban setting in Durban. The company provides drinking water and other essential services to the people of Durban and Pietermaritzburg.

Understanding chemical water engineering is an essential role of the engineering team at this site. The participant narratives recount their journeys prior to joining the company as well as within it. Their engaging accounts of how learning occurs in the company reveal several themes that are critical to this study. They include professional knowledge, work-integrated learning (WIL), regulatory bodies and soft skills. Section one presents a history of the company and the context within which it has developed. Section two presents the participant narratives and section three compares the themes that emerged across the participants' positions in the company hierarchy.

6.1 Section One: The context of APIP: Industry as service

History and Governance

Atlantis Purification Industrial Plant is a state-owned entity (SOE) that has provided clean drinking water and sanitation services to the cities of Durban and Pietermaritzburg since 1964. The organisation started with a staff complement of four and currently has more than 900 employees (Talcott, 2014). It now provides water to various municipalities that have praised the quality of the water. In 2012, APIP received the prestigious 9 blue drop award for quality management of its products. It has also received a number of other awards and honours (Talcott, 2014).

A Board of Directors and an executive officer govern the entity. The Minister of Water and Sanitation Affairs nominates the Board, which appoints the executive officer. The organisation is primarily regulated by two Acts, namely, the Water Services Act (Act 108 of 1996) and the Public Finance Management Act (Act 1 of 1999) (Ramnath, 2016). In addition to its core function of providing safe drinking water and sanitation services, APIP is a leading training facility for graduates, as well as the

unemployed. It has collaborated with National Treasury to address skills shortages among municipalities in KwaZulu-Natal by rolling out a five-year graduate development programme for engineers, technologists and technicians. Forty trainees are currently enrolled in this programme.The company also runs learnership and apprenticeship programmes that train both internal and external candidates across a range of fields, including Mechanical Engineering, Electrical Engineering, Boiler-making, and Motor / Diesel Mechanical and Instrumentation. These include artisan training (Annual Report, 2015, p.104). Its in-service training includes graduates from both traditional universities and UoTs. All the training provided is aligned to the requirements of professional registration bodies like ECSA.

To meet the needs of its employees, APIP has collaborated with UKZN to implement the Management Development Programme and the Emerging Management Programme. More than 100 employees have graduated from these programmes. The entity also provides bursaries to a number of students across a range of disciplines. The table below describes the employment categories in the company by race and gender.

Table 6
Organisational Structure and Diversity

Occupational Levels	Total Employees Trained	Total Female	Training Hours Female	Total Male	Training Hours Male	Total Hour per category
Top Management.	1	1	88	0	0	88
Senior Management.	39	7	104	32	536	640
Professionally Qualified and Experienced Specialists and Mid-Management.	144	43	684	101	1462	2146
Skilled Technical and Academically Qualified Workers, Junior Management, Supervisors, Foreman and Superintendents.	810	243	2820	567	6904	9724
Semi-Skilled and Discretionary Decision Making.	322	87	2700	234	5328	8028
Unskilled and Defined Decision Making.	111	37	544	74	1220	1764
Non-Permanent.	159	81	2220	78	1252	3472
Total	1586	499	9160	1086	16702	25862

(Annual Report, 2015, p104)

The table demonstrates that the company is well represented in terms of diversity and affirmative action requirements. It also boasts of an extensive community outreach programme where staff members engage in a range of activities beneficial to communities in the surrounding areas. The company's social responsibility programme involves regular testing of its water quality in order to ensure a high degree of purity. Equally important to APIP is ensuring that the environment is left in a pristine condition after

the use of various resources. A critical part of APIP's intellectual environment is training. While it engages seriously with staff training and education, it also plays a crucial role as a training facility. This training involves various streams of students at undergraduate and postgraduate levels. The table below provides a snapshot of the seriousness with which the company views training. All staff, from top management to non-permanent employees participate in training.

Table 7

Hours of training per occupational level

Occupational Levels	Total Employees Trained	Total Female	Training Hours Female	Total Male	Training Hours Male	Total Hour per category
Top Management.	1	1	88	0	0	88
Senior Management.	39	7	104	32	536	640
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Total	1586	499	9160	1086	16702	25862

(Annual Report, 2015, p.104)

Skills Shortage

The skills gap is a major problem identified by the skills development facilitator on the company's webpage. Malishe & Maduray (2015, p.24) report that many higher education graduates enter the workforce without the requisite experience, for example operator or artisan experience They report that there is a need to fast track the training of the neophyte. At the same time, there is a need to maintain long-serving staff whose skills cannot be replicated overnight. Malishe & Maduray (2015) also report that APIP was involved in addressing the skills shortages in the various municipalities in KwaZulu-Natal. In this respect, National Treasury sponsored 44 students from traditional Universities and UoTs to receive in-service and graduate training.

6.2 Section Two: Participant narratives

6.2.1 NEMO: Nose in the air

Growing up in the apartheid era had a profound effect on Nemo's schooling. He remembers that it was very difficult to study mathematics and physical science as few schools in Coloured communities offered these subjects. Nemo had to take two buses to and from school each day to access such a school. However, he performed well and was selected to represent the school at an Eisteddfod at the University of Cape Town. He attributes his interest in science to this event that gave him first-hand experience of university laboratories. The learners were also taken on a tour of industries that exposed them to

chemical processes. He says that this left an indelible mark and could well be what steered him in the direction of chemical engineering.

Having graduated with a degree in chemical engineering, Nemo sought employment in the chemical industry. Following stints in the paint manufacture, pharmaceuticals. insecticide/pesticide and aluminium industries, he ended up in the water industry. He says that one of the reasons that he remained was that, as a quasi-government sector, it offered job security as well as a housing subsidy that he chose over a company vehicle.

Mentorship and Communication

Nemo states that he had competent supervisors in all the places he worked, including Plascon, Huletts and Rentokill. A formative experience was working in a pub on Friday afternoons that enabled him to meet many people including senior management of the company. 'I met the CEO two or three levels above me. You learn to communicate and get on with people.' Nemo believes that this interaction was enabling since they took a genuine interest in developing people. He adds that he benefitted from the mentorship role played by senior management, which enhanced his career growth. Nemo feels that mentors should care about staff progression. He notes the differences amongst managers – some simply get the work done, while others make a difference. He recalls the words of one of his managers:

'…. drop what you are doing today – please come, there's certain people from the Water Research Commission.'

Nemo's managers thus helped him to network with key people in the industry. He tries to emulate this when dealing with junior members of staff. He cites the example of Ayanda, an employee that he mentors. Nemo makes it a point to involve Ayanda in professional activities like workshops whenever possible. At times, he has to justify Ayanda's attendance, but he goes the extra mile. He believes that mentors are responsible for at least 50% of the learning that takes place at companies. One of the most significant incidents that stands out for Nemo is when an elderly mentor from England visited him in Durban. The mentor was in his 80s and wheel chair bound, but wanted to make contact with Nemo. Like his mentors, Nemo is committed to his employees. He finds it rewarding when those who started out as young graduates are appointed to senior positions and recalls three such cases in the past ten years.

Applying concepts at work is an Art and Art comes with experience

According to Nemo, it is a challenge for both the supervisor and the employee to apply theoretical knowledge and academic training in the workplace. He says that graduates are unable to make the connection between concepts that they were taught in their second and third years at university and practical issues in the workplace. In his view, applying concepts 'is an art and that art comes with

experience'. It is the supervisor's role to help students and interns to connect what they learnt at university to their work in the company.

A further issue that Nemo identifies is that the way one is taught at university is decontextualised, with no links to the workplace. He says that 'you have to be able to interpret the nuances of what is being done there and then to apply it'. He adds that, only 5 to 10% of a theoretical concept is applied in dealing with a workplace issue. In his view, besides Mathematics, other theoretical knowledge is inadequate. In the first two years of work, one applies very little theoretical knowledge. He cites the example of engineering a BMW engine. Initially the Engineer will work on a very small component and the knowledge to build the entire engine takes 20-30 years to master. At this point, greater levels of abstraction are required and more than 40% of the theoretical knowledge will be applied.

Nemo notes that the engineering field within the Chemical Engineering sector is very broad and ranges from water treatment to making milk and running a nuclear reactor. How does one maximise the training so that graduates are competent to enter all these fields? The answer lies in broadening the theoretical base of their knowledge. Once they have grasped the basics at work, they should be trained for two years in a specific area such as water engineering.

Graduate attributes

Nemo feels that his personality or willingness to be nurtured by senior management enabled him to grow. Thus, it is critical to nurture good relationships in the workplace. He remarks that, 'a lot has to do with personality'. Nemo emphasises the importance of human relations and attitude in succeeding in the professional workspace. This is also true of young graduates entering the workplace for the first time. He says that his ability to communicate with the staff at different levels of the organisation enhanced his career. Equally, he feels that it is a part of managers' professional makeup to select someone to mentor – "it's just an innate sort of …one of those senses of comfort you get from seeing people go from being there to there". However, he believes that not all managers have this quality. 'I have fellow colleagues and managers who just get the job done and are not interested in people's development'. He describes himself as a person who "takes a lot of pride in seeing people grow and develop" and adds that one needs to go the extra mile when mentoring someone.

Nemo identifies various soft skills that he regards as crucial for the new employee. The first is business planning or strategy. He notes that university does not prepare graduates for this role and that it is the organisation's responsibility to impart this skill. Nemo insists that all graduates at APIP undergo training. He and his team developed the Management Development Programme that exposes graduates to 'the theoretical concepts of planning and business strategy'. Nemo is aware of the fact that

implementation of these concepts can be problematic and hence takes responsibility for this aspect of the training. He tries to emulate his mentors by remembering how he learnt strategy.

According to Nemo, a good engineer is someone who having come out of university, acknowledges that there is still much to be learnt: 'To know that I am not the complete product yet, nor will I ever be'. He describes young graduates with their 'nose in the air' who think they know it all. Nemo states that no one will teach such an individual or gravitate towards him/her as this attitude creates barriers. He recalls that a senior colleague had to sit down with a young graduate and make him understand that his attitude would hinder his progress. He is happy to report that the graduate has made good progress since he changed his behaviour.

Nemo argues that if a graduate creates the perception that he is full, 'like a sponge', no one will 'fill with him knowledge – like a vacuum he will remain empty'. He believes that an engineer's job is about solving problems, and communicating with people is very important because 90% of one says is the problem relates to peripheral issues, while 10% is the real problem. Thus, your ability to listen and relate to people and understand is very important because you could start working with the wrong problem and this wastes time and money.

Problem shooting in an Engineering context

Nemo emphasises the importance of the context in the engineering environment. He says one needs to understand the client in his/her context because, as noted previously, the problem that he/she describes could lie elsewhere. For example, at time, the problem is a human one in the form of the person's manager or the person below him/her. Nemo cites the example of sending technicians on site for two weeks to resolve an issue. After investigation, they suspect that the problem lies with the operators who are unable to follow instructions once the technicians leave. After a high-level investigation of the plant in Ixopo, it was found that the failure to produce good quality drinking water was not an engineering problem, but an HR issue. The investigators concluded that the problem lay in the technicians' inability to follow simple instructions. This leads Nemo to question whether these technicians learnt communication skills and the skill of following instructions at university.

WIL and social justice

Interestingly, Nemo's organisation has changed the WIL programme because they believe that one year is inadequate for the graduate to become competent. While the student is still able to graduate, he/she is retained for an additional year in order to develop his/her skills. However, the company only hires graduates with three years' experience. This means that there is a gap of one year. The graduate will have to leave the company, get employment elsewhere and then return to the company if he/she so

desires. To address this situation, Nemo initiated a developmental post that engages the graduate for an additional year. During this period, he/she completes an additional diploma or a postgraduate qualification. This enables graduates to remain in the system.

Once the trainee graduate enters a development programme, his/her salary increases and he/she is virtually guaranteed a position in the company. Nemo says that he had the support of his senior managers in implementing such a system in the face of organisational systems that are not very flexible. The inspiration for this initiative also came from his experiences with mentors who tried their best to provide training and appropriate experience.

6.2.2 DRAKE: Learning at a higher rate

Drake's formative years as an Engineer were spent in companies that had upgraded or undergone some kind of expansion. This enabled the young novice to quickly learn the ropes and develop his engineering skills. Drake's sojourn in the first company lasted four years, during which time he gained as much experience as possible and then reached a 'plateau'. Afraid to be saddled with experience in a single area, he ventured into the job market once more.

Although the second company in which he found employment was smaller, it afforded him the stimulation he so desperately sought. In the first company, Drake worked in multi-disciplinary teams, as well as with people with different levels of experience. These interactions not only assisted him but provided ample learning opportunities from different perspectives. The second company had limited human resources, but he was exposed to more aspects of engineering work like financial exposure, proposal writing and commissioning[4]. In addition, the company was German run and thus had an international work ethos. When Drake joined APIP's Research and Development division, it took him a while to get used to the water and waste environment. He says that he does not regret the move as he is stimulated at all times. One reason for this is his involvement in a variety of projects, including evaluation of filters and membranes, desalination, and surveillance cameras. Moreover, he is very involved in training in-service students as well graduates in a five-year project funded by National Treasury.

The Five-Year Project – A Training Plan

With funding of R90 million from National Treasury, APIP launched a five-year training plan to train chemical engineering technicians, technologists and engineers. While technicians were on experiential

[4] 'Commissioning is a process assuring that all systems and components of a building or industrial plant are designed, installed, tested, operated, and maintained according to the operational requirements of the owner or final client.' (Wikipedia)

training for six months to a year, the other two streams comprised of graduates. The overall objective was to give these graduates adequate workplace skills to ensure employment. The syllabus aimed to enable the novices to meet engineering competencies as per ECSA's requirements. Drake's portfolio included rotating duties to expose novices to challenges in different sites, assessments via mentors and ensuring consistent training.

The anticipated outcome of the programme was to produce well-rounded engineers with specialised skills in water and waste as well as other sectors that would be ready for professional registration. According to Drake, municipalities would absorb these engineers, as they require professionals with technical skills. For Drake, one of the most rewarding aspects of the project was to observe the intensity and level of work experience gained by the novice. This was evident when Drake had to sign their referee progress reports which outlined the different aspects they had covered in their short time at the company. Novices used these reports to apply for professional registration and he says that when he received feedback that the person was professionally registered, it was immensely rewarding. Management's confidence and trust in allowing him independence in running the project was also gratifying.

According to Drake, other companies and some universities also run such projects, but APIP chose to do so because of the quality of the graduates that they saw. However, he feels that they lacked technical competence and that the experiential training period was inadequate. Development of technical competence did not automatically mean the ability to hit the ground running. According to Drake, doing the job properly means interacting with people and systems, handling clients and suppliers over the phone and being exposed to different disciplines. Collaboration between universities and industry would enable extended practical training. Drake reports that the training programme supplies part of this need as graduates come in green and it takes time for them to assimilate these experiences. He refers to this process as longer exposure.

Drop in Standards

Drake feels strongly that there has been a drop in the standards at universities over the past five years or so. He is of the view that the standard of the content as well as the passes has dropped, enabling more students to graduate. He suggests an innovative idea to give students wider experience. For example, if they are working on filtration, the theoretical component can be done at university, but the practical side should be in a fully-fledged plant instead of a demo laboratory. They should be placed in industry for a week or so and then complete the work. He adds that many students do vacation work at university laboratories rather than in a work environment. According to Drake, the university environment does not enable the student to see the full impact of the work undertaken. For example, in the real work

environment, permits and legal requirements need to be followed when you have to discharge. In the university environment, one would not be expected to pursue legal opinion or documentation. Furthermore, the chemical used may not have a negative impact on the environment. This conservative approach robs students of important insights. Drake feels that the WIL programme needs to be revised. He suggests that a period of six months be added to the current year. This would include a theoretical component where students reflect on their experiences to consolidate what they have learnt.

Working in a Silo

Aside from the fact that students will be working in a real environment with real equipment and chemicals, Drake emphasises the importance of working with people. He feels that collaboration and knowledge of what other people and departments are doing are essential to prevent duplication and ensure that everyone is working towards the same goals. Drake says that interpersonal relationships and communication are as important as technical acumen. He adds that there would be fewer issues if everyone gets on with one another. Drake stresses that engineering work is not just another report that will be filed away; it impacts people and the environment. The student needs to be aware of how his/her work will assist the company, the industry and the nation. For this reason, he feels that communication through reports, seminars and networking across departments is critical.

Drake observes that graduates enter industry with a range of analytical and problem solving skills, but are unable to deploy these skills immediately. They have to orientate themselves and adapt to the environment to see how they can apply their skills. Use of theoretical skills often results in impractical solutions. One requires experience to judge whether or not a solution is feasible. He cites the example of a theoretical solution which suggests that a particularly small valve is required. In reality, such small valves are not manufactured. Only experience can provide such insight.

Sources of Knowledge

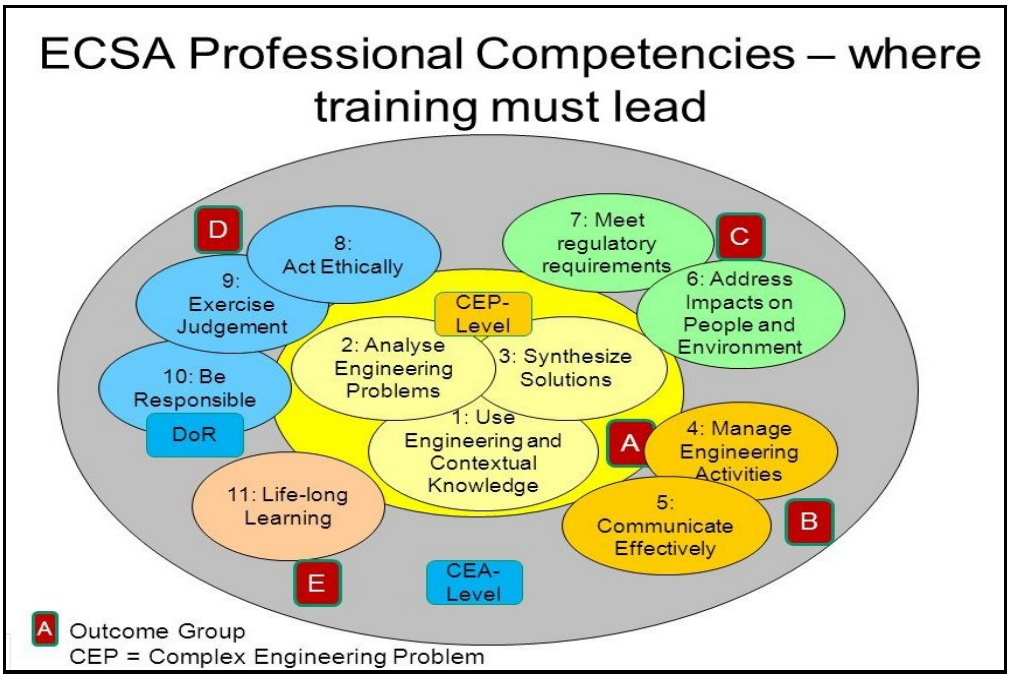
Drake seems immensely proud of the fact that the environment in which he works has people with more than 20 years' experience. He says that when there is a problem, one can approach these people and they will advise on an alternative solution. He stresses that they will not solve the issue for you but suggest ways of going about it. Drake adds that various resources are available on the internet and this may be the first port of call for those who want to research a problem. Thereafter, they could consult the organisation's archives for reports on previous similar problems. He notes that APIP has a database of reports on every sort of problem experienced in the past, whether it is a chemical tenure report, a process optimisation report or an audit report. The second stage is to consult colleagues or team members. Should this fail, senior members are called in to suggest solutions. Finally, the manager steps in to resolve the issue. Once internal resources are exhausted, external consultants are called in. He

highlights the need for a systematic approach to solving problems as there is no problem that can't be solved.

SAICHE, ECSA and the process of professional registration

The South African Institute of Chemical Engineers (SAICHE) plays a critical role in assessing the company's training programmes. One of the requirements is that trainees give a presentation on a given topic. Initially, it was decided that trainees should present on process design, process optimisation or trouble shooting. These topics were selected to satisfy SAICHE requirements for professional registration. Assessments are conducted by a panel of senior members. After the presentation, they indicate areas of weakness and development. Following this process, a mentor who is au-fait with ECSA outcomes and requirements and who sits on ECSA's panel, comments on the candidate's technical content as well as on the candidate's communication skills. He/she also assesses the readiness of the candidate on the areas tested. Should there be any areas for development, a report is submitted to the supervisor. The supervisor and the candidate have an opportunity to deal with the shortcomings in the next six months.

Although the training is for the graduate engineer, the technologists and technicians' training has been tailored to meet similar demands but at a lesser intensity. All three streams have to satisfy ECSA's 11 outcomes. These are listed in the figure below:



(ECSA, 2014)

Figure 7: ECSA's 11 critical cross-field outcomes for engineering

According to Drake, a professional registered engineer is required to be confident and competent to such a level that he/she minimises possible risks to the environment and people's health. He notes that once ECSA issues an individual with a certificate, this means that they have confidence that he/she will adopt a measured, ethical approach to everything he/she does. He highlights that a design flaw could cause the deaths of hundreds of people due to poor quality water or flooding. This is a heavy weight for engineers to bear. Drake notes that, while he does not remember receiving ethics training during his undergraduate years, he remembers a pipe bursting when he was working in industry and its effect on the community living in the vicinity.

Ongoing training and soft skills

Drake believes that staff need ongoing training and that one needs to keep up with what is relevant in the market. A person with ten years' experience needs refresher courses to update him/her on contemporary issues in the field. This includes courses like strategic management and negotiating skills. Engineers must be able to drive in order to move from place to place and should also have communication skills and report writing as well as presentation skills. They should be professional and courteous and not display arrogance. An effective engineer should have listening skills, should be able to hold their own in debates on technical issues, and be willing to training others and disseminate and share technical knowledge and expertise. Finally, they should not allow their personal emotions to interfere with their work.

He also notes the importance of students learning how to write abstracts and summarise. He cites the example of a student writing a ten-page report of which eight are unnecessary. People have to read quickly and make judgements based on what one has written. There are also cost implications and the impact of the project needs to be calculated. Drake sees a successful engineer as someone with a very strong technical background as well as ambition and willingness to continue learning. He feels that communication with other people is critical as is the ability to persuade others. Academics also need training. Drake believes that they are too theoretical and they need to use examples from real life instead of relying on old examples from textbooks. He also suggests that they need practical exposure to industry.

6.2.3 JACK SPARROW: Passion for innovation

Jack is a pleasant young engineer at APIP. He welcomes me into his office and seems willing to share his experiences and knowledge. He ushers me to a chair and smiles. I learn that Jack holds a unique perspective in that he is an Engineer and also has close links with a university. He previously lectured and holds a PhD in chemical engineering. Jack describes his core functions as process support, technical support and designing new projects. He says that his job is very enjoyable. He is also very involved in

training young graduates as a supervisor and occasionally mentors trainees. Jack is also involved in research, works with UKZN on a number of research projects, and sits on their Advisory Board. He made the leap into industry because he felt that the University did not allow for mobility and there were also financial considerations. He says: 'I have a passion for research and innovation'. Joining APIP was motivated by this passion and his interest in training.

Transition from university to work

Jack believes that it takes at least two years before a novice engineer becomes fully functional at a place of work. He feels that universities tend to spoon feed students and they get a rude shock when they start work as they are given instructions and left to their own devices. While he believes that support is important for some students, for example, with the use of Moodle and recording lectures, he feels that the textbook has become obsolete. He suggests that lecturers should not provide notes for one or two modules at university in order to explore whether students will turn to different sources of knowledge. Jack seems to recommend that lecturers should force students to read. Indeed, he made this suggestion to the advisory board. His view is that universities should train students to use different sources in order to expand their knowledge.

Teamwork and other skills

Jack regards technical reporting as an important soft skill. It is one of ECSA's 11 outcomes and universities have incorporated these outcomes into their curricula. He adds that within two years of the novice arriving at the workplace, he/she undergoes a training programme that develops some soft skills. He/she also becomes technically competent by being exposed to the field. Jack says that graduates use 10% of what they learnt at university because the field is very specialised. However, graduate programmes enhance their development and after two years, they gain a lot of confidence. It appears that APIP has a fully-fledged training facility that gives graduate trainees maximum exposure to various aspects of engineering work in the field. Jack notes that other companies have similar programmes but these may differ from company to company.

Teamwork is another soft skill emphasised by Jack. He observes that engineering is made up of multi-disciplinary teams that work closely with electrical, civil and mechanical engineers. He notes that team members have to play their part and learn a little about the contribution each member makes to the team. In this way, one's knowledge grows. Therefore, learning how to interact with others is crucial.

An enjoyable aspect of his work that Jack identifies is his ability to instil knowledge in his graduate trainees and ensure that they complete the training in a much shorter period than the stipulated two years: 'It's quite enjoyable, you know, to instil the knowledge, the experience and the soft skills.' He

views his trainees as products that need to be 'finished' in time and adds that he enjoys 'feeding' them a lot of information. He notes that he receives a report on the trainee's weaknesses from his/her mentor. Mentors are external industry registered engineers. He personally ensures that the trainee addresses the weaknesses identified through appropriate training. Jack enjoys his work as he states that young minds are eager to learn and are drawn to someone who is going to give them knowledge.

6.2.4 JULE VERNES: Okay, now it's boring

Vernes' narrative is punctuated by references to his boredom with the work assigned to him. On meeting him for the first time, I cannot help but notice his high energy levels and general restlessness. Vernes' career trajectory has been shaped by this notion of boredom and to a large extent has taken him to where he is presently ensconced. His first foray into the world of work was the company where he completed his experiential training. He speaks passionately about this period in his life and says it was an 'exciting experience to see the reactors that we talked about at school'.

While he adds that it was exciting to produce something that involved process control engineering – a module that he completed at university, this passion did not last long. After two years as an operator, the routine was killing him. He remembered the diverse knowledge he gleaned during his studies and felt disappointed that he could not activate it. To a large extent this prompted him to continue his B.Tech degree. However, being appointed a senior operator in a vertical promotion did not alleviate his boredom. He says that all the promotion entailed was 'an increasing volume and amount of reactors you control – the activities were the same'. At this point, he did some soul searching about where he wanted to go in terms of his career. He also states that the money was not so attractive. Sharing information with friends in the industry alerted him to possibilities of utilising his chemical engineering knowledge in other sectors like unit processing. He was also aware of the danger of forgetting what chemical engineering is about. The need for a career change caused him to look outside the paint industry.

Masters and the magic pond

Vernes found his magic pond when he was awarded a bursary and resigned from work to pursue a Master's degree at a UOT. Guided by his supervisor, he set out to separate algae from water Sadly, after four months, the pond dried up, and Vernes' project was doomed to fail. However, he managed to complete it using the facilities at APIP which were secured by his supervisor. He also applied for a contract post as a technician. Vernes says that he finally found a place that was stimulating. From his first day at APIP, he was busy with water projects. He adds that he has stayed stimulated in this research and development environment because there is no routine: 'you work with this project; when its finished, there's a new project'.

Amongst his other duties, Vernes mentors new recruits from UoTs, presents research papers emanating from his projects at conferences and has had papers published in conference proceedings. Vernes' most memorable project thus far is his management of the Durban Heights Project, a waterworks that treats six hundred million litres of water a day. The problem identified in the plant was the inefficiency of the existing filters and the resultant wastage of water. The final decision was to upgrade the filters. He conducted a pilot study in which the filters were upgraded and tests showed that the strategy worked. Vernes was very pleased that a solution was found and he was lauded for his work.

Reflecting on how he solved the problem, Vernes says that the first step was conducting an investigation using various sources of information. If a similar problem has occurred at the plant or another plant in the past, reports will be available. However, the problem Vernes was investigating was unique and he had to consult an international PhD. The process services manager was another important source of information. He notes that, 'We had to do a lot of studying of hydraulics, understanding filtration and dissolution in water theory'. He also attributes the success of the project to the efforts of the team with whom he worked. The project involved 24-hour shifts when conducting trials and was manned constantly by different teams. As Vernes was in charge of logistics, he was hands on. He says that the team worked well together and supported one another and that, 'we were not thrown in the deep end'.

The house

Vernes uses the metaphor of building to show that it takes a team to build a house. No project is undertaken by an engineer alone. It starts somewhere else before it comes to you. Each person has specialist knowledge and the project is thus a team exercise. He defines professional knowledge as specialist knowledge and links the notion of competence to the success of the project. If one is a weak brick, the house will be compromised – hence the need to be competent. He adds that professional knowledge is awareness of what one is good at, as well as basic theoretical knowledge or the core principles of the field in which one works. There are many sectors in the engineering field and one must be competent or have expertise in one's specialised area.

Practicals and projects

Vernes feels that students at universities should participate in more practicals and projects where they work in teams. This would prepare them for the world of work where the team that one is part of is not made up of friends or people one knows. He feels that he was disempowered at university because he chose to form teams with his friends. He concedes that the aim of the project was to teach students that one never works on a project alone and that one depends on others, but says that, as a student, he was not taken out of his comfort zone. While he made no effort to participate in the group's activities,

the group received a single mark for its project and those who did nothing still benefitted. He identifies this as a weakness.

Dynamic, flexible and versatile

In discussing the attributes of engineers, Vernes states that the university curriculum prepares one for industry by ensuring that one acquires new knowledge every day and each day is challenging. He says that when one enters the workplace, one should be ready for anything; in other words, one should be 'dynamic, flexible and versatile'. Another important attribute that Vernes identifies that is missing in graduates from UoTs is a sense of ownership. Tasks are regarded as duties that must be performed as opposed to taking responsibility for problems that arise. Vernes laments the lack of commitment displayed by UOT graduates. A criticism that Vernes levels at the UOT from which he graduated is that it made him 'sweat'. He feels that the curriculum was very crowded. However, he would not 'dilute' it, as it is important to ensure that graduates are armed with adequate knowledge to enter any sector within the chemical engineering industry. He also expresses the need for graduates to master the fundamentals and principles common across all the sectors. With regard to the curriculum, Vernes believes that it is comprehensive in that one can gain entry to any sector in chemical engineering. More importantly he says that it has the potential to spur them to learn independently.

Certifying an Engineer

Vernes says that ECSA's role is to 'certify a professional engineer and then regulate how a professional engineer should conduct him/herself'. He adds that ECSA safeguards the community by ensuring that expertise and specialisation are deployed correctly. He cites the example of a person who has experience in the petro-chemical sector and for some reason has been assigned to build a dam, just because he has been certified as a professional. How will he/she be able to design the dam when he/she only has experience in designing distillation columns? Such a scenario will be disastrous for the community. It is here that ECSA plays a role in ensuring that a person is certified in terms of relevant engineering experience.

ECSA also plays a key role in the issue of ethics. Vernes says that ethics must be considered by engineers because if they don't, we will end up with a polluted environment. He uses the example of a project that is given to an engineer. He/she needs to start by considering the end user of the project's products and how it will affect the next generation 20 years down the line. If the building collapses and ECSA becomes aware that it was one's fault, one is stripped of one's certification. ECSA also specifies the kinds of attributes that graduates are expected to develop. Vernes describes some of the attributes he considers important. Firstly, a professional should be reliable. In other words, if he/she is tasked with a project, his/her senior can rest assured that they can rely on him/her to deliver. If there is a problem,

it should be communicated on time in an open and frank manner so that the necessary resources can be deployed. The second attribute is honesty. If deadlines cannot be met, this must be communicated to the person in charge. Finally, a professional must be committed. Projecting and predicting outcomes entails experiential knowledge and knowledge of problem solving as well as theoretical knowledge.

6.3 Section Three: Constructions of professional knowledge

6.3.1 Soft skills

Nemo identifies the ability to communicate at different levels as crucial to a graduate's development. Equally, one's attitude is important. Positive results will be achieved if one approaches others with humility and the desire to learn. Drake echoes Nemo's sentiments and adds that the ability to persuade is critical. Linked to this is presentation skills. The graduate should have excellent listening skills and be able to debate technical issues. He/she should be willing to train others and disseminate technical information and expertise. He also highlights the need for report writing and summarising skills. Jack believes that technical report writing skills are important and notes that this is one of ECSA's 11 outcomes. These skills are taught to graduates during their two-year training programme in the company.

Being a team player is strongly emphasised by Jack and Vernes. Jack believes that graduates must be able to interact with multidisciplinary teams in order to learn about different disciplines and grow one's knowledge. Vernes feels that UOT graduates lack the ability to be team players. He uses the metaphor of a building to illustrate the importance of teams. Once one has completed one's task in building a house, one leaves it to the next specialist. If one is a weak brick, then the house will collapse. Hence the need to be an expert but also to be part of a team.

Other soft skills identified by Vernes are being dynamic, versatile and flexible. Nemo, on the other hand, identifies business planning or strategy as a soft skill that graduates lack, as universities do not teach this skill. He believes that it is the responsibility of the organisation to develop this skill in graduates. Drake agrees with Nemo in this regard. He states that one needs refresher courses to be relevant in the workplace, including those on strategic management and negotiating skills.

6.3.2 Work-integrated learning

Nemo feels that the WIL programme needs to be extended to two years from its current offering of one year. He justifies this by saying that it takes two years before students become confident to start making the link between the theory that is taught at university and its practical application in the workplace. Like Nemo, Drake feels that the WIL programme needs to be revised. He suggests that a further period

of six months be added. The additional training would include a theoretical component where students reflect on their experiences to consolidate what they have learnt. He also suggests that they do a more advanced course like mass transfer or water treatment and that practical exposure to being a specialist in this area should be included as an important component in the curriculum.

Jack states that he reads supervisor comments on trainee performance during the WIL programme and ensures that he addresses areas of weakness. Vernes provides illuminating details of his own experiences during the WIL programme. His initial excitement about interacting with equipment that he only saw in textbooks as a student was short-lived as the routinised activity started to get him down.

6.3.3 Professionality and identities

According to Nemo, graduates experience difficulty in making the link between theoretical knowledge and its practical application. He says that graduates use only 5-10% of the knowledge gained at university and that as they gain more experience and become more senior they are better able to grasp levels of abstraction. He also believes that the theoretical base of content knowledge needs to be broadened to include knowledge from other sectors of the chemical engineering industry. This would enable graduates to grow when starting work in any sector. Drake concurs with this viewpoint. He also feels that the standard of the content has been lowered over the past five years in order to help students pass. In addition, Drake feels that technical competence is wanting in graduates. This resonates with Jack's notion that graduates are spoon-fed at universities and that they need to be taught to learn independently.

It is not surprising that the participants feel that graduates need at least two years of training in industry to become competent. According to Nemo, only 5-10% of what is learnt at university is applied in industry. Drake attributes graduates' limitations to the inadequate time that they spend in industry. Although students are given practical work in laboratories at universities, he feels that it robs them of authenticity as they are unable to witness the real effects of the chemicals used on the environment. Nemo also bemoans the fact that students are taught in a decontextualised manner most of the time. Vernes shares Drake's sentiments about the effects of poorly resourced laboratories and lack of appropriate equipment on graduate readiness.

All four participants agree that graduate engagement with different stakeholders within and outside the industry is critical in developing one's knowledge. For Vernes, professional knowledge is the commingling of experience and knowledge produced during interactions with stakeholders. Jack extends this notion by suggesting that graduates be exposed to different disciplines. This involves

knowing a little of mechanical or electrical engineering. He argues that exposure to multidisciplinary teams, entails learning a little from each discipline.

However, when projects are localised, communication involves team members and senior management. Professional knowledge is activated during problem solving activities which usually involve projects. For example, Vernes reports that the first step is research around the problem. This involves consulting different sources of knowledge, starting with the company archives which contain reports on similar problems experienced in the past. Other sources may include internet searches of databases, journals and other sites. A critical resource identified by all four participants is human resources. Colleagues and senior personnel are regarded as important sources of information. Vernes notes that once the problem is resolved, there is the option to write a professional paper on one's findings and methods and to present these at a conference or workshop.

6.3.4 Regulation

While all of the participants are keenly aware of ECSA's role in accreditation and auditing, there are clear convergences and divergences of views between the levels of the hierarchy. It appears that the senior employees namely the manager and the trainer, take a more global view of ECSA's role, seeing it as part of a broader alliance of with government and the university sector to address issues of education and training. Nemo, the manager views ECSA as important in the continuing professional development of engineers. Vernes, the trainer, is guided by ECSA's requirements in the WIL programme where he is involved in hands on experience to train novices and write reports to guide them for the next six months with regard to addressing their development needs.

The novices and mentors show a keen understanding of ECSA's role in certifying professionals, international benchmarking, role in student placement and employment as well as in addressing shortfalls in undertaking audits. The mentor, Jack feels that it is more important to develop a well-rounded Engineer instead of tick boxing ECSA's 11 outcomes. Perhaps he is suggesting that ECSA can influence employees to become too prescriptive and to lose the essence of one's role-function.

Synthesis

In this chapter, I first provide a description of Atlantis Purifying Industrial Plant (APIP). Then I offer four participant narratives in which they outline conceptions of professional knowledge as experience within their hierarchical levels. These narratives included contributions from the Dean, a curriculum designer, mentor and a newly qualified graduate. Finally, I brought participant conceptions of professional knowledge in dialogue with each other.

CHAPTER SEVEN

A CASE STUDY OF PROMETHEUS PETROLEUM INDUSTRIAL REFINING (PPIR)

Orientation

The previous chapter focused on APIP, a company operating in the water industry. The participant narratives yielded a significant amount of data to weave a story of how learning occurs in this company. These stories provided four broad themes that framed the chapter, from which conceptions of professionals were drawn.

This chapter explores the second industry research site, namely, Prometheus Petroleum Industrial Refining (PPIR), which is situated on the outskirts of Durban bordering a residential suburb. The company produces fuel and other products for the petroleum industry. It is privately owned but is of key strategic interest to the country. The participant narratives tell of their journeys of learning from novices to highly experienced personnel. These narrative accounts provide the critical themes that frame this chapter. Section one presents a history of the company and the context in which it developed. Section two presents the participant narratives, while section three compares the themes across the four hierarchical positions of the participants.

7.1 Section One: The context of PPIR: Industry and the economy

History and Governance

Prometheus Petroleum Industrial Refining (PPIR) is one of Southern Africa's leading petro-chemical companies that has provided South Africa with a range of petroleum products since 1960. The company started with a modest staff complement of under 30 and has grown to well over 700 members of staff at different levels (Hoare, 2013). It currently manufactures petrol, diesel, paraffin, aviation fuel, liquid petroleum gas and base oil solvents, and marine fuel oil (Hoare, 2013, p.2).

In 2013, when PPIR celebrated its 50th anniversary, various state ministers lauded it for being an outstanding corporate citizen that contributes millions to the economy. The company is a national key point (Hoare, 2013, p.38) and its major shareholders are BP South Africa and Shell SA Refining. It is governed by a Board of Directors which appoints the Managing Director, while the leadership team comprising the heads of various departments reports to the MD. These departments include Human Resources, Finance, Maintenance, HSSE (Safety), Technology, Engineering and Production.

Aside from focusing on its core function, the production of petroleum products, PPIR is also engaged in upskilling workers at its training facility. It is involved in a range of collaborative activities, including skills training for local unemployed citizens and sponsorship of community projects. A critical aspect of PPIR's role in the community is to ensure that in producing petroleum, it does not pollute the environment. It has thus committed substantial funds to ensure that its relationship with the broader community is based on transparency and good faith.

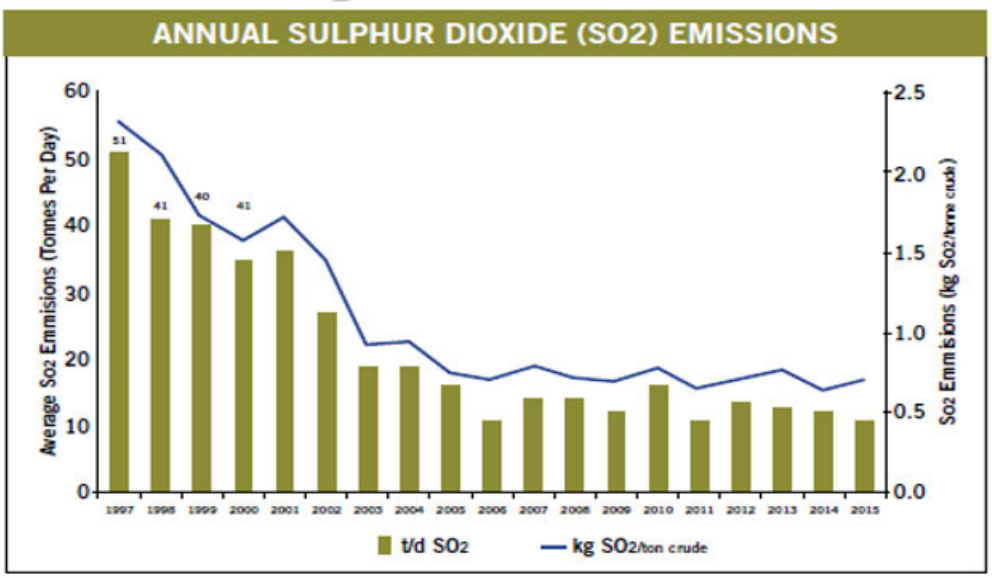


Figure 8: Sulphur emissions

(PPIR)Sustainability Report, 2015, p18)

The above graph plots the company's sulphur emissions over 19 years and illustrates steady progress in reducing this pollutant. The plant also emits other pollutants that can seriously damage the health of the surrounding community, including benzene, tylene, CO2, methane, and nitrogen oxide. It has adopted various measures to control the emission of these pollutants, including ambient air monitoring, which has resulted in reduced waste products in the air over the years. However, community activists have accused PPIR of discharging thousands of tons of sulphur into the atmosphere (Carnie, 2015) and environmental organisations have taken the company to court over its emissions (Carnie, 2015).

Due to such negative publicity, the company has ploughed millions of rand into various projects in the Durban South Basin communities. These include generous bursaries, school laboratories and other community projects. According to the company's annual Sustainability Report (2016), the organisation is proactive and engages with a range of stakeholders drawn from "local residents, neighbourhood schools, community organisations, representatives of all levels of Government and business organisations" (2016, 10). This includes formal interactions with at least 30 external bodies. More militant/activist organisations like the South Durban Community Environment Alliance (SDCEA) seem

to fall outside the ambit of these relationships. This organisation has accused the company of being responsible for many illnesses suffered by community members in the neighbourhood, including respiratory diseases like asthma. *The Guardian* newspaper paints a picture of PPIR's scenic surroundings that mask its more sinister role in what media has dubbed the 'cancer valley'[5]:

> Last week, beyond scenic palm trees, the entrance of the 'company' was patrolled by G4S security guards as gardeners mowed lawns beside the boom gates. An inflatable archway, with a cartoon image of a tortoise wearing blue overalls, proclaimed: "It's turnaround time. Let's deliver it safely." Last month a fuel line explosion here claimed the life of a worker and left two others seriously injured – one of many accidents over the years. (Smith and Carrington, 2015, p.1)

Given the nature of its products and the possible negative effects on the environment, safety is the company's first priority. Indeed, violating the rules is a dismissible offence as the lives of other staff members are involved as well those of community members. All training starts with the theme of safety. In its annual report under the rubric Human Capital, the opening line reads: "Refinery operations require a constant focus on the people agenda to maintain safe, reliable operations" (Sustainability Report, 2015, 11). Despite the various criticisms levelled against it, APIP has committed itself to uplift the nearby communities. The social responsibility spend is reflected in the figures of the table below which reflects just a fraction of the kinds of community projects in which it is involved.

Table 8

2015/16 PPIR social responsibility programme

ORGANISATION	DETAIL
Bahle Help the Aged Care Centre	Sustainability project
BBBEE and Enterprise Development	BBBEE related matters
Bluff Clinic	Parkhome and renovations
Bursaries	Skills Development
Centre for Rehabilitation of Wildlife - CROW	School Environmental workshop
Community Liaison Forum Projects	CLF activities and projects
Durban Business Fair	Stands for SMMEs
Ekwazini and Qhilika High School	Science Laboratories
Inqubeko Projects	Building renovations
Isaiah 54	Vehicle Donation
Jullo Foundation	Computers
Keep a child alive	Vehicle donation
KZN Children's Hospital	Province wide project
Lamontville HIV/Aids Centre	Vehicle Donation
Learners Salaries	Skills Development

(PPIR Sustainability Report 2015/16, 24)

[5] This refers to the South Durban Basin which is regarded as South Africa's most polluted site as it houses many industries.

The company invests in the community through the school talent pipeline programme that offers bursaries to deserving learners from the Durban South Basin community to complete Grades 10, 11 and 12 and encourages them to pursue careers in engineering. To date, 59 learners have benefitted. Students studying towards an engineering degree receive support in the form of tuition fees, textbooks and accommodation. They also undergo experiential training from their first year during their vacations and are paid a stipend. On completion of their degrees, these students follow the graduate engineer programme stream. The WIL programme for students from UoTs takes place on completion of their diplomas.

Training for unemployed students takes place via learner-ship programmes that follow CHIETA[6] accredited programmes like chemical operations, and analytical chemistry. In this way, the company offers qualifications and work experience to youth to enable them to be employed in the chemical industry. In 2016, CHIETA bestowed three awards on PPIR for its excellent skills development programmes.

7.2 Section Two: Participant narratives

7.2.1 MARY: Know what is expected and deliver

I wait for Mary in the foyer of the company. The private passage to the offices is replete with warnings, including speed limitations and care for animals. On a large television set in the foyer, the company CEO belts out messages about the importance of safety on site as well as the importance of teamwork. Mary is late for our meeting. I am not sure whether this is deliberate so that I can absorb the key messages from the CEO. When she arrives 10 minutes later, she apologises profusely as she ushers me into her office. As we climb the stairs, instructions on the walls state that the handrails must be held at all times. The offices we pass are small, but cosy and the passage reflects the light of many small laptop screens. Staff dressed in uniforms pass us. I smile and greet, but most seem preoccupied. As Mary asks me to sit, I notice a family photograph on her table. "Daughter?" I say. "Yep," she responds. "Lovely," I reply. She smiles.

As our interview begins, I am surprised by Mary's candidness. She says that while studying she was acutely aware that the financial position at home was challenging, and that she needed to get a job desperately. In her final year of her HR diploma at a Technikon (now UOT), she volunteered her services at a bank and quickly learnt the art of networking, focussing on what was valued in the

[6] CHIETA refers to the Chemical Education and Training Authority – a body comprising of various stakeholders in the chemical engineering sector.

organisation. This translated into full time employment when a position became vacant. Mary's experience at the bank was critical in landing her the job of Public Relations (PR) person at PPIR. She started as a communications officer before being promoted to Communications Manager, and then Sustainable Development Manager.

Mary's motivation for leaving the bank was the need for a more stable lifestyle as her role as Regional Manager took her outside the company most of the time. It was high pressure and she was constantly networking. In her own words, she wanted to 'slow down the pace of life.' Her role as Sustainable Development Manager provides an interesting perspective on how the company prepares to manage disasters. While there are mechanisms to deal with disasters within the company, it is left to the Sustainable Development Department to manage the media and the community. As the company is nestled alongside a community, any environmental issue like spills or pollution affects the community. Having the right people to interact with community activists and the media is a make or break situation for any company.

In this regard, Mary confesses that she has to 'bud relationships'. I take this to mean that she needs to nurture relationships with members of the media as well as with community members. Linked with this function are corporate social investment projects, particularly in areas severely affected by pollution.

Linkage between industry and university

Mary feels that the failure of the university system can be attributed to the lowering of standards at school level. She claims that when students reach university, they 'battle to pass and meet the grade'. She also feels that students are not independent or disciplined enough to cope with life at university. She advises that one way to address this problem is to strengthen the linkages between industry and the university. Mary feels that engaging students in more vocation related work could resolve this issue. She says that students should be exposed to industry training before they start working and calls for a more intense experiential programme. Another partnership she regards as very useful in addressing the skills gap is the nexus between industry and regulatory bodies like CHIETA and ECSA.

Lifelong Learning – 'You get complacent – you do things the way you do.'

According to Mary, lifelong learning refers to people who have been doing the same work for a long period of time. Mary remarks that we tend to lose our creativity and need to be more effective. In her opinion, this can be achieved by setting standards or benchmarks to aspire to. According to Mary, the company encourages further training and development by funding academic courses or overseas visits to complete qualifications. She cites the example of a team leader in the IT field who is sent on specific training to meet business needs. This also forms part of the employee's professional development and

growth. Mary feels that leaders need to be trained in a variety of fields. The company's leadership programme, *Evolve*, trains management at all levels, starting with senior management. Amongst other things, it focuses on how to manage teams as well as themselves.

Defining a professional: Know what is expected and deliver

According to Mary, a professional is someone that you do not need to chase or follow up. This suggests that the person is expected to work independently and deliver results and thus be responsible and disciplined. Time management is another critical aspect of professionalism identified by Mary. She feels that constantly being late, even if it is only five minutes, might cause others to question your dependability and reliability. She adds that business etiquette is important. Examples include greeting people in a formal manner, including your contact details in emails, and dressing appropriately. One should also avoid the use of vulgar or colloquial language. For Mary, professionalism involves engaging people in a respectful way.

Tanks – 'hold onto people like that for dear life'

Mary uses a very interesting word – 'tanks' – to describe her colleagues. While this is an obvious pun, it conveys how she perceives those with whom she works. The word conjures up a repository and carries connotations of strength. When applied to her colleagues, she sees them as embodying years of experience and knowledge. She believes that PPIR values people with rich experiential knowledge, noting that, 'we do succession planning around them'. This suggests that the insights they have gained over 20-30 years at the company will be transmitted to the next generation. Six years before a senior worker is expected to retire, he/she is given someone who shadows him/her.

Mary cites the example of an employee who retired after 40 years at the company and then wrote a book on his experiences at PPIR. She says that the book made such an important contribution that they used it to create another publication. For example, content on critical events such as when the plant was flooded was used as a guide to how to handle emergency situations in the future. Interestingly, Mary notes that the company archives report on engineering issues for future reference. Detailed reports are compiled on all problems that arise, including the solutions that worked and those that failed. When the company experiences any problem, engineers are expected to trouble shoot. One of their points of references is to check whether such a problem has a historical basis. The archives provide a very useful reference. Mary reports that the archives are kept in the library which also stocks other important material while diagrams and visual material are housed in a drawing room.

Fellowship

I am quite surprised by Mary's description of her work environment. While it is a hard engineering company, people are described as working as one team and in fellowship. She describes her fellow employees as people who will assist if something happens. In contrast, she describes the corporate world from whence she came as a rat-race in which people are busy chasing targets. At PPIR, employees are 'connected' and the company is 'people centred'.

7.2.2 SARAH: Academics are limited

Sarah graduated with an Honour's degree in Psychology from the former University of Durban-Westville. Her interest in research landed her an internship position with the Human Sciences Research Council (HSRC). She participated in an international project in Nottingham in the United Kingdom where she worked with the gay community and other minority groups on issues of reproductive health and HIV. She also lectured at the university during this period.

On returning to South Africa the following year, she re-joined the HSRC and worked on a number of action research projects. Thereafter, she joined eThekwini Municipality and worked on a number of community outreach programmes. This was followed by a stint with the EDCON and BIDVEST[7] groups as a training consultant. At BIDVEST, she worked with adult literacy groups. She later secured a position at Sun International as a training manager. Finally, she moved to PPIR and is employed in the Quality Assurance Unit where she takes care of employees' training needs.

Sarah's job requires in-depth knowledge of government legislation on training and skills development. It also involves developing systems to deliver quality training, and record keeping. All employees need training and development and their progress needs to be tracked. Sarah says that adding value is the most rewarding aspect of her job. This operates at two levels, namely, skilling people and saving the company money as the skills levy can be refunded. Sarah's job entails needs analysis to identify skills gaps in the workforce. This enables her to identify common weaknesses. The fact that other companies in the chemical industry follow a similar process means that scarce skills can be identified across the entire sector. Companies share information on either importing the requisite skills or building in-house training capacity.

They work the shift, they learn the skill According to Sarah, the company understands that students will not be fully prepared when they start work. She describes three ways in which the potential novice engineer can join the organisation, with each allowing for customised training. The first route is a learnership that is aimed at those who have just matriculated and have no training or tertiary education.

[7] EDCON and BIDVEST are listed on the Johannesburg Stock Exchange.

They join the company for a period of three years. In the first year, they enter a classroom and are exposed to a range of plant activities. Forty percent of the time is devoted to classroom activity and 60% to training on the shop floor. What they have learned theoretically is thus activated in the field. Sarah uses the example of a novice who is studying to be an operator in the field of chemical operations.

'They work the shift; they learn the skill' is how she describes the novice's interactions in the plant. The three-year stint is followed by a two-year internship, after which they become permanent employees as senior process technicians. During the internship, learning takes place exclusively in the plant. Interestingly, Sarah skirts the issue of how this qualification differs from UoTs' qualifications. She mentions, however, that PPIR does not employ technicians from outside. In other words, the internal feeder mechanism and inside training is the preferred option.

The company also uses an apprenticeship model to train novices, but this is mainly reserved for the trades which include instrumentation, electrician training and mechanical fitting. These novices undergo an intensive training period in which they spend 80% of their time in the field and 20% in the classroom. Apprentices graduate into permanent positions after three years as the training is very intensive. A trade-tested mentor is provided in the field to guide the practical training. The mentor keeps a logbook of the skills learned and rigorous assessment is the order of the day.

The company does not guarantee employment. Sarah indicates that this only occurs if there are vacancies: 'we can't over-employ because we train every year.' Thus, the company not only produces and refines petroleum products, but trains workers for employment in the petro-chemical sector. Students that enter one-year in-service training from UoTs are first oriented with regard to behaviour and safety issues for a week because these are crucial aspects of working in industry. The values of the company are also linked to the issue of safety. Critical amongst these is the need to follow instructions. Failure to do so can result in charges of insubordination.

Experiential training groups spend time with a Cognitive and Development Specialist focussing on issues that affect their performance in the company. Sarah says that they have 'time to reflect', as part of their learning at the workplace. On site, the learners are handed over to a mentor. The training includes monthly meetings with the mentor, who provides assessment feedback to the learner. A fourth stream of student intake occurs even before they finish school. Students with potential are identified at Grade 10 level and awarded bursaries to complete their schooling and tertiary qualifications. The company invites students to undertake vacation work as part of their experiential training and they are paid a stipend. Bursaries include tuition fees, accommodation, books and a laptop. According to Sarah,

these in-house trained students are preferred over outsiders for employment. However, she makes the point that taking on too many students exposes them to abuse; for example, in many companies, employees use students for menial tasks like making tea.

Building a pilot plant

According to Sarah, a critical aspect of community engagement is partnering with colleges and developing their infrastructure. In 2015, PPIR partnered with ComTech, a higher education institution in Umlazi that offers chemical operations learnerships to members of the community. The company crafted the college's syllabus and built a pilot plant so that students could gain practical experience. Staff offer lectures at the college and students visit the company in their first year of study.

Academics are limited

The company also creates opportunities for lecturers to update their knowledge of the latest technology used in industry. Sarah feels that there is a danger of lecturers becoming out of date when they rely on textbooks. By inviting them into the company, they are exposed to the latest ways of doing things which they can share with their students. Sarah feels that academics are limited in their knowledge as they tend to focus on conferences, workshops and academic journals. They thus lack practical knowledge. She cites the example of a lecturer who learns from his/her student who has undergone experiential training. The student shares information about the plant with the lecturer who has little knowledge of recent developments in industry. Sarah states that the lecturer will not be aware of certain knowledge if it is not found in a journal article or a conference paper. She is also of the view that companies will not reveal their 'trade secrets'. In other words, certain knowledge will not be disseminated in the public domain. One can only access it as an insider.

On the other hand, students are expected to have a basic understanding of the concepts in chemical engineering. For example, Sarah notes that a student in chemical operations should have knowledge of the concept of distillation. This should then be extended into a discussion on what distillation means in a chemical plant. In addition, they should be able to discuss the practical aspects of what they covered at university. This usually involves discussion of the challenges around developing a mini-plant. Students are expected to explain features of the plant or some of the challenges in constructing it. The idea behind this line of questioning is that the organisation can assess whether the student will be able to extrapolate his/her experiences or extend his/her knowledge on a larger scale.

Taking charge

Sarah identifies a number of soft skills that a novice should acquire. The first is independence. This is especially important for the graduate engineer who becomes a site lead. This means that he/she works without supervision and takes charge of a project. Sarah feels that this inculcates leadership qualities in

the graduate engineer. She also emphasises the need for teamwork skills. The organisation also emphasises listening skills and following instructions that are linked to ethics and safety. Employees at PPIR are expected to comply with the highest safety regulations. Inducted novices are first taught the basic rules, the most important of which are promoting safety at all times as PPIR's products can cause a great deal of destruction both on site and in the community that surrounds the plant. Employees contribute to community engagement by participating in various projects. They are encouraged to adopt projects, with the company providing funding on a rand for rand basis.

7.2.3 BALRAM: A badge that people like to wear

Balram is a senior chemical engineer in a managerial position. He has mentored Krish but maintains that mentorship is not something which can be formalised. As a manager, Balram has both academic and experiential qualifications. He graduated with a chemical engineering degree from the former University of Durban-Westville in 1998, and has worked at PPIR since then, starting out as a graduate engineer.

Balram describes his varied experience. He initially worked in the process unit, then proceeded to a bigger one that refines crude oil into products. He invokes images of complex equipment like cap crackers and separators to explain how products are transformed at molecular level to other products in highly complex processes. These experiences were preceded by his involvement in production engineering. The change in jobs gave him a better perspective on the plant's operations. The next level he proceeded to was plant unit manager and he currently holds the position of technical support manager.

For Balram, being a plant unit manager was most enjoyable because he felt unfettered and was able to work with diverse teams across disciplines. Responsibility for the entire project as well as for other disciplinary teams gave him a sense of fulfilment. He says, 'you achieve results for people'. Balram explains how the different teams come together. He uses the example of a problem on the plant distillation fences, where the engineering team works in collaboration with three other teams, namely, Technology, Production and HSE (Safety). The engineering team is responsible for maintaining the pressure outlet by inspecting for corrosion of the equipment, and checking its wall thickness. The overall manager must ensure that the regulations on pressure requirements are followed.

The technology team ensures that the correct fluids are placed within the distillation columns to produce the right results and products, while the production team monitors the equipment, opening valves, etc. The HSE team ensures that process safety is in place and the maintenance team is called out if anything

needs to be fixed. Balram explains that, as manager, he is responsible for all these teams and personnel. The technical details he provides reveal his passion and flair for management.

Closing the gap

In Balram's view, the first requirement of a graduate is the basic principles of chemical engineering knowledge, of which the key elements are the principles of process engineering design and operations. He breaks this down by drawing attention to the context in which the graduate will find him/herself, focussing on distillation, separation units and extraction units. He elaborates on the operations involving the fractionation column, the use of pumps and control valves and relief systems. This technical vocabulary stems from basic principles. Balram notes that the graduate will apply the knowledge that he/she gained at university.

Notwithstanding theoretical knowledge of basic principles, Balram believes that the graduate is still not fully trained for employment. He says that the knowledge graduates are taught in the company is not esoteric but builds on the basic principles they have learnt at university: 'We close the gap between the basics and what is actually required.' Balram feels that the graduate needs to get his/her hands dirty. By this he means technical competence. He advises: 'Put the overall on and walk around the plant.' He believes that one should be completely immersed in doing and acting in concert with machines and people. He further describes this as 'not coming to work with a tie.' This suggests that he does not believe that the engineer should be office bound. Balram sees himself as a senior person and therefore as an important source of knowledge. Other human resources as sources of knowledge include the external consultants he identifies. He talks about a service level agreement with subject matter specialists. He uses technology like Skype to keep in touch with such experts who are well known in industry and provide a vending service in terms of knowledge. They consult a range of human resources both within and outside the company.

Getting to know reality

Balram feels that WIL is a valuable component of the graduate's education, because he/she gets to 'know reality.' He cites the example of people who have come to undertake WIL but who have realised that it is not for them. On the other hand, many have thoroughly enjoyed it and have performed well even after returning to the company for employment. They receive a good foundation and they learn a lot about the company's processes and systems. He feels that, the more familiar one is with the systems in place, the better one's performance. Balram says that the company benefits from those who have previously been trained through WIL as they are better able to operate the computer systems, and the databases.

Balram feels that universities need to provide more practical experience for students to bridge the gap between theory and practice. He observes that when graduates are asked to design a pump, they struggle because they have never seen one. He speaks about the dearth of opportunities for students to undergo experiential training and feels that WIL should be customised in line with students' needs.

Passion to learn

Balram says that graduates should be flexible and have a passion to learn. He talks about having personal pride in desiring to do well. He emphasises the need for communication skills and humility, noting that one should not wear one's qualification on one's sleeve because there is a need to learn from others. This requires one to humble oneself as those from whom one can learn may be older and lack formal qualifications, but they possess a great deal of crucial knowledge.

Teamwork is another aspect that Balram highlights. He notes that the focus should not be on the individual, but the collective and how the team performed. He prefers to work collaboratively in a team. He cites the example of final-year students whose projects are assessed by their professors and industry representatives. Some students claim to have done the whole project on their own while others complain that some team members did not contribute. Balram feels that these groups should fail as they have not demonstrated teamwork. He believes passionately that it is the team that drives the organisation.

Defining a professional

According to Balram, being called a professionally qualified engineer did not make any difference to his career in the sense that it did not add any value. He says that he does not accord superior status to people with this professional qualification. He feels that some call themselves professionals, but they do not have exposure to the kind of knowledge that this requires. He believes that a professional is someone who has designed projects, can sign off on them and is legally liable for projects. A professional is not something standardised, but somebody who can design from scratch. There must be a sense of accountability and responsibility. He cites the example of a person who did not use the right quantity of steel in a building and problems occurred. Such a person can be held responsible. He talks about the title of professional as a 'badge that people like to wear.' Finally, he says that it is the people who work in a design environment for whom others have respect. It is these people who should be called professionals.

7.2.4 KRISH: Establishing a routine

On first impression, Krish appears highly cautious. He is concerned about the confidentiality of the company and the need to protect his anonymity. He says: 'I don't see the company confidentiality written anywhere here … my name will not be mentioned.' As a young graduate who is seeking to

make a good impression, Krish is concerned about protecting himself. His response to the first question regarding his early career is interesting. He couches it in a physical science metaphor of momentum and routine. He observes that good results emanate from establishing a routine which then gives one momentum. Establishing a routine is regarded as just as important as academic achievements. Krish notes that by third year, the academic aspect becomes more challenging. He describes the modules as more theoretical, scientific and abstract.

Krish's efforts in the company have been lauded and he received certificates and other awards for his outstanding work on a project. He says he feels immense pride and satisfaction with this recognition. He notes that he was acknowledged for creating a solution for clogged equipment. He identified a method to monitor preheated crude and its movement to a CD3 column. This enabled the technologists and engineers to ascertain which equipment needed to be cleaned. Krish describes this as a most satisfying accomplishment as it involved 40 different pieces of equipment.

Finished products

Krish feels that passion is a critical attribute of a graduate. Furthermore, he/she should be willing to work and to develop, and have a degree of competency. Krish also notes that misconceptions occur when people look to hire what they consider 'finished products'. It is assumed that graduates can slot into work without training. He believes that graduates still need to gain an understanding of 'operational procedures': 'We learn the theory, and the design and the concepts … but when you put that in practice there is a whole lot of operation and behind the scenes work that goes on and you need to learn those procedures.'

He draws attention to the intricacies of daily operations which are not taught at university. He also focuses on the skill of drawing all the disciplines together. This invokes an understanding of how the different knowledge 'dances' together. Krish adds that a professional must be confident and have teamwork, project management, and other general communication skills. He stresses the need to persevere, and to be diligent and consistent.

Who is a professional?

Krish defines a professional as someone who is an 'expert'. He qualifies this by saying that competence must be combined with experience. This is exemplified in the way in which the professional approaches problems. He/she draws on his/her knowledge and experience and there is no 'hesitancy'. Krish refers to experience in terms of projects that the person has handled and intimate understanding of the processes involved. The professional must have this knowledge as his/her disposal and must be able to recall it at any time – 'hey – I know how to approach this'.

Krish mentions that one need not be working in the engineering field to be registered as a professional engineer. He notes that some academics are registered as engineers as they do consulting work and are able to satisfy ECSA requirements in terms of achieving certain competencies and thereby acquiring professional status. Krish states that to be recognised formally as a professional engineer, one needs to prove one's competencies in different areas of knowledge. These include safety, process safety, fluid dynamics, and other competencies. He draws a distinction between someone with a paper qualification and someone who has demonstrated competence as a professional engineer.

Training

Krish is of the view that lifelong learning is essential and that one needs to constantly upgrade oneself. Aside from theoretical knowledge directly related to chemical engineering, he says that he reads business news, and information on fitness because, 'As an engineer, you have to be fit as well.' Krish believes that the knowledge that one gains at university does not remain with one forever; hence the need to revise it. Being a lifelong learner enables old concepts to remain relearnt and new concepts to be added to one's repertoire of knowledge. He highlights the need to read the right material and notes that one need not be enrolled for a formal course to gain knowledge. Learning can occur just by reading. He regards the MBA as a 'fancy degree' that people complete purely for the sake of having it on their CVs. Thus could suggest that he feels it has no value for an engineer. As part of their community engagement responsibilities, Krish and his colleagues have established a graduate engineering club where they engage in several community activities. These include feeding initiatives, book drives and other projects.

ECSA

Krish regards ECSA accreditation as critical for universities. He notes that ECSA benchmarks internationally with regard to the curriculum and engineering discipline and audits universities every five years. He describes the audits as a way of checking whether or not shortfalls have been addressed. At industry level, he states that ECSA encourages the placement of students in various industries. He also notes that ECSA certifies graduates to become professional engineers after they meet certain competencies and standards.

A degree is meant to cover everything

Krish believes that lecturers should have industry experience and industry personnel should have lecturing experience. He clarifies that lecturers cover more industries, rather than focusing on a few. However, he acknowledges that the curriculum is shaped in this way because it has to cater for students who will find employment in diverse fields like mining or the food industry: 'A degree is meant to cover

everything'. While electives focus on specific industries, he believes that lecturers with industry experience will benefit students as they will gain a more realistic perspective of the work environment. He observes that, when equipment fails, the problem it is not as easy to resolve as theory might suggest: 'You have to do this, and you have to compromise.' Here he refers to the messiness of the work site in terms of its unpredictability and the need to be prepared for such things. He feels that academics give the impression that 'everything is so ideal'.

Krish is quite diplomatic when quizzed about his lecturers and concedes that some academics do cover such issues, but this is not common practice. Another area that Krish believes needs to be addressed is the volume of work that the student is expected to cover. He compares his studies to other universities and remarks: 'Why go through such packed workloads when the same can be achieved by structuring the course slightly differently?' He blames the packed syllabus for high failure rates. At the same time, he concedes that all the theoretical information is important as 'it gives you a deeper understanding of everything'.

History repeats itself

Krish quotes the phrase – 'history repeats itself' to describe the kinds of problems that arise in the company and on site. The company policy is that a report must be written and filed on any problem that arises. It is available to all engineers as a source of information when dealing with problems. This historical data tracks previous events and how those problems were addressed and resolved. It should be consulted by those who suspect that a similar problem has occurred.

Human resources are another important source of knowledge. Senior staff members guide subordinates to problem solve. Other sources include the company library which houses guides and textbooks that focus on various processes in the industry. Krish says that he enjoys being mentored, especially by seniors who take time out from their busy schedules to assist: 'I enjoy the people aspect of it … especially when you get people who are willing to share knowledge'.

Krish also highlights the need to share knowledge in multi-disciplinary teams: 'you need to be consulting other disciplines for information. Projects include multi-disciplinary teams and information needs to be shared.' According to Krish, both the individual and the team are sources of knowledge. Krish says that people are one of the strongest assets when dealing with problems. However, when he is alone he tries to identify the issues by using root cause analysis. This involves exploring a number of theories one by one, testing and re-testing until the solution is found. He adds that, while at university, 95% of the solution is available; this is not the case at the workplace.

7.3 Section Three: Constructions of professional knowledge

7.3.1 Soft skills

Mary feels that a graduate should be independent, reliable and disciplined. Good communication skills are important. Adopting a formal, respectful tone in verbal and written communication is just as important. Sarah agrees that being independent is an important attribute of the engineering graduate as he/she will be required to work without supervision. She believes that this will inculcate leadership skills. She also highlights the need for teamwork, listening skills and following instructions as these are linked to the issue of safety.

Krish believes that a perfect graduate should be passionate, willing to work and to develop, and have a degree of competence. He concurs with Sarah that teamwork is critical, as engineers work in multidisciplinary teams. He feels that a graduate should be confident, have management and communication skills and should always persevere. Of the four participants, Balram most strongly expressed the importance of working in a team. He says he prefers to work collaboratively, rather than as an individual. He believes that it is all about how the team performed. Like the other participants, he stresses the importance of communication skills. He also feels that one must be able to humble oneself and be flexible in order to benefit from the knowledge of seniors. Both Balram and Krish feel that passion is an important attribute.

7.3.2 Work-integrated learning

According to Sarah, there are three ways one can join the organisation. The first is a learnership. These are people who have been selected by the company for training and who were previously unemployed. The second is those that have completed diplomas at UoTs and need to do a year's experiential training in order to graduate. The third stream is university students who study for an engineering degree. They are placed at the company during the vacation period over the four years. According to Sarah, the company prefers graduates who completed the four-year WIL programme. She also mentions that selecting too many students to train comes with risks and recalls students who were given menial tasks like making tea.

Balram feels that the WIL programme is a valuable part of the graduate's education as it enables him/her to experience 'reality'. He adds that it is a good way to determine whether or not one is suited to the chemical engineering stream. Like Sarah, he feels that the company benefits from students. Balram also believes that the WIL programme needs to be strengthened in order to bridge the gap between theory and practice. He cites the example of a young person who knows the theory relating to a pump, but has never seen one. He is of the view that the WIL programme should be customised in order to maximise its benefits for students.

7.3.3 Professionality and identities

Mary defines a professional as someone who is responsible and disciplined, works independently and delivers results. He/she engages everyone respectfully and conducts him/herself in a formal, dignified manner. This is reflected in his/her appearance and verbal and written communication. Above all, he/she must be cognisant of time as this will reflect dependability and reliability. Mary's understanding of a professional is echoed by Krish who views a professional as someone who is competent, backed up by experience. He/she must have knowledge at his/her fingertips, and have what he terms demonstrated competence. A professional shares knowledge with his/her team and should constantly update such knowledge.

Sarah agrees with Mary's notion of a professional as someone who is respectful, but he/she should also command respect and should be sought after for his/her knowledge. A professional also contributes to community projects and cares about the environment. For Sarah, professional knowledge entails basic understanding of chemical engineering knowledge; for example, knowledge of distillation processes. Balram also regards professional knowledge as comprising of knowledge of chemical operations, but feels that the professional must have practical experience. Like Mary, he feels that a professional must be accountable and responsible. However, he states that one should not wear one's professional qualification like a badge. He describes a professional as someone who is able to design plants and sign off on projects. He believes that these are the kind of professionals that are respected.

Sources of Knowledge

All four participants identified human resources as critical sources of knowledge in the workplace. The company library is also regarded as an important repository of knowledge as it houses internet facilities, guides and textbooks. Reports written by employees who have experience of specific problems at the plant are also archived in the library databases. From an organisational point of view, seniority is respected because of the knowledge associated with older, experienced workers. The older worker is a critical resource for younger staff members. Senior employees are respected by younger members of staff because of their knowledge and experience. According to Mary, PPIR's policy is to appoint a 'shadow' for a senior member who will retire in six years. The person shadowing the older employee is expected to acquire their skills and knowledge.

Unlike Mary, Sarah sees students as potential sources of knowledge. She feels that students who do a stint of experiential training return to the university with important knowledge that can inform lecturers of the latest trends at the workplace. She also mentions that although textbooks are sources of knowledge, they are limited in the sense that academic knowledge is fossilised by these textbooks as it is fixed in time. Given that Krish is a young employee, he reports that he enjoys the mentoring

relationship he shares with senior colleagues, especially when they take the time to explain processes that are not found in textbooks. He also enjoys participating in multi-disciplinary teams as he learns a great deal from the diverse opinions expressed. On the other hand, Balram sees himself as a senior staff member and therefore as an important repository of knowledge.

7.3.4 Regulation

The manager, Mary and Sarah the trainer share similar views with regard to the importance of developing strong linkages between government, industry and university and other stakeholders. For Mary, building on these relationships is very important, particularly in fulfilling ECSA's requirement's. Mary also feels that strengthening the linkage between industry and university will address the drop in standards at university by intensifying the WIL programme. Sarah, the trainer is the company's designated person to identify various government legislation pertaining to education and training of graduates. She ensures that the company adheres to ECSA requirements. It appears that maintaining strategic relationships between relevant stakeholders is a key objective of management at PPIR.

Novice and mentor views regarding regulation are strikingly similar with regard to regulation. Both Balram (Novice) and Krish (Mentor) share convergent views regarding ECSA's role at universities and in industry. At university level, they highlight ECSA's role in programme accreditation as well as in other auditing and benchmarking roles. At industry level, both are keenly aware of ECSA's role in certifying graduates to become professional engineers. Balram views diverge from the rest with regard to recognising ECSA in certifying professional engineers. Balram appears not to have faith in Engineers who wear their certification as a badge, instead he says he respects those who are able to sign off designs meaning he is respectful of engineers who have practical competency rather than a paper qualification.

Synthesis

This chapter comprised four sections. In the first section, I sketched a profile of Prometheus Petroleum Industrial Refining (PPIR). Then I provided four participant narratives which emerged from the hierarchical positions they occupied in the plant. These narratives included contributions from the Dean, a curriculum designer, mentor and a newly qualified graduate. Finally, I brought participant conceptions of professional knowledge in dialogue with each other.

CHAPTER EIGHT

A CROSS-CASE STUDY OF ACADEMIA AND INDUSTRY'S CONCEPTIONS OF PROFESSIONAL KNOWLEDGE

Orientation

The previous chapter presented and analysed the data gathered at the second industrial site, PPIR. It explored the genesis of the company, its focus on training and its product offerings. The four participants' narratives were presented, from which various themes on professional knowledge emerged. The chapter concluded with a comparison of conceptions of professional knowledge among participants at different levels of the organisational hierarchy.

This chapter presents a cross-case study of academia and industry's conceptions of professional knowledge. It is divided into four sections. The first section explores conceptions of soft skills across industry and academia. Section two focuses on conceptions of WIL while in section three, I show how professional identity is linked to conceptions of professional knowledge. Section four explores regulatory bodies' influence on conceptions of professional knowledge.

8.1 Section one: Soft skills

8.1.1 Academia

8.1.1.1 Comparing conceptions of soft skills across levels in the hierarchy of the academic institutions

Deans' perspectives

The Deans at both UoTs are intensely aware of the need to prepare students not only for academic literacy and life at the university in general but also to ensure that they are employable. This is not surprising given Technikons' history and their close relationships with industry. The Deans also express similar views on the importance of communication skills. This could be in response to industry complaints about ill-equipped students. The Dean from AUT acknowledges that this has been a weakness in their syllabi and notes that they are being redesigned to accommodate such skills. However, the evidence from the other participants suggests that while this is an avowed objective, it is not being activated at the level of teaching. Instead, core subjects like Mathematics and Physical Science take priority. In contrast, the SUT Dean believes that soft skills should be emphasized before disciplinary knowledge. This suggests that well-rounded development is the objective at SUT, while at AUT, the emphasis is on students' employability. Soft skills are also associated with professionalism – the Dean at SUT believes that meticulousness and accuracy are hallmarks of a professional and that these qualities

need to be nurtured in students. The student is viewed as an agent of change and therefore leadership and communication skills are prioritised. The SUT Dean highlights that writing skills, especially the writing of technical reports, are crucial for the future engineer. He emphasises the need for students to learn how to summarise and the need for oral communication skills as graduates will engage with a range of stakeholders. While AUT prepares students for the community of engineers at work, the SUT Dean aims to develop individual critical thinking skills.

Curriculum designer perspectives

Both the curriculum designers identify students' lack of confidence as a problem. For Chaku, this is reflected in students' reluctance to take the initiative and their desire for teaching material that will enable them to pass. He blames the type of teaching they experienced in the past, which produced students that are docile and subservient. He also cites this as a reason for their inability to transition from technicians to engineers. For Freddy, lack of confidence is reflected in students' lack of perseverance. He also talks of students showing a lack of respect which he views as important for teamwork. He adds that students lack clarity in their presentation skills and notes that an ill-conceived report can cost the company millions.

Mentor perspectives

The views of the mentors from AUT and SUT converge when it comes to the soft skills of communication. They agree that oral presentation skills and the writing of technical reports are important. However, they have different perspectives when it comes to how to teach these skills. Chameli feels that weaker students need to be identified and referred to the writing centre for remedial action. In contrast, Jungli Billi is of the view that students should be given opportunities to practice their writing and speaking skills. While it is debatable which method is more effective, one perspective takes a deficit view and sees the need to act on students' weakness while the other empowers students by enabling them to grow through making mistakes. Jungli Billi believes that the system needs to change to accommodate students; she feels the teaching of soft skills should not be lumped in one semester. Given that students and lecturers do not always regard the teaching of soft skills as critical, lecturers need to be constantly motivated to take such teaching seriously.

Novice perspectives

The soft skills of self-learning, developing independence and self-discipline are emphasized by the novices at AUT and SUT. They also identify time management and meeting deadlines as important. These skills would obviously be important to those who are young and inexperienced as they find themselves in a new environment where deadlines are set and they need to organise themselves in the face of the bewildering range of tasks assigned to them. At industry level, there is no one to assist;

hence the need to develop independence, exercise self-discipline and be responsible for one's own learning. The novices also agree on the importance of teaching oral presentation and report writing skills. Don offers mature insight when he comments that the teaching of soft skills is compromised by the way in which the syllabus is structured and loaded with other more priority subjects.

8.1.1.2 Comparing SUT and AUT

With regard to soft skills, both UoTs recognise that the acquisition of communication skills is important for students, but the way in which this is activated differs across the institutions. Both institutions also agree that oral presentations and technical report writing are critical skills. They also view time management and meeting deadlines as important to engineers. Other mutually agreed on important attributes are self-learning, developing independence and self-discipline. At both institutions, the focus is preparing students for employability. Both agree that students lack self-confidence.

Differences exist between the two institutions in terms of how communication skills are activated. AUT tends to hold a deficit view of students as lacking writing skills and therefore sends them for remedial classes while SUT finds fault with the system and acknowledges that students require more practice in class. For AUT, students' lack of confidence emanates from the kind of teaching they experienced previously, which induced a sense of subservience and docility. At SUT, lack of confidence is reflected in students' inability to persevere. While both institutions prepare students for employability, SUT sees the need for engineers to be well-rounded employees and agents of change; hence, leadership skills are emphasized. AUT, on the other hand, prepares students to acculturate to the community of engineers and the workplace.

8.1.2 Industry

8.1.2.1 Comparing conceptions of soft skills across levels in the hierarchy of the organisations within industry

Manager perspectives

Both managers within industry regard soft skills as critical to the smooth running of engineering workplaces. They agree that soft skills provide opportunities for employees to influence both external and internal stakeholders. While both view soft skills as critical for the graduate, Mary links them to professionalism while Nemo feels that such skills are required for problem solving.

Mary emphasizes the need to convey a professional image through the way one speaks, dresses and writes. While these seem to be outward trappings, for Mary, projecting a positive image is very important. Communication skills are seen as essential to build good relationships with outside

stakeholders, that is, the community affected by the site and the activists in the precinct. Problem solving at this level involves putting out fires that can give the company a bad name; hence, a lot of money is channelled in this direction. She also emphasises conflict management skills, time management and community projects like building schools, laboratories and other facilities in the communities involved and offering bursaries to students from these communities.

Given that APIP is part of the service industry, Nemo feels that employees must have a clear understanding of the client's problem. This is often messy in the Schön swamp sense as problems in the engineering context are not easily defined or clear. This can be attributed to clients' lack of knowledge of where the problem lies. For Nemo, soft skills, particularly listening skills enable employees to attend to clients' needs and to clearly determine the nature of the problem. Understanding the person and the context of the problem situation provides vital clues as to how the issue can be addressed. One can only apply theoretical knowledge to conceptualise the problem and offer solutions once the problem is clearly understood.

Since engineering problem-solving involves interactions with a host of stakeholders, communication is critical. Problems with regard to understanding cost the company in terms of time and money. Listening skills are, however, also linked to following instructions. Nemo states that good communication skills involve engaging with all stakeholders to improve one's chances of learning. This needs to be combined with humility and willingness to learn. Nemo also warns against arrogance by newcomers. Here he seems to suggest that the experiential and tacit knowledge that one gains from peers and one's superiors are equally important.

Mary describes her colleagues as tanks of knowledge and highlights the importance of shadowing these experienced workers in order to ensure that their knowledge is not lost. This points to the importance of tacit knowledge. Both managers stress the need for compliance. For Mary, the graduate must be self-disciplined, while Nemo highlights that employees must be able to follow instructions. Interestingly, writing is associated with professionalism in that it must be accurate, and polite and not cause offence. The managers also agree on the importance of leadership skills and being tactful.

In summary, according to these managers, the soft skills that are valued in industry are independence, and being responsible, disciplined, and tactful as well as a range of communication skills associated with reading, writing, listening and speaking.

Trainer perspectives

The trainers at PPIR and APIP both focus on oral communication skills. For PPIR, listening and following instructions are critical, presumably to ensure that safety standards are met in a risky industrial environment. In contrast, APIP foregrounds the communication skills of presenting, persuading and debating. The difference is that one is active while the other is passive. It is therefore not surprising that APIP wants graduates to train other graduates to share their technical skills, while PPIR would like to see graduates who are independent and who can work with less supervision. Aside from the other communication skills, PPIR highlights the importance of report writing and summarising while the APIP trainer does not mention writing skills, but highlights the need to develop leadership skills.

Mentor perspectives

Both mentors emphasize teamwork as a vital skill for graduates as they will be working in multi-disciplinary teams. They also agree on the need to develop a sense of confidence. PPIR feels that a stint at the company will promote confidence, while APIP believes that students are spoon-fed and that this could account for their lack of confidence. APIP also feels that students do not read and this hampers their ability to locate sources of knowledge. APIP stresses the need for project management skills as well as perseverance.

Novice perspectives

The notices also emphasize the need for teamwork skills. Vernes and Balram state that the ability to communicate is critical when dealing with projects and multi-disciplinary teams. Balram recognizes people as critical sources of knowledge in projects and values the attributes of perseverance, diligence and consistency. The novices also agree that students lack commitment and willingness to work hard.

8.1.2.2 Comparing APIP and PPIR

Convergence

Staff in both companies see the need for employees to be compliant. For PPIR, the graduate must be self-disciplined, while for APIP, he/she must be able to follow instructions. Both stress the importance of leadership skills, the development of strategic skills, and communication skills, particularly oral communication. Writing skills that are emphasized are report writing and summarising. However, PPIR's notion of communication skills takes a more passive mode as in following instructions, while APIP highlights presenting, persuading and debating that are more active in orientation and function. Both organizations point to the need for teamwork and that employees should be able to work in multidisciplinary teams.

Both companies regard confidence as a critical attribute and agree that students lack confidence. For APIP, this stems from too much spoon-feeding by lecturers while PPIR emphasizes WIL to instil confidence. PPIR also feels that students lack reading skills and this hampers them in locating critical resources. Both organisations feel that graduates lack a sense of commitment and willingness to work hard.

Divergence

For APIP, the purpose of soft skills is to engage in problem solving. This is achieved by ensuring that the nature of the problem experienced by external clients is clearly understood. PPIR feels that soft skills are required to build the company image and one's own sense of professionalism. For the manager, this is reflected in how one dresses, and one's oral and written communication. Communication is used to build relationships with communities affected by the pollution generated by the plant. Problem solving and communication are used to put out fires in these communities when any issue risks tarnishing the company's image. Time management and conflict resolution skills are also emphasized. At APIP, listening skills are required to cater for clients' needs as this is a service industry. In this company, communication skills are used to increase opportunities to learn from other people. Hence the need to humble oneself.

8.1.3 Soft skills: Comparing academia and industry

Convergence

The UoTs feel that soft skills broadly prepare students to deal with challenges at the university and in society and to acclimatize to the world of work. For industry, soft skills enable the graduate to problem solve – a key outcome of engineering activity. The sectors agree that communication, teamwork, leadership skills, independence, and sense of confidence are important soft skills, with communication regarded as critical.

The ability to accurately report findings is considered important in industry as well as one's ability to summarise. This is due to the fact that, in the world of work, time and resources cost money. Oral presentation and writing skills are critical in ensuring that clients' problems are well understood and interpreted correctly. Both sectors strongly agree that technical report writing skills should be emphasized. Teamwork is considered an important skill as personnel in engineering workplaces operate in multidisciplinary teams to solve problems. This skill also underscores the importance of good communication skills.

Leadership skills are linked to the notion of teamwork and both sectors feel that students need to acquire such skills. They also highlight the need to develop graduates who are independent and can work

without supervision. It is therefore not surprising that the attribute of self-confidence is identified as lacking in students.

Divergence

The UoTs regard creative and critical thinking as an important skill to be taught to students. The world of work associates professionalism with the soft skills of communication. UoTs feel that students lack confidence because of the manner in which they are taught particularly when they are spoon-fed, resulting in docile and subservient behavior. The participants from industry highlight the need for leadership skills in order to be able to manage projects, while at universities it is about students managing change.

For Rahul, the university is a place where critical thinking should flourish. This includes questioning long-held assumptions and ways of doing doings – hence, he feels that young graduates have the potential to change the status quo. It calls for the development of leadership skills. In contrast, the industry players feel that novices should be socialized into adopting a quiescent nature and being respectful and obedient. Mary also highlights the need to be disciplined – one should accept the way things are done at the workplace and not question it.

The UoTs note that the written report is an important source of knowledge as it forms part of institutional memory. These reports are archived and referred to whenever a problem arises in the company. Freddy states that for every problem encountered, a report needs to be written. However, the lack of report writing skills points to deficits among students in terms of a lack of initiative, confidence and perseverance in searching for information to solve problems. There seems to be a contradiction here in that debating skills are an important part of an employee's repertoire of skills when challenging the status quo. Given that industry expects workers to be compliant, the emphasis on this soft skill is surprising. However, when one considers its role in solving engineering problems, it is reasonable to expect of an engineer in training. Deploying such a skill does not mean that the worker is not toeing the line.

Industry personnel do not subscribe to a deficit view of students and offer a more robust description of communication skills and attributes that they consider important. For example, students are expected to know how to debate, negotiate, summarise, manage strategically, present and listen attentively. Debate is an important aspect of problem solving in engineering. This is presumably with members of the team or engaging with the supervisor to describe and evaluate the problem and its solution. The ability to work in teams is also emphasized. Co-workers are expected to share knowledge unselfishly. This notion of working in teams and sharing knowledge in communities of practice seems to contrast with

how universities prepare students to work and think independently. Industry's emphasis on listening skills and following instructions is important as safety is a major issue at the workplace. Accidents can cost time and money; hence the focus on ensuring that novices are acculturated into following instructions as well as the importance of listening skills.

8.2 Section two: Work-integrated learning

8.2.1 Academia

8.2.1.1 Comparing conceptions of WIL across levels in the hierarchy of the academic institutions

Deans' perspectives

Fundamental differences are apparent in the way in which the deans from the two UoTs view WIL. The SUT dean describes WIL as highly beneficial to both lecturers and students, while the dean at AUT regards it as a failure. The SUT dean comments that academic staff who visit sites are up to speed on new instrumentation and processes in industry, while students are exposed to the scale of instrumentation and how to use it.

The dean at AUT views the WIL programme as a dismal failure for both staff and students. Firstly, not all students get the chance to undergo experiential training (WIL). The SUT dean agrees on this point and notes that when the economy is booming, industry provides more spaces for students. The dean at AUT feels that many students are simply used as low level employees or assigned menial tasks like making tea. In addition, students are expected to write a number of reports based on the projects assigned to them. This overload causes a great deal of frustration for students as well as lecturers. The dean at AUT therefore believes that the responsibility for specialist training should lie in the hands of industry. The SUT dean suggests that universities should train supervisors from industry with regard to assessment procedures, and other general teaching skills.

Curriculum designer perspectives

Chaku believes that industry does not value its own role in shaping students' learning experiences because students are treated as employees. The implication is that they may believe that training students is the responsibility of universities. The lack of responses from supervisors with regard to inputs for projects that students need to complete further indicates their lack of interest in WIL. In contrast, Freddy feels that it is critical that an internship is completed as it complements what is learnt in class. He believes that professional knowledge requires inputs from both universities and industry as it comprises theoretical and practical knowledge.

Both participants agree that students receive inadequate training in industry. For the curriculum designer at AUT, the main cause is the supervisors' workload. Previously there were many engineers who could act as supervisors but this situation has changed and too many students are attached to one supervisor. Freddy from SUT blames the poor quality of training on the inadequate time devoted to WIL. The current period of six months is regarded as too short. Freddy offers many models for a WIL structure drawing on his Congolese and international experience. Some universities offer a WIL programme multiple times during the course of a degree while others offer it after the degree is completed. Students that undertake WIL after they have completed the syllabus will have a better understanding of the theory-practice dynamic than those who perform WIL during their degree.

The two curriculum designers identify a range of problems that students experience during their WIL at industry sites. For AUT, the main issues are that students are treated as low-level employees and that many students cannot access WIL training. Students that do not complete this part of their programme cannot graduate. The SUT participant notes that WIL is not in sync with the job students will get after graduation. Furthermore, little theoretical knowledge is used in practice-based WIL. The syllabi at universities do not sufficiently cover the knowledge that is applicable to WIL and industry is not providing theoretical know how. The onus falls on the university as industry expects students to have knowledge about appropriate tasks. While the university has an elaborate WIL manual, this does not cover how supervisors will assist in teaching the requisite skills. Concerns were also raised that WIL does not cover all aspects of the chemical engineering programme.

Mentors

The mentors from both UoTs regard WIL as important in preparing graduates for the workplace. For the mentor from SUT, it gives students a realistic view of the workplace context in terms of concept and size. The knowledge gained is also very useful to students. For the AUT mentor, the experience is necessary and valuable as the graduate is able to activate the theoretical knowledge gained at university and ultimately to graduate. Both agree that there should be stronger ties between industry and the institution.

While the mentor from AUT seems highly enthusiastic when talking about the WIL programme, the SUT mentor appears subdued. Further probing revealed the reasons. The mentor from AUT is intimately linked to the WIL programme and was instrumental in writing the manual. Her passion for WIL was evident in her innovative classes with students in order to reflect on WIL experiences. The mentor from SUT seems uninterested in WIL. She gives the impression that industry is non-compliant in their partnerships with the institution with regard to WIL and that there is a need for a more rigid structure for student training. One reason for the stronger relationship with industry at AUT is that industry is

incentivised to forge a relationship with the university. The WIL programme is written up as a learnership programme. A learnership programme means that the company will be able to solicit funding from the government for its training. However, such partnerships require strong channels of communication and much goodwill between the company and the institution. Chameli notes that WIL is highly structured and comprehensive.

Novices

The novices shared both positive and negative impressions of WIL. On a positive note, both agree that it familiarises the graduate with life in the plant and its context and equipment. This will reduce his/her anxiety in a new environment. However, the novices note that there is wide variation in the standard of training offered to students – from highly formalised and structured training programmes to situations where students are exploited as menial labour. Don is frank about mentor laziness at industry level while Runli is silent on this issue except when she cites her traumatic experience at the hands of one of her mentors.

Runli and Don agree that WIL may promote students' employability. Exposure to the work context provides opportunities for students to display their learning and flair and increases their chances of employability by becoming visible. Runli is concerned about funding and incentives for student training. She suggests a three-way partnership among the university, industry and government where the government provides tax incentives for companies and organisations that offer such training.

8.2.1.2 Comparing SUT and AUT

Convergence

The participants from both UoTs believe that WIL is important in preparing students for future employment. Students and staff become familiar with the environment of the plant in terms of concepts and equipment. Staff benefit as they remain abreast of the latest technology in industry. Students become familiar with the people and processes in the workplace context. Both institutions also believe that WIL is essential in activating theoretical knowledge. AUT participants attribute this to supervisors' heavy workload and note that the state of the economy and the drive for profit means that there are fewer staff to train students. The SUT participants feel that the way in which WIL is structured is problematic. A new model is required as well as more commitment from industry. It was also noted that there are wide variations in WIL experiences, ranging from students being exposed to sophisticated programmes to exploitation for menial tasks.

Divergence

For some, WIL has failed as it exploits students and not all students participate in WIL programmes. The two UoTs have different relationships with industry. AUT has an incentivised programme in the form of a learnership which seems to encourage industry to support the training of students. SUT has a poor relationship with industry. Staff in industry are regarded as unwilling to assist and lazy, and do not acknowledge their critical role in training. Industry feels that their role is to train specialists, while the university should train supervisors. Finally, SUT feels that the government should play a more robust role as the third party in WIL.

8.2.2 Industry

8.2.2.1 Comparing conceptions of WIL across levels in the hierarchy of the organisations within industry

Manager perspectives

Both managers feel that there should be closer collaboration between industry and universities and that existing partnerships should be strengthened. Mary calls for big players like the government and regulatory bodies to be part of such partnerships. There is also the shared belief that inadequate time is allocated to WIL. Mary feels that students should be exposed to the workplace from their first year of study, while Nemo has customised WIL training by extending it by a year. Students benefit as they are able to graduate after a year's WIL in industry, but will return to complete the extra year required.

Trainer perspectives

For the trainer at PPIR, Sarah, learning in the WIL programme involves "doing the shift and learning the skill." Although she talks about a period of reflection with a Cognitive Officer, this is presumably to help the student to assimilate into the company. In contrast, the trainer at APIP understands learning as more than simply technical competence. He says it should include interaction with a range of internal and external stakeholders as well as familiarity with the company's systems.

Both trainers agree on the need for compliance on the part of students, but have different conceptions of what this entails. For PPIR, compliance is about following instructions and behaving appropriately as well as adhering to the values of the company. Compliance for APIP means that the student is exposed to the real world consequences of their actions. As such, problem solving includes ensuring that by-laws are followed with regard to how chemicals outflows may impact the environment.

The APIP trainer calls for the training programme to be extended as well as more practical applications of the theoretical concepts learnt at university at the company rather than in university laboratories.

However, no details are provided as to how this process would unfold. PPIR seems content with the status quo with regard to WIL.

Mentor perspectives

There is convergence in the mentors' views on WIL in three respects, namely, the beneficiaries of the WIL programme, regarding WIL as a slice of reality, and the need for customisation of the WIL programme. Both mentors regard WIL as important to the student's development. Balram considers the organisation as a beneficiary because a WIL graduate who is employed by the company does not need to be retrained. In terms of WIL being a slice of reality, they use the examples of pumps that students see in textbooks and students coming in contact with basic equipment. Finally, the mentors call for WIL to be customised.

Novice perspectives

Employability was raised by both novices in their narratives regarding the WIL programme. This is understandable as obtaining a permanent job is the next stage of transition for students. The novice at APIP notes that WIL provides opportunities to locate jobs within the company as the student already has a foot in the door. However, Vernes asserts that unemployment increases when some students cannot secure WIL spaces before they complete their studies, as they will not graduate. For Krish, preparation for employment meant being mentally ready to market oneself. Fortunately, he found employment in the same company.

Both novices comment on the excitement of seeing engineering concepts come to life in the workplace, suggesting that their theoretical orientation at university was very relevant. Although Krish found working in the new environment pleasant and the people very friendly, he was surprised at the vast difference between seeing things in textbooks and real life processes at the workplace. Vernes also found employment in the company where he completed his WIL training. He worked as an operator and over time quickly became bored.

8.2.2.2 Comparing APIP and PPIR

Convergence

Convergence between APIP and PPIR is built around three core issues, namely, beneficiaries of WIL, mirroring reality and customisation of training. It is very possible that a student who receives WIL training will be employed by the same company because he/she has relevant practical knowledge. The company that hires the student saves time and money as the student has already been trained. Exposing students to the company's equipment, processes and people enables them to be acculturated into the

workplace context. This slice of reality is critical for student development. However, the participants agree that the structure of WIL needs to change, with APIP stating that it should be extended by a year while PPIR feels that it should start from the first year of study.

Divergence

For PPIR, learning involves mastering a skill or developing competence while for APIP it is about interacting with stakeholders and assimilating into the company. Compliance also means different things. For PPIR it refers to following instructions, behaving appropriately and adhering to the values of the company while for APIP is it about complying with by-laws.

8.2.3 WIL: Comparing academia and industry

Convergence

Both sectors agree that WIL provides opportunities for graduates in terms of employability and employment. Students and university staff benefit from the programme as they become familiar with the technology and processes involved. For the student this holds them in good stead for future employment, i.e., it makes them market ready. The WIL programme also facilitates acculturation of the student into the workplace context. Some companies offer jobs to graduates that show promise. In this sense, having a foot in the door is advantageous. There is also agreement that WIL activates the theoretical knowledge provided at UoTs and that the level of training and exposure is inadequate. Both sectors call for greater collaboration between all stakeholders, including government.

Divergence

There are divergent views on how WIL programmes should be structured, with some feeling that the programme should be extended by a year and others stating that it should start from the first year of study. Limited training is blamed on poor industry participation and the packed curriculum.

8.3 Section three: Professional knowledge and identity

8.3.1 Academia

8.3.1.1 Comparing the link between professional identity and conceptions of professional knowledge across levels in the hierarchy of the academic institutions

Manager perspectives

The Deans at the UoTs agree that professional engineers should have basic theoretical knowledge in science and mathematics and be able to apply this knowledge. Competency and proficiency are also important. A professional is also viewed as a leader who oversees the completion of projects from

beginning to end. He/she embodies independence and has a sense of responsibility. These skills and attitudes are complemented by good communication skills. The Dean at SUT feels that a professional engineer should be well rounded and not only knowledgeable about the sciences. He/she should also be exposed to philosophy and the arts. He also sees the professional as a creative thinker and innovator.

Trainer perspectives

For both UOT trainers, a professional does not only have technical or engineering knowledge, but also focuses on the responsibilities of being a good citizen. For the AUT trainer, he/she must be aware of social issues and contribute to humanity in different ways. The SUT trainer sees the professional as a problem solver with the ability to apply his/her theoretical knowledge and care for the environment.

Mentor perspective

Both the mentors at the UoTs associate a professional with ECSA registration and competence in the 11 outcomes outlined by ECSA. They also feel that the professional should be able to apply fundamental knowledge in the real world. Furthermore, their work should not negatively impact the community as they are bound by an ethical code.

Novice perspectives

The novices at the UoTs also associate professionalism with being certified by the regulatory body, ECSA. Both also agree that professionals must comply with the ethical code of practice. A professional has a good understanding of key chemical engineering concepts and can apply them in real-life situations.

8.3.1.2 Comparing SUT and AUT

There are three main areas around which the UoTs converge in term of professional knowledge and identity. The first is that a professional must have fundamental core knowledge of Maths and Physics and must be confident in applying such theoretical knowledge. Secondly, professionals exhibit several attitudes and characteristics. He/she should be disciplined, independent, a leader, reliable and responsible. The professional also needs to be able to communicate with all stakeholders. The third aspect is that the professional needs to be a problem solver and his/her solutions must not negatively impact the environment or people. A professional is also associated with ECSA registration. The UoTs' views differ when it comes to the type of knowledge a professional ought to have, with SUT calling for a more well-rounded engineer and for the curriculum to make space for philosophy and the arts.

8.3.2 Industry

8.3.2.1 Comparing the link between professional identity and conceptions of professional knowledge across levels in the hierarchy of the organisations within industry

Manager perspectives

For both managers, professional identity is tied to notions of competence, a sense of responsibility, and appearance and interpersonal behaviour. This involves speaking respectfully and writing using business etiquette. The professional must know what is expected and be able to deliver; in other words, be competent to carry out the project and stay with it until completion, working without supervision and being responsible. Time management is also important. The managers agree that engineering relates to problem solving. For Mary, resolving the problem is important, while Nemo stresses that identifying the correct problem is an art that a professional has mastered. In this regard, he stresses the importance of communication, specifically listening skills in order to correctly identify the problem under investigation. He/she must have basic engineering knowledge and be an expert.

Trainer perspectives

For the trainers in industry, the title of professional is equivalent to being signed off by ECSA that one is competent to do the job and that the environment will be safe. For the trainer at PPIR, it is important for the professional to use technical knowledge to enhance production and efficiency, and thus increase profits. The APIP trainer feels that the professional should be unselfish and share his/her expertise with team members. He/she should also be courteous and not arrogant.

Mentor perspectives

The industry mentors state that ECSA defines what a professional is and this is associated with competence, particularly in the 11 outcomes. The APIP mentor feels that a professional must be able to interact with all stakeholders and see the bigger picture, ensuring that people and the environment are safe. For the mentor at PPIR, a professional must be able to sign off drawings and will be the person who is legally accountable if there are any mishaps due to the designs being flawed. The professional is a person who has earned respect due to their knowledge and experience, rather than their formal qualifications.

Novice perspectives

The industry novices associate a professional engineer with someone who is technically competent. This is in sync with ECSA's 11 outcomes. For the novice at APIP, a professional sees the bigger picture in that any project will have effects on the environment and consumers. He/she needs the skills to communicate with all stakeholders, and is a problem solver and a team player with multidisciplinary

skills. For Krish from PPIR, the professional must have proven competencies in a number of engineering fields, and not simply paper qualifications. He/she must display a level of confidence in that there should be no hesitancy in problem solving or projects since he/she has the requisite knowledge on which to draw.

8.3.2.2 Comparing APIP and PPIR

Convergence

Notions of professionalism in both companies are based on issues relating to competency. Staff from APIP suggest competence in different knowledge areas. They also cite the ability to draw the connection between theory and practice, describing it as an art form. For both companies, a professional is someone with more than just a paper qualification. The professional is viewed as a person with knowledge and experience. The industry players identified the following attributes of a professional: being independent, reliable, confident, and disciplined. Time management is also considered important. Being a professional is also about ensuring that projects do not harm the environment. For APIP, professionalism is reflected in one's appearance and conduct, and oral and written communication.

Divergence

For APIP, it is important to be a team player and be unselfish with technical expertise. It was also noted that the professional should make the world a safer place. For PPIR, technical knowledge must be used to enhance production and efficacy and make a profit.

8.3.3 Professional knowledge and identity: Comparing academia and industry

Convergence

Although understanding of what professional identity is varies across academia and industry, there are many points of convergence. These cluster around three main themes: professional knowledge, personal attributes and the issue of ethics. For UoTs, professionals use the theoretical knowledge gained at university to carry out operations in the field. Industry's understanding of professional use of knowledge is engaging with industrial processes using theoretical knowledge to trouble shoot. The personal attributes universities value, include critical and creative thinking. Industry on the other hand, feels that engineers should be compliant and follow instructions to ensure safety. Other qualities that are valued by both sectors include communication, being a team player, being responsible and leadership.

Divergence

While academia and industry agree that ECSA engages with ethics in its 11 outcomes, the way that they construe it is different. For industry, especially APIP, this is a critical issue as its products pollute the immediate environment. Ethics has thus become a rallying point to ensure that relationships are

developed with all stakeholders in the immediate environment that are affected by the pollution in order to stave off possible activist action.

8.4 Section four: The influence of regulatory bodies

8.4.1 Academia

8.4.1.1 Comparing views on how regulatory bodies influence conceptions of professional knowledge across levels in the hierarchy of the academic institutions

Manager perspectives

The managers had both positive and negative views on this issue. The AUT manager feels that ECSA accreditation is critical in maintaining standards, at both local and international level. However, it becomes negative when it is too prescriptive, particularly when academics become bogged down in administrative processes instead of concentrating on teaching. Rahul feels that ECSA's role is positive as firstly, it ensures that the programme is relevant and of high quality so that students can find employment when they graduate and secondly, it ensures that the environment is protected by including ethics in engineering programmes.

Curriculum designer perspectives

Both the curriculum designers state that ECSA defines the basic requirements of the chemical engineering curriculum. While SUT representative, Freddy regards ECSA as prescriptive, Chaku the AUT representative feels that ECSA is broadening the role of the chemical engineer by not only focusing on technical knowledge, but also including social issues. His defence of ECSA could be due to the fact that he sits on ECSA accreditation panels. He also blames the Department of Education for pushing the research agenda at universities; this has resulted in the chemical engineering programmes ranging from 'cheese to chalk'.

Mentor perspectives

The mentors at the UoTs agree that ECSA impacts registration, accreditation and standards; curriculum construction and knowledge areas, and ethical issues. The mentor at AUT states that she adheres to ECSA requirements with regard to syllabus construction. For the mentor at SUT, ECSA involvement at the syllabus level conveys the total impact the regulatory body has on engineering programmes. For the SUT mentor, ethical rules of behaviour as engineers means simply accepting the guidelines provided by ECSA. For Chameli, on the other hand, the issue of ethics is intimately linked to how engineers should be trained to care for the environment. An important issue that Jungli Billi raises is the

gatekeeping role played by ECSA in deciding who can practice engineering and who can make decisions, which are linked to issues of power.

Novice perspectives

The novices at the two UoTs agree that ECSA influences curriculum construction and pedagogy. Their viewpoints differ on accreditation and meeting standards. The novice at AUT focuses on the macro issue of professional registration of engineers and technologists, claiming that the process is not well marketed. Unlike Don, she demonstrates awareness of the Department of Education's influence on the regulatory process at universities. It is possible that Don's fear of ECSA, reflected in his nervousness, prevented him from fully articulating his awareness of regulation at university.

8.4.1.2 Comparing SUT and AUT

Convergence

Both UoTs regard ECSA as highly influential in higher education, from its influence on pedagogy and curriculum construction to the registration of engineers. There is agreement on its registration function as well as its role of accrediting university programmes. These functions are seen as a means to maintain standards at both local and international level. The standard and relevance of the programmes enable graduates to obtain employment. The UoTs also agree that ECSA defines the basic knowledge and requirements of the curriculum and that it promotes ethical conduct.

Divergence

AUT believes that accreditation places too many administrative burdens on academics, to the detriment of their teaching. It also states that the Department of Education has pushed the research agenda at UoTs, with the result that teaching has suffered. Thus the engineering programme differs widely across the academic landscape in South Africa. Although AUT feels that ECSA broadens the scope of the engineer by including social issues, SUT feels that ECSA plays a gatekeeping role of deciding who practices and makes decisions.

8.4.2 Industry

8.4.1.2 Comparing views on how regulatory bodies influence conceptions of professional knowledge across levels in the hierarchy of the organisations within industry

Manager perspectives

Both the industry managers view ECSA's role in higher education as being part of the nexus of relationships among universities, the government and regulatory bodies to improve the quality of education and output as well as address the gaps identified by CHIETA. However, one may ask whether

these partnerships are not conspiring to maintain the status quo. While Mary feels that the bigger players like government are very important in forging such partnerships, Nemo is more concerned about the professional development and registration function of ECSA at an individual/ personal growth level. This is consistent with his philosophy about developing staff members.

Trainer perspectives

PPIR has a designated staff member who interfaces with regulatory bodies including the government to keep track of new legislation as reflected in white papers and national skills development strategies. This staff member works closely with the chemical SETA in partnership with CHIETA in terms of how legislation affects them. The trainer at APIP is more hands on in terms of understanding the role of SAICHE and being involved in the daily processes that involve the operational aspects of candidates' training. For example, to ensure that the trainee is meeting ECSA requirements, a report is written and this evaluation is used to guide the trainee for the next six months.

Mentor perspectives

The mentors note that ECSA is involved at different levels of the engineering graduate's career trajectory from student trainee to engineer. It does so through accreditation and benchmarking at the level of the university as well as alignment of the syllabus with its 11 outcomes. At the level of the graduate engineer, it provides a professional licence to practice. For Jack, the development of a well-rounded engineer is more important than merely 11 outcomes.

Novice perspectives

The PPIR novice sees ECSA accreditation as important for universities. International benchmarking of the curriculum content is also important. Audits are seen as a way of addressing shortfalls. The novice adds that ECSA encourages student placements and certifies graduates to become engineers. The APIP novice sees ECSA as a certifying agency that also regulates engineers' conduct. It is linked to ethics and safeguards communities.

8.4.2.2 Comparing APIP and PPIR

For PPIR, maintaining relationships with key regulatory players is part of its strategic programme to build a nexus of similar thinking stakeholders to ensure smooth functioning. It regards ECSA as a stakeholder that improves quality and output and address gaps through accreditation and audits. APIP is more concerned with professional development and ECSA registration at an individual level. This company seems to be less focused on ticking boxes and more concerned about developing a well-rounded engineer. While PPIR works well with CHIETA, the chemical engineering sector SETA, to

keep abreast of the legislation affecting the industry, APIP works well with SAICHE, and is involved in daily processes that deal with the operational aspects of a candidate's training.
Both companies regard ECSA accreditation as important for universities, as is international benchmarking with regard to the content of syllabi, while audits are seen as a way of addressing shortfalls. Both also feel that ECSA encourages student placements and is critical in terms of certifying graduates to become engineers.

APIP notes that ECSA is also involved in the regulation of professional conduct, particularly when it comes to issues of ethics and protection of the environment. PPIR, in contrast, ensures that smooth and open channels of communication are available between the community, activists and the company. Its community projects invest heavily in providing infrastructure for laboratories and other types of facilities that benefit the community.

8.4.3 Regulatory bodies: Comparing academia and industry

Convergence

Both the companies and the UoTs feel that ECSA is intimately involved in higher education, from its influence on pedagogy and curriculum construction that defines the basic knowledge required in engineering practice, to the registration of engineers. In general, industry sees ECSA and other regulatory bodies as crucial to its smooth running; hence the companies strictly abide by the latest legislation. Indeed, PPIR has a designated staff member to liaise with regulatory bodies. Both sites work well with the chemical industry SETA, CHIETA as well as with SAICHE. These bodies provide useful guidance with regard to macro policy issues and daily operations on the shop floor. Academia and industry are both keenly aware of ECSA's role in the registration and professionalization of engineers. They agree that ECSA plays an important role in shaping graduates' future employment as well as in placing trainees in industry. Finally, they agree that ECSA regulates the conduct of employees.

Divergence

The UoTs note that ECSA has been too prescriptive and this has a negative effect on teaching. The Department of Education is also criticized for pushing a research agenda instead of encouraging good teaching. Finally, ECSA is seen as a gatekeeper by UoTs in terms of who is allowed to practice and make decisions.

Synthesis

This chapter presented a cross-case study of academia and industry's conceptions of professional knowledge. The first section focused on conceptions of soft skills across industry and academia, while section two explored conceptions of WIL. Section three examined how professional identity is linked to conceptions of professional knowledge and section four investigated regulatory bodies' influence on conceptions of professional knowledge. The following chapter compares the findings presented in this chapter with the extant literature.

PART THREE: CROSS-COMPARATIVE ANALYSIS OF DATA

Chapter Eight is a cross-comparative analysis of the data presented in part two using the various themes identified. The interpretations that emerge in this chapter are then set in dialogue with the key issues and themes in the extant literature in Chapter Nine. This ensures that a theoretical and conceptual analysis is created. Chapter Ten is the crown of this section which draws all the parts together to synthesise a new engagement with the data. This is the distillation of the thesis regarding the phenomenon of conceptions of professional knowledge as experienced by academics and industry personnel.

CHAPTER NINE

TOWARDS AN INTEGRATED PROFESSIONALISM

Orientation

In the previous chapter, I charted conceptions of professional knowledge across academia and industry as revealed by the data. This comparative analysis revealed convergences and divergences in the way that conceptions of professional knowledge were understood and applied in the two sectors. The convergences mainly revolved around the theme of regulatory influence while divergences were strongly linked to conceptions of practice knowledge.

In this chapter, I look at the different notions of professionalism at play in the analysis and in this way respond to the first critical question: what is professional knowledge? To answer this question, I marshal the various forms of professional knowledge yielded by the data, setting them in dialogue with one another. I further categorise two broad conceptualisations of professional knowledge into *agentic* and *regulatory* forms. Theoretical knowledge, practice knowledge, cultural knowledge and personal knowledge are set in contrastive dialogue with regulatory knowledge. What becomes evident is that regulatory professionalism plays a significant role in the way in which the world of engineering is understood in industry as well as in academia. The world of industry is strongly regulated as it requires and maintains compliance and control in order to serve its agenda, while the world of academia is increasingly responding to market and other forces, forcing a reluctant acceptance of regulation. Also at play are various forces that compete with systemic regulation in academia. I characterise the effect of these forces as *phronetic professionalism* which arises from diverse formulations of professional knowledge. These competing forces are illustrated in Figure 9 below. In general, this chapter seeks to harmonise these various elements of professionalism into an integrated notion of what I term a phronetic regulatory framework, drawing together the two worlds of academia and industry.

In section one, I outline the different forms of professional knowledge at play in the world of work and academia. I refer to this relationship between these multiple forms as a phronetic understanding of professionalism. In section two, I discuss how forces of external regulation influence constructions and conceptions of professional knowledge. I refer to this kind of knowledge as a regulatory understanding of professionalism, showing how it influences notions of professional knowledge in both academia and industry. I also highlight the quest for a more agentic rather than a capitulative professionalism that is strongly evident in academia. In section three, I argue for a combination of these notions, balancing the practical, personal, cultural and theoretical dimensions of the conceptions of professional knowledge. The interactive, integrative and dialogical interplay between these different elements

constitutes what I refer to as *regulatory phronetic professionalism* which accepts the reality of regulation but equally responds to the practical and ethical dimensions of chemical engineering work.

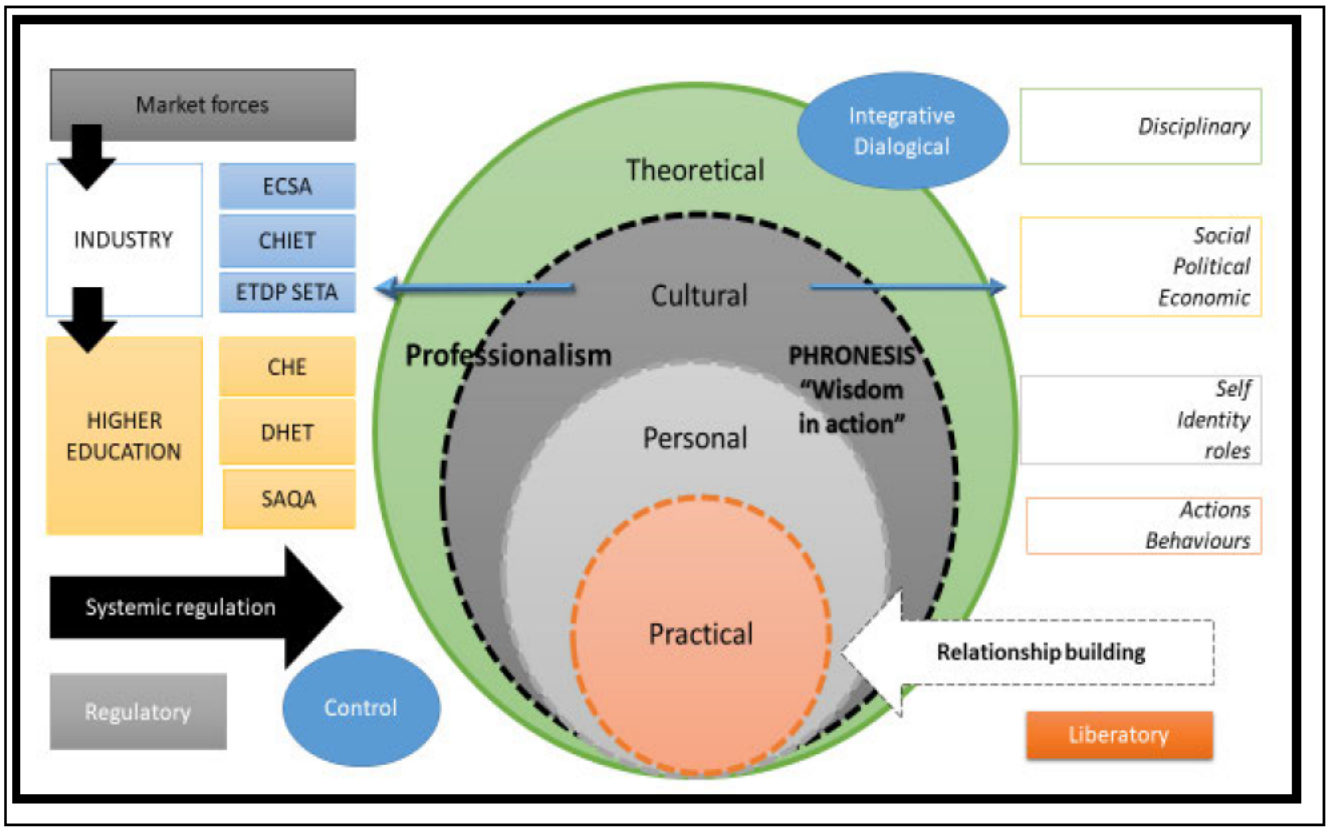


Figure 9: Forms of professional knowledge conceptions at play

9.1 Section One: Phronetic professionalism

9.1.1 Autonomy and the professions

In this section, I argue that despite challenges to its autonomy and legitimacy from both globalisation and local regulatory control, the critical role of the university as a producer of new knowledge needs to be defended. These sentiments are reflected by the research participants who articulate that the role of the university is not to train incumbents for industry, but to innovate. Universities should lead industry rather than the other way round. These concerns are highlighted by Beck and Young (2005) in their discussion on the type of professionalism that should prevail within university education settings in the current context of rampant capitalism, marketisation and accreditation regimes.

Beck and Young (2005) advocate for the creation of a new kind of professionalism with weaker ties to the acquisition and production of knowledge in universities as compared to the world of work. They

suggest that the workplace and its emphasis on *knowledge in practice* should have a more dominant influence on the new professionalism. While I acknowledge that the contextual conditions prevailing in neo-liberal markets have weakened the rigour of codified knowledge at the university, I believe that this definition of the new professionalism implied by Beck and Young (2005) is flawed. Their notion of professionalism strengthens aspects of practice to the detriment of abstract knowledge.

My own position is that both abstract knowledge and practice knowledge need to be strengthened. Such a dialogical, interactive interplay of knowledge forms from both worlds will better prepare students and prospective professionals for the workplace. Of course, such a call will entail that universities claw back some of the territory that they have lost to globalisation and local regulation. Beck and Young (2005) pose the question: Is this possible given the current reality on the ground or should one simply throw in the towel and give in to market pressure? Clearly, this signals that a different kind of professionalism needs to be fleshed out. In the remainder of this chapter, I argue that an agentic professionalism that integrates all forms of professional knowledge should be equally emphasised. This does not deny that, in the enactment of varied knowledge systems, each localised context will privilege different forms of knowledge in divergent intensities given local imperatives.

Earlier, I hinted that abstract knowledge needs to be bolstered, and that the universities' academic agenda needs to be realigned to produce innovative knowledge. This could prompt opposition from various sources, supporting the notion that academics are holed up in their ivory towers producing one academic publication after the other which may or may not connect with the everyday world of professional practice. It is not uncommon for this notion of the "selfish academic" to be reflected in the work of theorists (Beck and Young, 2005).

The university staff that participated in this study call for the standard of core engineering knowledge to be raised, while industry representatives identify the lack of student engagement at the workplace. Pressure from industry is compelling UoTs to include more practical knowledge in their curricula. This might be considered as creating a dilemma for academics (Wheelahan, 2012). Furthermore, universities are being driven by the higher education authorities to increase student throughput rates. This suggests that, rather than being autonomous, university curriculum designers are being forced to adopt practical and expedient strategies to adapt their curricula and ensure higher graduation output, which could be regarded as a lowering of academic standards.

Wheelahan (2012) is justified in describing the weakening of theoretical knowledge as a social justice issue since it will prevent the student from 'imagining the impossible'. Universities are increasingly

seen as certifying agents rather than as drivers of alternative forms of more valuable knowledge that could benefit the marginalised and the poor. Students themselves, especially those from the working class, are now offered weaker forms of disciplinary knowledge in vocational education institutions (Young, 2006). The abandonment of deeper levels of epistemic engagement in higher education in order to broaden access may be a viewed as a betrayal of the social justice agenda touted by modern curricula.

It appears that academia is unknowingly complicit in preserving elitism by denying access to epistemic quality and is thus regarded by the wider community as self-interested and self-preserving. I believe that the obsession with codified knowledge as a way of providing epistemic access may be a romantic notion. Both *contextual* and *theoretical* knowledge are necessary to enable access to worthwhile knowledge systems that support a broader social justice agenda. In contrast to those that portray universities as ivory towers, I believe that a more interactive relationship could be promoted whereby theoretical knowledge is strengthened through dialogical interaction when students encounter authentic workplace settings.

Both forms of knowledge are required to resolve everyday problems in the world of work. The participants from both industry and universities said that encountering real-life problems forces them to reflect on the theory they learnt and they sometimes read up on the issue to update themselves and solve the problem at hand. How can academia shed its image of being elitist and self-preserving? One suggestion is to reimagine the nature of the relationship between their own world (with their own internal imperatives) and the world of work (which is driven by its own imperatives).

Since abstract knowledge can be packaged (i.e., commodified as marketable products), it appeals to those who tweak professional education in order to make a profit. This type of manipulation by the captains of industry and those driven by profit in the free market, as well as massification and marketization, militate against the strengthening of theoretical knowledge. In many ways, the world of work could also be considered to be guilty of "tweaking professionalism in the interests of profit". Professional knowledge seems to concern itself less with ethical issues and is being sacrificed at the altar of econometric agendas. The econometrics of the world of work and its profit mentality take precedence over all other considerations.

To summarise, an agentic professionalism acknowledges that a variety of professional forms of knowledge exist, and these forms of knowledge have come under pressure from a variety of external forces which threaten to reshape them to suit the market agenda. Forms of professional knowledge will need to be strengthened, integrated, and contextually deployed in order to perform effectively in academia as well as in diverse workplaces. Thus, if the worlds of academia and work are to escape the

pressures of marketisation and commodification, rather than accusing each other of irrelevance, they need to find ways to engage in constructive dialogue.

9.1.2 Theoretical knowledge

Codified or propositional knowledge is knowledge that is mainly located in the university and is likely to be represented in textbooks, journals and other academic textual forms (Eraut, 2009; Young, 2006; Kinsella, 2012). This knowledge which applies to a discipline or subject is often reconstructed when used in universities' syllabi. Academics decide on the relevance of the subject matter to the needs of the learners and make judicious selections of knowledge areas they deem fit for purpose. It is in this sense that Barnett (2006) sees education as facing both ways: one to the disciplines and the other to the workplace.

Eraut's (2009) metaphor of an iceberg effectively explains the relationship between theoretical knowledge and its application in practice settings in the workplace. For Eraut, codified knowledge is that which is located metaphorically above the water and is explicit. The way in which this codified knowledge is used in practice settings is less visible but highly complex, involving recontextualisation and shifting from its original domain within the world of academia into the world of work. The knowledge which occurs in practice settings is mainly described as tacit. It occurs in informal situations in a series of embodied social encounters (Kemmis, 2014; Eraut, 2009; Kinsella, 2012). This study shows that the interregnum space (between the university and the workplace) has the most potential to articulate how the theory/practice debate can be addressed.

In Eraut's (2009) metaphor, the part of the iceberg which is visible above the water represents codified knowledge which is explicit and can be easily learnt from textbooks. The greater part of the iceberg which is hidden under the water represents learning that is implicit or tacit and cannot be adequately explained. Eraut makes the point that the learning which takes place in workplace contexts is likely to be located under the water. This hidden knowledge process is what he refers to as tacit knowledge that is developed informally in various embodied social encounters in the workplace. This is consistent with this study's findings, where participants note that only a limited range of theoretical knowledge learnt at university is used in the workplace. Eraut (2009, p.12) notes that a practitioner's repertoire remains dormant until it is activated by specific triggers in the context.

In this section, I explore the role of codified or propositional knowledge in professions. I examine how the professional exercises jurisdictional control via abstract knowledge. This also links with issues of university autonomy. According to Gamble (2010), 'the formalised nature of a knowledge base, in terms of knowledge elaboration at various levels of abstraction that make connections with the task areas of

a profession, is what makes professional jurisdiction strong. It is also the level of abstraction of the knowledge base that determines the level of graduate or post-graduate entry qualifications'. This notion of standards is further developed by Wheelahan (2012) who proposes that weak codified knowledge undermines the possibility of imagining the future. It ties in with industry complaints that novice graduates are not able to "hit the ground running" and that there is a drop in standards in universities. Their inability to engage immediately with pragmatic challenges promotes negative stereotypes of the world of academia and its relevance to the workplace.

9.1.3 Migratory /practice knowledge

In this section, I use the notion of migratory knowledge to explore how learning occurs at different practice settings as graduates transition from the university to the workplace. The word "migrant" conveys the idea of movement and in this context suggests how professional knowledge is transferred from one setting to another. This transfer is not simple or linear as it might appear, but involves complex processes in which knowledge is re-contextualised, re-appropriated and reconfigured as it journeys across different practice settings where different requirements may shape the character of the knowledge required. It often requires integration of various types of knowledge to meet the demands of new learning in new contexts (this conception of migratory knowledge is explored in more depth in the following chapter).

Using Wenger's (1991) community of practice theory, I show how the context enables various knowledges to be activated. As students journey from university to work, they pass through an interregnum space called experiential learning or WIL. This space has been under-theorised and could offer new insights into how some of the theory/practice dilemmas can be addressed. This issue is explored as I make the case for migrating knowledges as contributing to the development of phronetic professionalism. Eraut (1985) observed more than two decades ago that not much is understood about how graduates use the professional knowledge gained during their undergraduate years, and the ways in which they are socialised in the workplace as well as the continual learning that takes place. This study throws light on how academics and industry personnel view practice knowledge as it moves across different contexts. An important part of a novice's learning in professional education is how to use the knowledge gained in different contexts. Different kinds of knowledge are activated as this migration occurs in which both university and industry contexts are required to develop a more holistic conception of professionalism.

Within the migratory knowledge model, teaching and learning for workplace contexts need to be reconceptualised as teaching and learning for a single system in which all stakeholders should be engaged in a *dialogical process of learning and teaching* from lecturers, to students and workplace

mentors. The model should also include artefacts which would mediate the pedagogical processes that are involved in the distribution and generation of knowledge. If the disparate sites are viewed as part of a single continuum, the blame game between industry and higher education will be reduced and more robust collaboration can be expected. Within the migratory model there should be facilitation between staff across sites – for example, industry personnel should get involved in syllabi construction and academics could be involved in on-site training of newly graduated engineers within the workplace. Cross-site sharing of pedagogical and other forms of knowledge will allow for a deeper understanding of students' needs.

Although many stakeholders facilitate learning for novices, ultimately, the novice her/himself will need to activate the theoretical knowledge gained from higher education in the different contexts in which s/he finds her/himself. S/he has to learn how to bring the codified knowledge in dialogue with other forms of knowledge in order to address the engineering problems that arise in the workplace. Thus, students also have an agentic responsibility.

9.1.4 Cultural knowledge

This section argues that cultural knowledge which enables learning in and through work (Billet et al., 2004) plays a key role in unlocking critical aspects of a newcomer's own knowledge through socialisation into the workplace. I explore how learning and knowledge are influenced by both macro- and micro-social forces. The skills and knowledge that the newcomer brings need to be mediated by the prism of cultural knowledge in order to be successful. In this section, I explore the role of cultural knowledge in the context of the workplace and relate it to workplace learning. I also chart differences in the invitational qualities of the workplaces cited in order to understand how the workplace provides opportunities for staff to engage in activities which accord with the values, mores, habits and practices of the workplace.

According to Billet et al., (2004), affordances are inequitably distributed and are heavily influenced by norms, practices and affiliations (cliques, associations, and status). He contends that opportunities to learn are not only afforded to students but come with a specific agenda: to sustain the work practice in the interests of individuals or groups (2004, p. 2). He adds that learning also depends on personal agencies comprised of values, subjectivities and identities (2004, p. 2). When a newly graduated student enters the workplace, s/he is immersed in a very different culture from the one s/he was used to at university. S/he has to imbibe the mores, values and rituals of the workplace and will need to meander through various physical pathways, engaging with people from different hierarchies and artefacts of different functionalities along multiple pathways. It is this series of encounters and collisions that

enables the newcomer to acquire the cultural knowledge necessary for enacting practice. Such embodied knowledge is highly situational and interactional at many levels.

As cultural knowledge varies from domain to domain across and within workplaces, it resists attempts to codify it, nor can it be represented in any packaged form. It is intimately tied to the geographies of the workplace. This entails taking account of how physical structures in the workplace impact on knowledge generation as well as how past practices (the traditions, rituals and regulations which constitute cultural knowledge) do so. The nature of the services and products produced, the architecture, and relationships with internal and external stakeholders all influence the production of cultural knowledge.

Through acculturation over time, the newcomer acquires knowledge of these different shaping attributes of the workplace as s/he journeys from being a newcomer to becoming an old-timer. Newcomers' acculturation and socialisation occur at both a conscious and unconscious level. Their integration usually begins with an induction process and a period of training. Although this may seem to be a passive process, much depends on the newcomer's active, conscious effort to imbibe and reflect the values and rituals of the workplace. According to Billet (2004), such agentic action is shaped by an individual's personal history and identity. The cultural knowledge at university and that at the industrial workplace differ significantly as the nature, function and structures of these organisations are different. Indeed, cultural knowledge differs from organisation to organisation. This is particularly problematic for the newcomer as cultural knowledge is complex and is unlikely to be codified. It may be situational or tacit and could be learnt in the context of the practice in which it is embedded.

Cultural knowledge is both broad as well as specific. It deals with the nature of the organisation, and its values and norms, and takes into account the prevailing ethos. It encapsulates the phrase "how we do things here" (Eraut, 2008). However, this innocuous phrase masks its complexity. While it points to the notion of performance, the description is not directed to actual practice but to the different ways in which that practice is constituted and the richness of the affordances that can be found in the context that either enable or constrain performance. The newcomer learns by acquiring an understanding of the contextual ways of how a practice is constituted. These contextual ways take into account the timing, the people, the artefacts and the general situation before any engagement occurs (Eraut, 2008).

In the table below, I compare and contrast some of the worldviews about the cultural knowledge of the organisations selected in the water and petroleum sectors. This suggests that even within the world of work, the specific nature of the cultural environment is not necessarily homogenous, even when they operate using the same domain disciplines such as engineering professionalism

Table 9

Comparison of two industrial sites

	Water sector	Petroleum sector
	Service driven	**Profit driven**
Structure of buildings	**Open plan type of building structure. Buildings blend in with the environment. Easy access.**	**Narrow aisles, lack of communication, TV blaring out instructions, security turrets reminiscent of apartheid security apparatus. Very strict entry and exit protocols, security checks, boom-gates and high tech.**
Atmosphere	**Welcoming, warm, easy going.**	**Officious, formal, instructions to be strictly followed – rule governed. Surveillance, control.**
Management/mentoring style	**Mentoring for next generation. Highly personalised style of mentoring sets up a standard and example. Expectation of innovation and critical thinking.**	**Management style is impersonal and aloof. Expectation of compliance.**
Effects on staff	**Desire for stimulation. Driven to improve basic services.**	**Staff have a desire to please. Community service fulfils a specific agenda: Silencing of voices of activists. Efficiency and safety**

The four points of comparison provide a contrasting picture of the two organisations. Despite the fact that they operate within the broad jurisdiction of the discipline of chemical engineering processes, the cultural modes in which they operate are quite different. Students who seek experiential training or novice graduates who seek employment should be made aware that organisational cultures differ significantly and can influence how staff engage with management and other groups within the company. The table below provides an example of how organisational cultures differ at UoT sites.

Table 10

Comparison of two university of technology sites

	Sharrukh University of Technology (SUT)	Amir University of Technology (AUT)
	Independent	**Merged**
Governance	**Autocratic - power historically determined, although changes have recently occurred in governing structures. Currently the Council is the highest governing body. Staff tend to be compliant rather than confrontational.**	**Democratic – appreciation of different governance structures as mergers encouraged debate and discussion of governance issues. Staff is activist.**
Physical size	**Smaller, intimate physical structure. Relationships tend to be personal and strong.**	**Larger – more facilities and courses. Impersonal feeling, isolation.**
Curriculum offerings	**Limited offerings. Although students come from a range of linguistic backgrounds, all students are African while the staff is from different race groups.**	**Wider range of curricula offerings. Wide diversity of students with diverse interests.**
Teaching style	**Lecturing style – teaching intensive. Students expected to be compliant, and passive.**	**Expectation that students will be active, independent and innovative.**
Management style	**Deans – activist**	**Dean – compliant**
Expectations of staff and students	**Expect products to be passive Lecturer centred Traditional**	**Active/Independent Innovative Facilitation Student centred**

As the above table shows, the two UoTs also differ significantly in terms of their history, governance structures, size and curriculum offerings, resulting in a unique cultural ethos in each context. They also have divergent cultural practices, mores and values. SUT has a history of autocratic control and chose to remain an independent entity while other UoTs were pressured to merge with bigger higher education institutions. AUT has a more democratic governance style. SUT is smaller than AUT physically and is the only higher education entity in South Africa that is situated in a former African suburban township setting. AUT is located within the city centre and boasts a diverse student population, while SUT has a homogenous student population. The curriculum offerings at SUT are limited due to its size. It has inherited a pedagogical style that is teaching intensive and lecturers are expected to be compliant and passive.

It is thus likely that students traversing between their academic institutional setting and specific workplace sites will carry with them heritages of these cultural contexts as they negotiate the process of becoming a professional.

9.1.5 Personal knowledge: self, subjectivity and agency

This section explores the notion of identity as part of personal knowledge in order to deepen understanding of the relations between learning, work and the self. Personal knowledge is the knowledge that a person has acquired since birth and it may include her/his skills and general knowledge. Skills are defined here as those acquired formally and informally, in a range of different fields. For example, a person may be skilled in using particular pieces of equipment or could be a skilled negotiator. While some of these skills have been learnt in the workplace, the graduate is equipped other skills when s/he enters the workplace. The general knowledge that the person has acquired represents all the knowledge acquired over time through contact with various agencies and structures like the family, community, school, media, university, friends, and acquaintances. Each is a source of knowledge for the graduate, with various interactions contributing to personal knowledge.

When the person enters the workplace, s/he brings a tapestry of experiences and knowledge with her/him. This personal knowledge serves as an important resource on which to draw when interacting in the workplace. Eraut's definition of personal knowledge below reflects much of the participants' conceptions of personal knowledge:

- *Codified knowledge* in the form(s) in which the person uses it
- *Know-how* in the form of *skills and practices*
- Personal *understandings of people and situations*
- Accumulated *memories of cases* and episodic *events*
- Other aspects of personal *expertise*, *practical wisdom* and *tacit knowledge*
- *Self-knowledge*, *attitudes, values* and *emotions* (Eraut, 2004)

For many of the participants, learning occurred when personal knowledge was brought to bear on a new situation in the workplace. The newcomer is often described as having to struggle to find various sources of knowledge in order to define the problem encountered and to devise a suitable solution. In the engineering context, this often means first exploring one's own understanding of the problem, then using one's skills to identify relevant sources of information. Communication skills are used to interact with senior members to identify similar problems and obtain advice. The success of these interactions depends on the attitudes and values of the newcomer. According to the participants, "old-timers" were quick to pick up on the "newcomer's" attitudes and dispositions and were often more willing to assist

someone who was humble and willing to learn. This is consistent with the extant literature on the attitudes and values of newcomers as critical factors in learning in the workplace.

Eraut (2008) makes the insightful observation that, in our drive to focus on various types of knowledge, competences or standards, we have tended to make these features atomistic rather than holistic or integrated. He argues that all kinds of knowledge, theoretical, situational and personal, need to dance together in order to accomplish the tasks required in the workplace. Personal knowledge in its various manifestations of self, subjectivity and identity plays a key role in activating the other forms of knowledge previously identified.

This section emphasised the need for consideration of the interplay of various forms of knowledge (situated, spatial and personal) that need to be activated as individuals learn to be and become a professional. Moreover, this interactivity is complex, multiple, and not always coherent and stable.

9.2 Section Two: Regulatory professionalism

This section explores three recurrent themes that emerged from the review of the study's findings. They are largely driving forces outside of the organisation that influence the nature of professional knowledge. They include globalisation, marketisation (at the wider conceptual level) and the issues of accreditation and regulation (at the local operational level).

In this section, I argue that current notions of professionalism have been influenced by the role of national regulatory bodies, namely, the Council on Higher Education (CHE); Engineering Council of South Africa (ECSA); South African Qualifications Authority (SAQA); and the Department of Higher Education and Training (DHET). Drawing evidence from the study, I show how these bodies have generated a compliance model of professionalism in the field of engineering as they have advanced a systemic, regulatory function that is guided by normative control. One can argue, as many of the participants do, that the obsession with adherence to external rules and regulations undermines the quality of the professional knowledge generated.

In this section, I also explore the third critical research question: Why is professional knowledge shaped the way it is? I explore the theme of regulation within the chemical engineering profession using Foucault's (1991) notions of panopticon and governmentality and show how power is used both overtly and insidiously to influence and shape the contours of professional knowledge in disciplines and in practice.

9.2.1 Globalisation, massification and professional knowledge

Control and reshaping of professional knowledge in disciplines to match the needs of growing marketisation have been a hallmark of higher education in the past twenty years (Hall, 2019). This growing commodification of education is clearly reflected in the changes that have occurred at universities to meet new performative criteria influenced by neoliberal ideals (Olssen & Peters, 2005). Accompanying these changes is growing managerialism within universities suggesting that many official university systems are adopting a capitalist perspective. Performance management, and operational reviews at various levels (institutional, departmental, programme, curriculum and staff performance reviews) play a central part in the control and construction of disciplines, subjects, and staff. This is executed through the use of power and buy in by staff who subject themselves to perpetual scrutiny via quality assurance mechanisms. In general, programme accreditation and quality assurance are the function of the Council of Higher Education (CHE) which is carried out by the Higher Education Quality Committee (HEQC). This body also provides the criteria for programme accreditation (CHE 2012, p.16).

The primary regulatory body for quality assurance in Engineering in South Africa is ECSA. As a statutory professional council, ECSA's power to conduct programme accreditation emerges from the legislation around professional councils, in particular, the Engineering Professions Act of 2000. This act mandates ECSA to regulate the field of Engineering through activities like programme accreditation as well as registration of individuals to practice within the Engineering profession. In higher education, a signed memorandum between the CHE and ECSA empowers the latter to ensure quality assurance in the field of engineering education. The Engineering Council is now responsible for the accreditation of diploma and degree Engineering programmes at universities throughout South Africa.

9.2.2 The regulation of professional knowledge

ECSA regulates professional knowledge by ensuring that curriculum and syllabus design at universities are tightly controlled with clearly defined prescribed criteria and standards. While curriculum developers are able to design their own programme mix, they are limited by the minimum credits and notional hours assigned to each knowledge area (ECSA 2019, p.9). It is for this reason that Mutereko argues that ECSA determines graduates' knowledge profile (2014, p. 241). In essence, this means that ECSA is shaping the future engineer through specifying the exit level outcomes for each programme. Subject areas are also heavily prescribed. This is evident in the participants' reports on their experience of subject choices.

Although the CHE encourages the linkages between the world of academia and the world of professional practice via the WIL programme (CHE 2011, p.17), the study participants reported that there is a heavy focus on core science subjects in Engineering programmes, with very little room for anything else.

The study participants reported that there is a heavy focus on core science subjects in Engineering programmes, with very little room for anything else. Although ECSA allows for complementary subjects (56 credits), the timetable is loaded with "science heavy" modules. While a subject like Communication is viewed as essential, it is not prioritised and very few credits are assigned to it. As a result, Communication is dispensed with in a single semester.

The fact that curriculum developers do not use the complementary subject space more creatively suggests that the potential to "humanise the Engineer" is lost. Despite ECSA's focus on codified knowledge, some industry participants report that little of this knowledge is used in the workplace. Others lament the drop in the standard of graduates produced by universities. This suggests that they regard candidate engineers as lacking in codified knowledge.

9.2.3 Panopticon and governmentality

According to King (2006, p.3), knowledge is a critical power resource for producing subservient individuals. This is achieved in two ways – overtly and insidiously (Foucault, 1991). Foucault's notion of panopticon demonstrates how the state is able to regulate various structures in society. A well-known analogy of Foucault's theorisation is that of the description of surveillance systems in a prison where the prison guard, located in a watchtower overlooking the campus, has an overarching (panoptic) view of all the elements that it oversees. Those in the prison are made consciously aware of the elevated position of the prison guard in order that they will believe that the guard is able to see and therefore regulate all conduct under her/his gaze. Thus, regulatory force is symbolically and structurally located to highlight its power to control and sometimes, the mere presence of the watchtower, without personnel, is enough to convey the surveillance function.

In many ways, a structure like a university resembles Foucault's prison. Like the watchful eyes of the prison guard, universities use power and surveillance to keep things and processes in shape. For example, the university is stratified along an axis of power. Stakeholders within the university occupy positions with unequal levels of power. Those in positions where they can regulate others have more control and power. Such regulation might not always be overt in terms of overseeing the work of subordinates (as in the case of the prison guard in the watchtower), but is structurally located in the hierarchies of the system. For example, students, who are at the basic level, have very little power, while lecturers can command power in many respects. The exercise of domination is replicated in the

relationships along the hierarchy across heads of department, managers, administrative officers or even the principal of the institution. This process of domination and subjugation is exercised at all levels along the axis of power at universities as well as in industry.

A panopticon design is a structure where prisoners are unable to see the prison guards and hence feel themselves to be constantly under surveillance. As a consequence of this perennial state of surveillance, prisoners start to self-police and in this way come to regulate themselves. This is a very powerful metaphor to apply to the education system to describe the ways in which quality assurance systems operate as panopticon devices to create self-policing academics. In order for such a structure to become operational, it needs to be completely embedded within the prevailing ethos of the university. It should be recognised that every now and then there may be disruptions in the form of attempts to alter the patterns of hierarchical power (such as during student protests, or labour resistance). However, the overarching surveillance ensures that the systemic order of the power endures structurally, as normative patterns of conduct revert after periods of disquiet.

The CHE and ECSA play a critical role in deciding what a professional engineer looks like. They also decide on the norms and standards and what is admissible in programmes at university level. The CHE accredits institutions at the macro level, while ECSA is responsible for programme accreditation. While the CHE is expected to brief the Minister of Higher Education and Training on all matters relating to higher education, ECSA engages with academics in building capacity in programmes across all forms of universities in South Africa. Both bodies may be accused of fostering a conservative and elitist, Eurocentric notion of professionalism.

Nonetheless, these regulatory bodies play an enabling role in ensuring that other stakeholders critical to the triple helix relationship are cooperative. While the relationship between industry and ECSA can be described as collusive, it is also collaborative in generating a strong engineering profession. Collectively these regulatory forces serve as a form of panopticon, assuring the stability of the notion of what is considered useful and valued knowledge systems within the broader social system (many professional councils argue that they protect the “public interest”). The professional councils offer a normativising agenda usually presented in the description of national hallmarks and standards. These standards and practices are sometimes collaboratively co-established by partners from within the university system, but are often benchmarked against elite institutional practices across different national higher education institutions. They thus protect the interests of these elite worldviews, albeit in the name of “quality”.

9.2.4 Embeddedness

This section explores the extent to which ECSA's accreditation discourse is embedded in the university system. I do this by briefly exploring the participants' views on accreditation. The discourse of accreditation is well entrenched in the minds of university staff from academics to the dean as this process lies at the heart of what academics do, that is, teaching and learning. Since accreditation deals with programme reviews, it follows that it focuses on the syllabus, subject guides or course notes, interviews with academics and a perusal of their subject files.

ECSA personnel call for subject files and interview academics on a range of issues affecting the teaching and learning process, including assessment. Subject guides, and assessment methods are scrutinised and visits are conducted to classrooms to observe lessons. In short, the entire life of the academic is placed under a spotlight. Where previously, university evaluation was done internally, an external body now evaluates and assesses. Since ECSA accredits programmes, it investigates the course content or syllabus and determines the extent to which it complies with ECSA requirements. It also examines teaching methods and interviews staff and students in this regard.

Although ECSA is primarily involved at the programme level, involving the HOD and academics, it also interviews students and the Dean. Its influence thus cuts across all levels of the university hierarchy. At the individual level, academics seem to have internalised the discourse of accreditation to the level that they are able to cite the 11 ECSA critical cross-field outcomes without difficulty. Foucault calls such internalisation of discourse governmentality and its power operates at a very insidious level.

Whereas ECSA's overt power is conveyed through its accreditation processes, its subtler reach and insidious control is activated by those whom it scrutinises. Drawing on Engebretsen, Heggen and Eilertsen's (2012) study of accreditation in engineering education, Mutereko (2017) shows that supervision via the professional council tends to privilege certain kinds of knowledge. He adds that 'supervision is reformulated in the form of governmentality to allow for self-control mechanisms' (2017, p. 239). Thus, once the process of accreditation is initiated, the evaluated internalise these processes such that control shifts from overt to insidious.

For Foucault, governmentality is more than just the discourse of a discipline. It works not only through overt surveillance but also in the ways that people collaborate to reach their goals (Engebretsen, Heggen and Eilertsen, 2012). By enabling people to feel free to reach their potential, the regulatory force is able to sustain its order and control. Power is thus expressed through its invisibility and is therefore at its strongest. The study participants do not regard ECSA as an instrument by which the government or

market-driven economy exercises power over the university; instead, they see it as an enabler of outcomes.

In participating in the game of audits, the participants become part of ECSA's machinery, thereby rendering their own complicity invisible. The process is viewed as "benign". Industry participants like Krish regard ECSA as a way of addressing shortfalls in engineering education. It is seen as an entity that certifies graduates to become professional Engineers, and that places students in various industries. Mary calls for a stronger nexus between industry and the regulatory bodies to address gaps in students' education. The university seems to have been omitted in this relationship. Does this suggest that the future of the university may be bleak? By successfully performing the dance of certification and winning the approval of ECSA and the university authorities, academics engage in what Foucault calls the 'technology of self' (1991). This concept draws attention to the ways in which various knowledge practices constitute subjectivity but arise from a complex interplay of structure and agency. Hence academics self-constitute themselves from their various academic practices whether this is in reluctant complicity with the regulatory forces or of their own free choice through agentic action.

9.2.5 ECSA as Janus-faced

Despite its incestuous relationship with industry and the DHET, ECSA's intentions seem pure. A deeper look at its critical cross-field outcomes offers insight into the conceptions of professional knowledge that the regulatory body intends to drive. These are constructivist in nature as they focus on context and the production of knowledge in relation to stakeholders rather than reliance on codified knowledge. They also hint at the importance of using one's critical thinking and wisdom to ensure the community's safety. While outwardly it may appear that ECSA is protecting nearby stakeholder communities, in reality, it is also protecting employers of the products of universities.

At least in theory, in ECSA's 11 outcomes, theoria, craft, poeisis and phronesis seem to dance together. Unfortunately, the reality on the ground is that current notions of professionalism and academics' strong adherence to external requirements do not allow for deeper exploration of the values espoused in the following cross-field outcomes that I argue are constructivist in nature:

- Work effectively with others as a member of a team, group, organisation, community.
- Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation.
- Use science and technology effectively and critically, showing responsibility towards the environment and health of others.
- Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

- being culturally and aesthetically sensitive across a range of social contexts;
- Exploring education and career opportunities;
- Developing entrepreneurial opportunities (ECSA, 2004).

In practice, with the auditing regime couched in the language of marketisation and managerialism, a very different conception of professional knowledge is being driven. While codified knowledge is preferred as it can be easily packaged as per market demand, academics are encouraged to ensure that the appropriate documents and files are in place in order to comply with certification either for accreditation or for becoming a professional graduate. Consequently, the focus is on codified knowledge that is easy to handle and the messy swamp of practice and wisdom is avoided.

To sum up, the paradox is telling: Does ECSA use the outcomes as a selling point because they are constructivist in nature and have broad appeal or does it mask the policing nature of the entity by holding up its virtuous heart? While ECSA seems to be protecting the "public", it is largely protective of the captains of industry, the market and middle-class values. The fact that ECSA can decide who to exclude from professional registration endows it with considerable power. This policing role includes seemingly neutral worldviews of what constitutes a professional, norms and standard and the bounds of the profession (Nudelman, 2020). The fact that ECSA encourages discipline boundaries suggests that it sees the profession in a somewhat elitist fashion, which in many ways panders to the practitioner's self-interest concerning both the status of the profession and the practitioner's salary.

ECSA's ubiquitous presence in the professional lives of university staff suggests the power that it wields at both a conscious and unconscious level. ECSA requires that subject files be sent for scrutiny in order to accredit programmes and these files will contain course content. Staff who do not conform to knowledge frameworks suggested by ECSA through its 11 outcomes are called to an interview. Such overt control and scrutiny of files and teaching in the classroom suggest that the regulatory body serves a policing function. As noted previously, ECSA and the CHE have signed a memorandum in which the latter shares its responsibility for quality assurance with the former (Mutereko, 2017). This suggests that they are in sync with regard to the values and interests that they might be protecting.

9.3 Section Three: Integrated professionalism

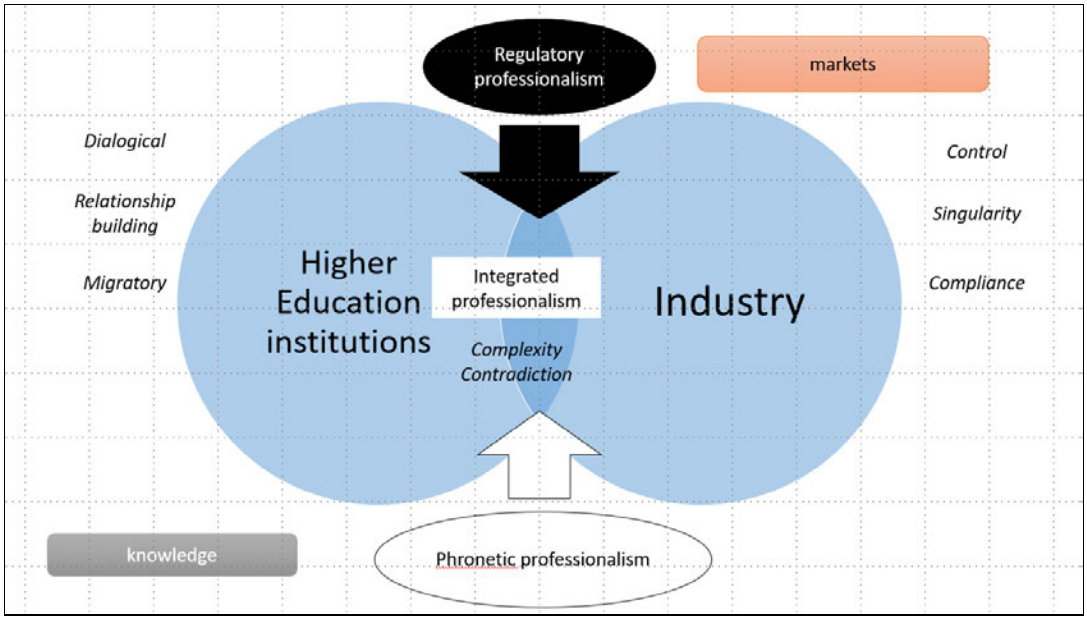


Figure 10: Integrated professionalism

In this section, I offer a model of professional knowledge that integrates a phronetic professionalism and a regulatory professionalism, allowing for a more complex and nuanced understanding of the conceptions of professional knowledge inherent in the relations between industry and academia. Both forms of professionalism are viewed as critical to the execution of professional learning and practice. Whereas market-driven conceptions of professional knowledge tend to seek a more compliant sensibility among professionals which prioritises profit-driven enterprises and processes, a more phronetic professionalism seeks to animate an activist agenda in which autonomy is valued.

Professional knowledge within a market-driven ethos is dominantly subservient to the needs of the enterprise[8]. This knowledge is strictly regulated by the various regulatory bodies that ensure a singularity of purpose – to subvert learning and teaching to market orientations. The exercise of control through various prescripts ensures the creation of self-serving, compliant subjects. Productivity and process efficiency and competency are valued; these values drive the capitalist enterprise. In contrast, a phronetic professionalism values the exercise of informed judgement and wisdom to ensure that professional learning and practice are directed to an *activist agenda*. Professional autonomy and creativity are valued and service to both the environment and the citizenry are emphasised. Professional

[8] This dominance might be countered through peripheral references to a social responsivity in programmes such as "corporate social responsibility" projects.

knowledge which emerges in this context is dialogical, reflexive, relationship building and migratory. How professionals negotiate between the two professionalisms is the subject of remainder of this section.

In arguing for an assimilation of the two competing forms of professionalism described above, I show that they offer a richer understanding of learning and workplace practice in the context of professional knowledge transfer from university to industry and vice versa. Previous research into forms of professionalism has tended to view it in binary terms. These debates have either focused on the issue of autonomy at universities or have critically analysed the effects of marketisation and managerialism on professionalism. By bringing regulatory professionalism and phronetic professionalism together in an integrated phronetic professionalism, I argue for a more inclusive and comprehensive perspective on the way in which professional knowledge is deployed in the workplace (see Figure 10 above). A more complete picture emerges of the professional as one who acknowledges the realities of regulation and also values autonomy, service to the community and competency.

The usefulness of such a model is that it provides an understanding of the professional as someone who is not enclosed in her/his ivory tower, insulated from the social world around her/him. Instead, it allows for a view of the professional as someone who responds dynamically to changing physical and cultural conditions of learning and practice. It highlights that professional identity is a highly complex and paradoxical phenomenon, and that experienced professionals are able to step out of their traditional roles and adopt seemingly contradictory positions and agendas. Professionals can be just as comfortable with regulatory control as with notions of competence and autonomy. In both the academic and industry sectors investigated, managers and deans were able to shift roles and engage in diverse, hybrid activities. The research also showed that the manner and scope of this hybrid divergence in roles are varied and critical.

Within the two major notions of professionalism identified, that is the liberatory and the regulatory, a range of knowledge forms are deployed when practice is enacted. Liberatory professionalism includes knowledge of the self, cultural knowledge, theoretical knowledge, pedagogical knowledge and knowledge of practice. In contrast, regulatory professionalism foregrounds knowledge that is used by the marketplace to exert control over the academic space. With various configurations that portray regulatory and liberatory knowledge as integrated and critical to professional practice, and complementary, the model suggests that professionals need to adopt different mind-sets in their areas of specialisation. While regulatory knowledge has been viewed negatively as being too prescriptive, it does allow for more order and stability and commonness in the current economic climate although it may be tied to marketisation and globalisation. An integrated phronetic professionalism thus has the

potential to counter adversarial relationships and build a collaborative culture which is mutually beneficial. The characteristics and forms of collaborative ventures are explored below.

This section explores how managers and other employees integrate different identities to enact professional practice. These identities may seem contradictory, but they are harmonised to constitute a networked system of identities, rather than a singular identity. Here I refer to a professional who has to undertake a managerial role, which often leads to a hybrid identity. The ways in which these professionals draw on institutional and professional logics provide unique insights into hybrid behaviour. The professionalism enacted is neither liberatory nor regulatory but is a hybrid of the two approaches.

9.3.1 Forms of hybridisation

In the data, various forms of hybrid roles were evident. The first is the *subservient hybrid* role. In this type, the professional capitulates to the demands of market and regulatory forces. The manager plays the role of the traditional manager but also performs optimally to meet the company's goals and objectives. The findings show that the manager shows genuine concern for the environment in which the company is situated and ensures that community projects benefit the people living in surrounding communities. However, these activities also have the effect of silencing any opposing voices and ensure a compliant workforce. The company's image and primary goal of profit-making through smooth operations are prioritised.

The second type of hybrid form is the *empowering hybrid*. Here the managerial function is not only to ensure a profit and smooth running of operations, but the manager is also an activist in the sense that s/he takes a personal interest in mentoring employees. Nemo refers to the importance of imparting soft skills and strategic management skills to his novice employees as a way of empowering them. This impulse emerges from his own formative years at the company when his managers took a personal interest in his development.

The third type of hybrid professional is the *transformational hybrid*. This professional uses her/his position to ensure that the younger generation of upcoming professionals is transformed from compliant novices to critically engaged employees. An example of this kind of hybrid is Rahul, the artist engineer who wants to fashion the leaders of tomorrow. For Rahul, this means that they need to be critical thinkers.

The fourth type of hybrid is the *rowdy professional*. Such a hybrid finds her/himself in such a position by accident and has to function to the best of her/his ability. Although s/he has to work within the

confines of the rules and regulations, s/he fulminates against rules that s/he feels are prescriptive. Although a witness to the negative effects of regulatory professionalism, s/he nevertheless complies with the dual impulses inherent in her/his roles as a manager and academic.

It is theoretically possible that the newly emerging graduate who enters the workplace might adopt different elements of the kind of professional they become in response to day-to-day operations in the world of practice. Internally too, fluid hybrid notions of professionality could be activated in varied contexts, with specific audiences and to activate targeted agendas.

Synthesis

In this chapter, I argued for an integrated professionalism which accepts the reality of regulation but responds to the practical and moral dimensions of chemical engineering work, and acknowledges the need for agency by professionals. The chapter also provides an understanding of the multifaceted nature of professional knowledge and the complexity of its enactment in practice in engineering sites, at UoTs and in industry. I showed how the different forms of professional knowledge are multi-layered and are activated differently by each professional in the enactment of practice. In conclusion, I drew on the notion of hybrid professionalism to show that professionals' need for autonomy and agency is balanced and guided by the need to operating in a regulatory framework that caters to the diverse needs of today's professionals. The following chapter presents the thesis of this study which elaborates how notions of professional knowledge can be activated in divergent and creative ways.

CHAPTER TEN

A MIGRATORY PROFESSIONALISM

Orientation

This concluding chapter comprises six sections. In the first section, I elaborate the notion of *integrated phronesis,* which was introduced in the previous chapter. I first probe the idea of phronesis, showing how the concept has been expanded to explore professional knowledge since its origins in the work of Aristotle. Thereafter, I explore the integration of this elaborated phronesis with the concept of professionalism, structuring this combination at three different levels: *integration of spaces* of learning: namely, the university and industry; *integration of personnel* within and across these sites of learning, and finally, *integration of the* spaces with the socio-economic system.

In section two, I work towards the development of a synthesis of academia and industry's conceptions of professional knowledge, in order to build a thesis about professionalism. Emerging from the various formulations of integration across spaces, people and systems, and the recurrent metaphoric analyses of migration and migrants, I distil the thesis of *migratory professionalism* which acts as the nub of this thesis. I depict this notion as consisting of six phases of an unfolding, evolving relationship between academia and industry. The thesis suggests a reconfigured partnership across the world of academia and the world of work.

Section three discusses the *significance of the study*, including its theoretical, methodological and contextual contributions.

Section four presents the *limitations of the study*, while section five makes suggestions for *future research,* and the last section presents the concluding thoughts.

10.1 Section One: Integrated phronesis

If we take phronesis as an organising framework for an exploration of professional knowledge (Kinsella, 2012), what are the implications for the ways in which higher education prepares students to meet the demands of the workplace? How does this translate into preparing students for the world of practice? To answer these questions, we need to look at how phronesis has been re-conceptualised. Current formulations of phronesis differ significantly from the way Aristotle conceived it 2000 years ago. Although a multiplicity of understandings characterise this notion today, I focus on those that deepen understanding of the relationship between higher education and the workplace.

For Aristotle, phronesis included notions of ethics (Kinsella, 2012) and it was also associated with practical wisdom. Aristotle coupled the concept with two other virtues, namely, techne and episteme. While episteme can be linked to current understandings of scientific codified knowledge, techne can be associated with craft knowledge or practice (*ibid.*). Kinsella draws heavily on Schön (1983) to invigorate the concept of phronesis using the latter's notion of reflection. In Kinsella view, phronesis emphasises reflection as a means to guide one to practical wisdom through the uneven terrains of practice. Kinsella's (2012) debt to Schön and Dewey can be gauged in her formulation of the characteristics of phronesis. Below, I expand on Kinsella's conceptions of phronesis and add a few new ones when reviewing professionalism.

The notion of an integrated phronesis is novel and therefore charting its evolution as a concept is problematic. However, the earliest suggestion of a possible integration was perhaps attempted by Plowright and Barr (2012) in their exploration of different forms of professionalism and the role of phronesis in responding to some of the challenges facing professionals. At its most basic form, the integration refers to the fusion of different forms of professional knowledge, namely, episteme, techne and phronesis (Plowright &Barr, 2012; Tynjala et al., 2020; Kristjansen et al., 2021). But these writers suggest that integration may mean more than simply an integration of different types of knowledge. Context, reflection and emotions, as well as moral action are some of the themes that have been identified as constituting the integrative qualities of phronesis.

10.1.1 Characteristics of an elaborated phronesis

In order to understand the term phronetic professionalism, we first need to consider some of the characteristics of the concept phronesis that have been elaborated as a consequence of this study. Phronesis can be regarded as embodied, relational, dialogic, artistic and transformational. These conceptions are drawn from the lived experiences of the participants reported in chapters four to eight.

Pragmatic phronesis

When making judgements, professionals use a practical frame to consider the usefulness of their decisions given the prevailing circumstances. Decisions derive from the practitioners' experience of the world and in considering solutions to problems encountered, they will first consider the viability or fit of the proposal. In the industry case studies, participants reported that as engineers, they first had to intensely study the problem and were then expected to provide ample justification for the pragmatic solutions suggested.

Embodied practical rationality and phronesis

Embodied phronesis suggests the interconnectedness of mind, body and context to apply wise judgement. This integration of body, emotions and the artefacts on site, including re-orienting of the self within the physical space, conveys a Gestalt understanding of phronesis. Nicolini (2012) captures this succinctly:

> The appeal of practice theory lies in its capacity to describe important features of the world we inhabit as something that is routinely made and re-made in practice using tools, discourse and our bodies. From this perspective, the social world appears as a vast array or assemblage of performances made durable by being inscribed in human bodies and minds, in texts and objects, and knotted together in such a way that the results in one's performance become the resource for another (Nicolini, 2012, p. 2).

The study participants note that a professional will solve problems without overt or conscious thinking. This is a very telling statement that suggests a special kind of intelligence that is imbued in the physical actions undertaken by the competent practitioner. Over the years, the practitioner has developed a repertoire of engagement with her/his context: tools, artefacts, people and spaces that enable a speedy response to problems that may engage newcomers cognitively. These become intuitively embedded in their being. Their ability to recognise problems and act immediately to resolve them emerges from phronetic thought.

Artistry and phronesis

I owe the next insight to an engineer who is also a Dean of the Engineering faculty at a UOT. According to him, phronetic professional judgements embrace an *artistic sensibility*. Other similar, less articulately conveyed views are that professionalism involves creativity and imagination. Thus, in as much as the decisions taken acknowledge practical solutions, the experience of practice is also regarded as an art form. This not only enables greater enjoyment and contentment, but also provides a way of actualising potential within professionals. It suggests that artistry is not merely amusement or diversion, but also a performance of one's self, as a commentator and contributor to one's environment.

Ethics and phronesis

A phronetic professionalism takes into account the nature of the decision being made and how it impacts those who will be influenced by its effects. Ethical concerns need to be a central feature of the judgments made by professionals if they are to be respected in the world. In reflecting deeply, they should consider the implications of their proposals on people, animals and plants. However, the current obsession with appeasing the forces of marketisation and globalisation means that the new mantra is efficiency and profit. The little voice of conscience that speaks to the welfare of people, animals and plants is easily silenced. Wise judgement is not simply a cerebral process as Aristotle would have us

believe, but is intimately tied to the broader social and environmental context. Phronetic professionalism derives its agency from situated, ethical understanding of professional knowledge.

Dialogic phronetic judgement

The relational nature of phronetic judgement not only allows for engagement of the self, but also takes into consideration engagements with significant others in the practice context. The novice engineer reflects deeply on problems drawing on a range of previous experience and expertise, knowledge and insight, and then proposes potential solutions. The data from this study shows that, these solutions were then critiqued by a panel of experts drawn from management. This process of iterative interaction between self-resources and the contextual, experienced resources of the work context best exemplifies the dialogic nature of problem-solving in engineering contexts. It is likely that each presenting professional context will yield its own discursive space of interlocutors, and interaction therewith would involve continuous judgment-making. Within the academic and industry contexts observed in this study, an oft-repeated pattern of problem-solving and judgement involved the novice engineer presenting her/his potential solution to a panel of experts before applying the communally agreed-upon solution in the field of practice. This panel made suggestions and the final product emerged from a dynamic dialogical process.

Transformative or agentic phronesis

Preparing the next generation of leaders to take the country forward is how one activist/Dean of Engineering described his role. Clearly, this academic viewed his role as more than just being a traditional lecturer, but included a vision of transforming young students into responsible leaders and good citizens. Here the Dean is enacting a phronetic professionalism which embraces the notion of the professional as a transformational leader. In this scenario, the professional will be expected to focus less on responding to pragmatic issues at hand, and more on engaging with the emancipatory possibilities of the practice situation. S/he is expected to critique received wisdom from others and to transform the given situation for social justice by overturning traditional ways of doing things through the power of imaginative possibility. This is her/his professional responsibility.

Hybridity and phronesis

A characteristic of phronetic judgement is the kind of thinking that emerges when forms of hybridity are infused into the practitioner. There is a blending of agency notions of professional knowledge and regulatory notions of a professional. In making judgements, the professional takes a unique vantage point, that of a hybrid professional who sees things from many viewpoints, including the agentic and the regulatory.

In this section, I expanded the notion of phronesis by attributing to it various characteristics that are relevant to how a professional responds to contexts in which different forms of knowledge are required to execute practice. What emerges from the entanglement of the different forms of knowledge is a phronetic professionalism characterised by agency, hybridity, dialogism, embodiment, pragmatism and artistry. These characteristics function to engage the professional more deeply with the problems faced by her/his clients.

10.1.2 Integration of an elaborated phronesis and professionalism

In the previous section, I showed how an expanded phronesis reflected through the prism of entangled forms of knowledge deepens understandings of professionalism, particularly its agentic and regulatory characteristics. In this section, I elaborate how phronetic professionalism needs to be integrated at three different levels. The first is at the level of institutional/organisational spheres, namely, the UoTs and the industry sites (spatial integration). Secondly, they need to integrate across and within the structural levels of the hierarchy of the sites (personal integration). Thirdly, the integration needs to happen at a macro-level across the social and economic system (systemic integration).

Integration across spaces

Integration between the university site and the industry site means that there is a need for collaboration between the two discreet sites to merge and form a 'third space' which should include phronetic elements from both worlds. Phronetic professionalism also needs to be integrated into the different levels of the hierarchy at both sites in order to engender the kind of transformational thinking and practice required to prepare novice graduates and workers.

The primary agents in bringing the worlds of academia and industry together are the academic mentor and WIL supervisor. In doing so, they should manifest a special kind of knowledge which I term as *migratory knowledge*. This embraces the phronetic aspects of integration, including its agentic and regulatory impulses. However, it also includes knowledge of the social and global as well as cultural forms of knowledge. While this knowledge is seemingly discreet and derived from its baseline location, within the separate spheres, these agents are best able to potentially straddle the interconnection that serves as a bridge across the two contexts.

Integration across levels

Phronetic integration will need to permeate all levels of the hierarchy at universities and industry sites to ensure a deeper and more meaningful understanding of the relationship between these worlds. At university level, current understandings of WIL are limited to specific academic staff members tasked with the responsibility of ensuring that students find suitable places in which to perform their WIL

requirement of six months. During this period, the academic staff merely go through the motions of supervising and meeting their industry counterparts to complete the ritual of WIL. Invariably, the contractual relationship is one of placement of students, rather than the development of a partnership between the student and the workplace context.

In a phronetic dispensation, all academics will be required to engage deeply with the idea of migratory knowledge. A more intimate understanding of the processes involved in WIL will enable academic staff across all levels to contribute to the development of a curriculum and pedagogy appropriate to the WIL process. This process will not be a stand-alone undertaking but will need to be fully integrated into the broad formal curriculum of the university. University staff will not only engage with novices and management, but also reach out to their industry counterparts to engage collaboratively in this phronetic endeavour.

Integration with the social system

Integration at the social level involves the different ways in which society is implicated in the teaching and learning situation in which novices are prepared for the workplace. In a phronetic third space, community members and organisations need to be represented in the dialogical processes between universities and industry to ensure that the processes and products created do not have an adverse effect on those living in close proximity to industry sites. As shown in this study, current practice is that industries use money and power to silence activist campaigns that seek to draw attention to the harmful effects of the waste products polluting the environment.

Integration of phronetic thinking and acting at the personal, institutional and systemic levels will contribute to greater professionalisation. By engaging with the self, community and the world, the development of the professional is viewed in inclusive terms rather than in adopting a narrow parochial vision. In the next section, I elaborate on how academic and industry conceptions of professional knowledge converge by exploring the notion of *migratory professionalism*.

10.2 Section Two: Towards a thesis on academic and industry conceptions of professional knowledge: Migratory professionalism

This section builds a thesis around the concept of professionalism by synthesising academic and industry conceptions of professional knowledge. By engaging these conceptions across spaces, people and systems, and through incorporating the recurrent metaphoric analysis of migrants and migration, I crystallise the notion of a migratory professionalism. This is then presented as evolving from six phases

of an unfolding relationship between academia and industry. I conclude this section by drawing on a triple helix framework to explore a reconfigured relationship between academia and industry.

10.2.1 The migrant, geographic crossings and professional knowledge

In trekking from one space to another, the migrant's sensibility needs to be open to possibilities as s/he traverses across changing learning geographies. Likewise, professional knowledge is dynamic and stable at times, changing when necessary to accommodate new relationships and ways of seeing as it meanders through the contours of academia and industry. The novice's forays into a strange new world, leaving behind an old dispensation with its familiar people, objects and pathways, bring a great deal of uncertainty and fear, which may affect the performance of her/his duties. Winning legitimacy, acquiring a new identity and adjusting to a new environment can be problematic.

The problem with current pedagogy within professional knowledge and academic spaces is that it foregrounds codified academic knowledge rather than ways in which students can cope with new work environments. There seems to be an implicit transfer of responsibility to the graduate student themselves to manage migration from the world of academia to the foreign world of work. Curricula do not capacitate students to merge the situational and emotional aspects of work. Personal narratives or stories, such as those revealed in this study, are one potential resource to activate an interactive space between academia and the world of work. These narrativised accounts have an emotive content which can be used as a basis for deep reflection for a graduating professional. The kinds of challenges recounted by practitioners both in and outside academia could form the basis of critical reflection on post-work placement workshops and new kinds of pedagogy that deal with university-industry interface experiences. This could assist in dealing with a range of professional issues that are practical, dynamic, dialogical, transformative, agentic, ethical and artistic.

The hybridisation of these multiplicities constitutes a sophisticated resource for a migratory professionalism. Moreover, these experiential knowings, from both worlds, whether positive or negatively experienced, enable one to tackle a range of complex issues about being and becoming a professional, including issues such as racism, and gender inequality. Migratory professionalism is not about seeking a reductionist, simplistic certainty, sanitised to only the pragmatic and parochial, the expedient and the efficient. Instead, its agenda is to promote and tackle the multiplicities of authentic complexities of studying, being and becoming a working professional.

While practice knowledge, with its links to the social creative contexts, is regarded as highly individualistic and is expressed in multiple ways, some theorists regard theoretical knowledge as fixed. Indeed, many of the study participants tended to see chemical engineering as consisting of core science subjects. However, these circumscribed understandings of different forms of professional knowledge

have come under pressure. As understandings of professional knowledge acquire greater complexity in the crisscrossing of epistemological and ontological streams of thought, reductionist technicist, dialogical constructivist, agentic critical realist and pragmatic materialist ways of looking are beginning to intersect, revealing greater layers of complexity to notions of professional knowledge.

I draw on the analogy of migrants and migration to illustrate the complexity of this interchange between two boundaried contexts. In her/his quest for survival, the migrant is expected to be able to adapt in flexible ways to deal with the new circumstances of ever-changing contexts. Her/his experiences are complex and layered as s/he experiences many (foreign) cultures. The migrant's own cultural traditions criss-cross with her/his adopted ones in changing landscapes and her/his practices reflect an eclectic mix of different traditions. By "own culture", I refer to the heritage and cultural traditions which migrants carry into the "new world". These may be the same or quite different from the traditions that they will experience in their host country. Acknowledging the complex merging of cultures allows the migrant to fully integrate into the host society while perhaps also retaining elements of her/his own cultural identity.

It should be noted that in the fluid migratory space, the migrant is also aware of all cultures' potential to be modified, adapted, and re-imagined. Migration is thus an act of creativity and innovation. It is also a space where it is recognised that one's cultural legacies are not essentialised, homogenous, stable and completely incontestable. They may embed elements that constitute an internal dialogical contestation. Culture simultaneously embeds sets of complementarities and paradoxes. After all, it is by definition a fluid interpretation in relation to space, time and context. Migration allows for a critical vantage of one's source and host contexts, spaces and actors.

Likewise, notions of professional knowledge, which circulate within the confines of the identified activity systems like the university and industry site, are flexible and integrated, enabling a more complex understanding of professional knowledge. The novice engineer who enters the new workplace is mainly equipped with theoretical knowledge and limited technical competence with regard to a few instruments. In order to problem solve, s/he needs knowledge of the workplace that is much more layered and complex.

The migrant criss-crosses uncharted seas using the guidance of her/his astrolabe and the stars to steer the ship to safety. The sea refers to the treacherous nature of the cross-over from one system to another; for example, the university graduate moving into the workplace context. The astrolabe is an ancient instrument which sailors used to navigate the seas by charting the position of the stars. The stars that the graduate uses to guide and navigate in the new seas in which s/he finds herself, are the sources of the knowledge located in the new environment, including the network of available human and non-human resources.

This metaphor calls attention to the material embodiments used in practice. Material embodiments in the engineering workplace refer to not only the tools that an engineer will use to problem solve but also how s/he uses her/his body to interpret the spaces that s/he inhabits. For example, the physical smell of oil will alert her/him to a machine that is malfunctioning or a beep may provide other kinds of information alerts. Thus, her/his practice may respond in unconscious ways in which her/his body reacts to the environment. Equally, the ways in which s/he interacts bodily with the machinery and tools in the workplace will convey much of her/his learning, but in implicit ways. A novice engineer will need to develop these repertoires to demonstrate sophisticated, integrated professional competence.

The astrolabe represents the box of skills that the novice engineer brings from her/his previous culture of the university, and that s/he hopes will enable her/him to engage creatively with the new and hostile environment of the workplace. However, the astrolabe is merely a guiding tool to steer the journey. The journey is one which professional themselves will need to undertake in response to this complex ambient environment. The choices of the journey develop a particular form of episteme, techne and phronesis that is evolving, mutating and migrating. The mission is not a sole but a communal journey with multiple actors, and different spatial contexts inside, within and across academia and the world of work.

10.2.2 Border crossings

To the migrant, borders are highly emotive spaces that either represent old tyrannies from which they have escaped or prisons to which they may be deported. Borders come to symbolise the potential for a new life of liberation, if the transition can be made successfully. The theme of border crossing is thus highly valued as a theoretical exploration. In bringing the worlds of the university and industry together, the outward and inward flow of knowledge through porous borders may be one strategy to create a robust relationship between the systems. Borders are spaces that are resource-rich for inter-professional encounters. They are the point at which different systems co-mingle and generate a third space.

This thesis therefore, argues for the creation of such a space in which the university and industry engage in what I call discursive procreation. A migratory professionalism argues for a hybrid space in which the two entities create a new space in which the boundaries are not seen as limitations but as liminal spaces where creative transitions occur. This third space which is both a psychic and pragmatic construction, will be managed by representatives of all the stakeholders involved in the learning process. These include representatives of government bodies, academia, industry, and regulatory bodies. Where previously, power and jurisdictional control within collaborations were skewed in the direction of the regulatory bodies and government, a more equitable power distribution is envisaged in a new dispensation with each sector representative having an equal say.

10.2.3 Knowledge transfers: Universities and industries

In the South African context, knowledge transfer from UoTs to industry is primarily limited to the WIL programmes that have been put in place to ensure that undergraduates receive some exposure to practice in real-world settings before they graduate. As former Technikons, UoTs historically enjoyed stronger links with industry than traditional universities and one might expect vestiges of this relationship to still exist. Given the different relationships between these sectors, what are the implications for knowledge transfer from one context to the other?

Within UoTs, lecturers are guided by the content found in particular configurations of courses or disciplines that make up degrees. These are also linked to the field in which these disciplines are situated. Lecturers who have been exposed to occupational practice, either through their own experiences or vicariously, are guided in their selection of content to embed in their syllabi. Eraut (2009) makes the point that when faculty make selective in-house appointments of graduates to academic positions, not much priority is given to those with relevant occupational experience in engineering fields. Consequently, there is a tendency to pay attention to the worth of the candidate to the discipline rather than on relevant industrial experience. It appears that universities are preoccupied with codified formal knowledge probably because opportunities for experiential knowledge are limited to laboratory sessions and WIL encounters.

It is only fairly recent that the WIL practicum experience has become a subject of study and reflection. Codified knowledge is knowledge that has been written down from occupational practice by those who have experienced or witnessed it in a particular discipline. It may contain the laws and maxims of that discipline, as well as the ways in which processes and products are performed and constructed (Eraut, 2009). In my fieldwork, the participants reported that documents produced within industry, like the reports written by engineers when they encounter problems, are recorded and kept in the company library. These reports become the archival material which other engineers will consult when a similar problem is encountered. This saves time, effort and money.

The official archive constitutes the company's codified texts (knowledge base) and is guarded and regulated by senior personnel. This gives management a sense of how problems are diagnosed and addressed. A weekly progress report is also sent by more junior personnel to upper management to keep the latter informed on the company's progress and documented codified knowledge base. Although the report takes a written form and usually follows a specific template which may differ from company to company, engineers are expected to deliver an oral report based on their findings after investigation of a problem. This allows for discussion of the issue and immediate feedback from a range of role-players, including senior engineers who can advise on processes that need to be followed. These unique oral

and written reports constitute the lived memory of the organisation and make up a body of professional knowledge into which novice incumbents need to be inducted.

What kinds of knowledge are transferred from the university to the workplace? Does the codified body of knowledge from the latter filter into the spaces of the former, and if not, why not? In order to answer these questions, this section first sketches the broad context for the emergence of different forms of knowledge in the context and evolution of both universities (academia) and companies (work). Learning is shaped by the context in which it occurs and in the process, it also shapes the context. Knowledge sharing occurs in dynamic contexts whose contours are always evolving as new knowledge is created and shared.

The university and the workplace are two very dynamic contexts in which learning occurs. Not only do humans interact to produce knowledge; there is also an exchange of *artefacts* created by personnel in each context. For example, a university might draw on a wide network of relationships in the social discourse community of theoreticians and researchers (its "context") to produce the knowledge it requires. Such networking also includes engagement with its unique artefacts like books, machinery, and other discursive arrangements like conferences, seminars, workshops, and meetings, usually embedded within conventionalised structures and systems. These assemblages of objects impact on learning and subsequent production of knowledge within academia.

By drawing on the socio-material perspective of knowledge creation, I highlight all the relevant influences on the ways in which knowledge is constructed in social contexts. This description of how universities produce their knowledge can be argued to be different from the processes and products that the world of work chooses to establish its unique codified knowledge systems. It is not therefore not surprising that the two worlds are considered as serving divergent discursive communities, with divergent agendas.

Codified academic knowledge is a common form of explicit knowledge in the university setting. This can be found in print or virtual textual forms, and is made accessible via publication by editors and webmasters who will look closely at the language and content of the article. The content of these texts is academic and they are generally housed in libraries and are now available on the internet. The academic orientation of these texts deals with issues that mainly focus on disciplinary knowledge. As the university is stratified into different faculties and departments based on compartmentalising subjects and disciplines, academic texts are organised along fields or disciplinary lines.

Successful transfer of academic knowledge from one system to another will depend on how the borders of the two systems are defined. Are the borders strongly regulated to avoid permeability? Are legacy mandates strongly clung to, or is there fluidity to embrace new worlds and cultures? Are these spaces

for migration indeed collaborative and dialogical? Will there be enough opportunity for the individual who has successfully negotiated their journey in one place to be able to harmoniously journey from university to the workplace? Whose knowledge-making systems and cultural worldviews will come to be considered the preferred rational and pragmatic rules of operation? Will graduates be able to activate their theoretical knowledge drawn from their training contexts, in the world of work? Will they be able to successfully negotiate using the university's learning and company's facilities to extract potential explicit knowledge to problem-solve? Are graduates sufficiently oriented to the diversities of new cultural worlds and their attendant cultural workplace logics? Will the novice graduate and the newly-appointed professional be granted access to the codified knowledge archived within the company? How is access to the codified knowledge of the world of work activated?

At university, the graduate may be a successful student who is able to master a particular subject and complete all her/his tasks using the explicit knowledge provided by the textbooks and the lecturer. In the workplace, this person assumes another identity as a young professional and is placed in a situation where s/he has to problem solve. Using theoretical knowledge may not be as easy as acquiring it at university. A range of issues is at play that s/he has to consider. For example, s/he is not working as an individual, but is part of a team and has to ensure that her/his part of the work is completed on time in order for the next multidisciplinary team to take over. S/he has to present her/his work to a colleague and a supervisor summarising the salient points such that they make perfect sense.

The problem to be solved needs to be thoroughly researched, and senior members of the company need to be probed about it. Theoretical and abstract knowledge will be used at a much later stage. Thus, at the workplace, codified academic knowledge needs to be activated in conjunction with other kinds of knowledge. The study participants consistently reported that only a limited proportion of codified academic knowledge was used in problem-solving. Of course, this does not mean that codified theoretical knowledge is not useful – on the contrary, it forms the basis of all disciplinary learning. Together with practice knowledge, it is used to innovate in the workplace.

While codified knowledge is explicitly taught at university, *personal knowledge* may be more difficult to acquire formally as much of it is acquired informally and it is therefore tacit in nature. Eraut (2008) describes personal knowledge as that which workers use to enable them to think, interact and perform. Graduates have different levels of such skills and they are not formally taught at university although they may be partially addressed within courses on communication skills. Communicative skills are imparted to undergraduates in order to enable generic, abstract communicative strategies to activate dialogue as a professional. This kind of "communications-knowledge" is usually of a structural-functional character rather than directed towards specific professional domains.

A graduate who is not adept in using communication skills will have difficulty in negotiating the terrain of the workplace as this involves communicating with workers at different levels. A codified version of personal knowledge is the art of writing various kinds of reports. These are covered at university in the form of writing exercises and written assessments. Codified knowledge of writing skills is considered valuable at the workplace as coherent and accurate reports are required.

Personal knowledge also includes everyday knowledge of people, and know-how in the form of skills and practices. It is usually aimed at activating self-knowledge, attitudes and emotions. These affective levels are perhaps by-products rather than centrally foregrounded within communications curricula. Although Eraut isolates each different knowledge type, he makes the point that attitude to knowledge should be holistic rather than fragmented (2008, p. 2). University curricula that aim to develop graduates' communicative competences perhaps need major reconsideration since they tend to defend fragmented, disconnected ways of being rather than activating a more holistic consideration of what communication entails. This is compounded by the specific nature of different professional-communicative discourses both inside and outside academia and the world of work.

Besides structural systemic challenges, one also needs to consider the nature of *specific individuals and their personal characteristics and personalities* as they traverse the two worlds. How well a person is integrated into the workplace will also depend on their individual nature as well on her/his communication skills. Many of the participants reported that a person who is aloof and has a haughty attitude may be shut off by members of the team. It appears that team members value a humble disposition and willingness to learn. Lave and Wenger (1991) assert that old-timers control access to the community of practice (COP) and that the relationship they share with their mentees is paramount (Lave & Wenger, 1991). Forming personal relationships at work with supervisors and colleagues depends on the personal knowledge one can use. A further insight into workplace knowledge is provided by Eraut (2004) when he suggests that a number of COPs may exist at any given time in a workplace context. This is true of the field of chemical engineering. Membership of one COP may deepen understanding of knowledge in another one.

This section outlined the various types of knowledge that are used in the two activity systems, namely the university and industry. They include *personal knowledge, cultural knowledge, practice knowledge, codified theoretical knowledge* and *knowledge of the self*. In any given instance, knowledge is never isolated or fragmented. The use of different forms of knowledge is seamless and the more competent the practitioner, the more facility s/he has with professional knowledge.

The process of becoming a professional entails a journey of migration both into one's own legacies (oneself), but also the system from which one's unique cultural forms, rituals, beliefs and practices

originate. Developing professionalism could be a dialogical, artistic migration of self and others. The successful journey is potentially one of creativity, innovation and re-imaginations.

10.2.4 Migratory professionalism

In fleshing out a framework that examines the learning trajectory of transforming novices into professionals as a single system, I invoke the notion of a *migratory professionalism*. The word migrant conjures up images of emigration from poorly resourced spaces to resource-rich countries, border crossings, and "alien" invasions. While these images tend to be negatively portrayed in the media and public discourse, I rehabilitate the metaphor of migrancy to consider its usefulness in conveying ideas about professional knowledge as deployed in understandings of how novices traverse the worlds of academia and industry. This section details six phases of a migratory professionalism which explores professional knowledge trajectories in inter-professional encounters as in WIL programmes. I conclude by proposing a triple helix framework to explain the need to reconfigure traditional relationships between universities, industry and regulatory bodies.

10.2.5 Six phases of migratory professionalism

This section traces the evolution of the newcomer to professional in the six phases that emerged from the study's findings. These are summarised in Table 11 below.

Table 11

Knowledge transfer model

Stage 1	**Identity at the margins**	**Novices engage with self-knowledge. Rethink themselves as they cross into industry. Familiarity of new space, artefacts and people. Professional knowledge as engagement with materialities and emotions. Use of previous knowledge to mediate new situation**
Stage 2	**Sojourn at the margins**	**Knowledge in practice. Activation of theoretical knowledge. Reconfiguration of old into new.**
Stage 3	**From the margins to the mentor**	**Partnering with mentor, teams and collaborations.**
Stage 4	**From mentor to centre: Mastering cultural knowledge**	**Ease of practice. Tacit knowledge becomes habits of hand, body and mind. Development of new knowledge**
Stage 5	**Re-contextualised knowledge and competent practice**	**Demonstration of expertise**
Stage 6	**Professional phronetic practice**	**Use of phronesis to inform professional action**

Stage one: Identity at the margins

I have labelled the first stage of knowledge transfer from the university context to the workplace as *self-work* as it involves a clash of identities. Students who make the transition undergo an identity change and start viewing themselves as novice workers. During this period, novice workers become familiar with the new environment; its learning spaces, artefacts and fellow workers. They have to re-think themselves from consumers and regurgitators of codified knowledge to active users and creators of knowledge in real practice settings. In their interactions with the material embodiments of the new space, novices quickly acquire new knowledge. This learning contrasts sharply with that gained at university which tends to be more theoretical in nature. University learning has come under sharp criticism from industry personnel who claim that students are unable to apply the theoretical knowledge gained in practice.

Another key finding as expressed by participants in this study is that deep reflection about the practicum experience is lacking at their universities as there is no place in the curriculum for such reflective practice. The study also shows that academics are of the view that the codified knowledge acquired by students at university is sufficient for practice situations in the workplace. The participants from industry claimed that only a limited amount of such knowledge was utilised. Moreover, since university preparation for engineering work caters for a broad sector to ensure employable students, novice workers find employment in sectors for which they did not receive specialist training. A fairly common conception is that novices are expected to hit the floor running. This study shows that while this may be true in some quarters, the majority of the industry personnel agree that a period of training is required before newcomers are expected to work independently in the field.

The creation of a third space is necessary to deal with such anomalies in the system. Students need to be capacitated to use their theoretical knowledge to deal with problems in different sectors. In addition to equipping them with detailed codified knowledge, more time should be devoted to capacity building, teaching them how to engage with new and alien work environments.

Stage two: Sojourn at the margins

I have termed the second stage of knowledge transfer sojourn as it emphasises the newcomer's need to display *familiarity with the physical features of the site and artefacts*. At this stage, the novice is familiar with the site and its sounds, but is still not confident to undertake tasks on her/his own. S/he is placed in a team and given specific tasks to complete. Novices find it difficult to read a situation in the workplace as they might only perceive attributes or aspects of the problem situation. Proficient workers view situations holistically and are able to identify the most important aspects of the situation. They reflect on experiences, learn from colleagues and superiors and try to link current experiences with those in their memories.

As noted previously, the skills of *selection and reorganisation* with regard to theoretical knowledge will take place in situations that are "messy" and "unpredictable" after transfer from the university to the workplace. The latter space is characterised by Schön's (1983) swamp metaphor where the neat solutions to problems that novices would find in university textbooks, do not exist. A university, there are no cost or time limitations; therefore, there is no urgency to find solutions. Time and money are lost when problems occur at the workplace and efficient solutions need to be found despite the swampy messiness of things. This is one example of the important differences between the two institutions.

While in the team, the novice starts to build confidence, but also finds the situation uncomfortable and uncertain as s/he is collaborating with more experienced senior personnel. In trying to be perfect so as to not appear incompetent and lacking in knowledge, s/he makes mistakes. Thus the new context of work is characterised by discomfort and a lack of confidence. Knowledge use is tentative but the safety net of senior personnel allows for mistakes.

Stage three: From margin to mentor

In stage three, knowledge transfer mainly occurs between the *mentor and novice*. In this stage, a newcomer is fortunate if a benevolent old timer takes her/him under her/his wing. The mentor creates opportunities for the novice to gain more diverse experience, increase her/his knowledge and thereby progress rapidly through the ranks. The participants reported that attitude and communication skills play a critical role in ensuring interaction between mentors and their mentees. Novice members who have been marginal team members become core members after a few years and are eventually promoted to team leader. The staff member is then allowed to work independently on-site because s/he has demonstrated competence in a particular area of expertise.

Workplace managers are aware that many who make the journey from UoTs may not have had the relevant experience that is required. Despite this, many graduates are taken on, and with time and training they seem to have done well. Nonetheless, industry would prefer graduates to be fully-prepared. This issue needs to be debated. Academia feels that it is not their job to train students for specific jobs – this is the prerogative of the industry in which the young novice finds her/himself. The university provides the codified knowledge, and the learner has demonstrated in examinations and other assessments that s/he fully understands the import of the theoretical jargon. The problem lies in applying this theoretical knowledge to practical problems.

Problems are ubiquitous, and institutions and organisations will address them in different ways. While the workplace places higher value on practice knowledge, it does not abandon theoretical knowledge but sees it as critical in engaging new problems that defy regular solutions. Theoretical knowledge is thus as necessary as practice knowledge, and they need to be *integrated* to solve problems.

Acquiring the cultural knowledge of the workplace and that of academia is quite different. Although one is attached to a mentor in the workplace, it is the COP that enables acquisition of significant knowledge to function effectively. The mode of acquisition is not a formal examination, but *participation in practice*. A conception shared by many participants is that theoretical knowledge can be easily transferred as it is general. However, not all theoretical knowledge is easily codified as much of it is tacit and can only be conveyed in situations of practice.

While there is no doubt that theoretical knowledge is easily packaged, transferable and is general, there are instances when the core knowledge that one receives from university only forms the base of the knowledge that one still needs to acquire. This is in regard to specific workplaces. For example, in the chemical engineering context, being prepared for the water industry means quite a different thing to being trained for the paint industry, despite the fact that core engineering knowledge in mathematics and the sciences may be common to both. The novice newcomer needs to accumulate the theoretically specific knowledge of the sector in which s/he is placed. This thesis calls for *specialised training* to be provided by industry. Expecting the newcomer to be fully prepared without any training suggests that industry wishes to abdicate the responsibility of training graduates and newcomers. This adds to the blame game played by academia and industry where each accuse the other of not engaging students effectively. The third space that I advocate for should address this practice/theory gap in a more substantial way and bring all stakeholders together in robust debate on the responsibility of teaching and learning and training in academia and industry.

I now turn to an important aspect of *transfer* which is highly individualistic, and deals with the dispositions of the transferee. The importance of communication skills was noted previously, as well as a humble attitude. In this section, I continue this discussion, showing how dispositions enable a newcomer to become easily socialised. Participants reported that the development of a person's professional identity and self, and soft skills are particularly important in order to succeed in the workplace.

To summarise, the third stage of transfer is gaining a *situational understanding* of the network of people, their skills, personalities and preferences, observation of processes in the work space and mastering engagement with artefacts relevant to the practice.

Stage four: From mentor to centre: Mastering cultural knowledge

The curriculum at the workplace is created by the community and access is granted to the newcomer via *legitimate peripheral participation* (Lave & Wenger, 1991). In other words, the newcomer starts at the margins of the community. Opportunities for engagement unfold as the curriculum is determined not by systematically following the outcomes to be met, but by observance and the invitation from

supervisors and senior personnel to participate in the community's activities. Knowledge is generated in practice and its circulation is strongest amongst peers.

The newcomer assimilates and absorbs the activities of the master and her/his fellow workers. Many participants complained that they did not go through an induction as a way of introducing them to the community of practitioners. In preparing the candidate, universities should ensure that their pedagogy offers students practice in oral communication skills. These would include introductions, fielding questions, sustaining conversations on a professional level, and being strategic in negotiating one's position *vis-à-vis* others and superiors.

In familiarising themselves with the culture of the organisation, newcomers should become aware of the company's mainstream activities, including who participates in these cultures and what tools are used to accomplish the tasks. They then need to sharpen their skills in using these tools in the hope that they will be invited to participate in mainstream projects. In the meantime, they are expected to demonstrate competence in performing marginal tasks. Industry reports that before newcomers can engage in more complex tasks or practices, they will occupy a trajectory of positions. They are placed in different areas in order to gain exposure to the different types of work practices in the field. Industry reports that in each position, the candidate trains for three to six months before moving on to the next level of training. During the newcomer's journey through these COPs, s/he learns about the technical aspects of the practice but, crucially, also who is involved in the COP.

The third stage of knowledge-transfer entails recognising what knowledge and skills are relevant. In the classroom, the educator presents a range of theories that may be used at a given time and discusses these critically with the class. In the workplace, however, time and a heavy workload do not allow this luxury. The employee confronting the problem relies on memory and other cognitive processes to determine the way forward. The process is tacit and also involves embodied responses. Theory is embedded in the practice. The choice of which theory and practice will be undertaken will depend on the practitioner's experience and the relevance of the practice most suited to the problem. In many cases, the practitioner relies on support from the team rather than a textbook or journal. At best, there may have been a similar problem in the past, and a report on how it was dealt with may exist in the company library.

The study participants also mentioned that local and international consultants can be accessed online for immediate feedback on problems. There are thus no ready-made or neat solutions; the problem is resolved through tacit responses and collective consultation. Furthermore, theoretical knowledge of the relevant processes that was acquired at university may be triggered by a specific situation. The skill of the practitioner lies in matching the two processes: recognising the appropriate theory and matching it to the problem Over time, novices start to recognise patterns of problems that develop in the workplace. Ways of problem-solving may also change as new learning occurs about situations and new technology

in the workplace. In sum, choosing the right theory and response will depend on the practitioner's experience. For the newcomer, making mistakes and learning from them – troubleshooting and learning and leaning on others for guidance, is part of the learning trajectory.

Stage five: Re-contextualising knowledge

Knowledge transfer often involves knowledge that needs to be *re-contextualised* (Bernstein, 2000). This often implies that a selection is made and changed to meet the needs of a changed situation. Take for example, academics who need to teach students some important aspect of chemical engineering. They will first consult the syllabus in order to choose the relevant topics for discussion. They will then decide how to reformat the knowledge in order to make the pedagogy effective. Thus they seek to look two ways, namely, to the field of specialisation which is the discipline and to the teaching of students in a chemical engineering class at university. The new knowledge that is pedagogised will be taught to students and this needs to be interpreted by students and later be re-contextualised at the workplace. Making relevant and using the knowledge gained in the classroom to fit the messy field of practice is challenging for students.

Stage six: Professional phronetic practice

In this stage, the employee is ready to be *credentialed* as a professional. This may occur formally as in formal registration with a professional council. At the workplace, solving problems becomes easy for the professional as her/his familiarity with the field and expertise provide the means of engaging successfully with issues at hand.

The professional not only demonstrates competence but also builds socially responsible ways of undertaking projects into her/his solutions. S/he demonstrates both the agentic and regulatory dimensions of professionalism.

In the next section, I use the triple helix model of knowledge integration to consider a new, revitalised relationship between academia, industry and regulatory agencies.

10.2.6 Reconfiguring academic and industry relationships: A triple helix

This section argues for the notion of a triple helix as a framework to explore conceptions of professional knowledge across the three domains of academia, industry and regulatory agencies. This framework demonstrates a process of preparing graduates not as a disjointed and fragmented system, but as a single one that fuses university teaching and learning with authentic practice encounters in appropriate workplace contexts.

I use the notion of a spiralling triple helix as a framework to explore integration at the personal, social and system levels. It acts as a *physical* as well as a *discursive* construction. As a physical space, it

locates the learner in an environment which will prepare her/him to handle the challenges of the workplace. It points to the physical spaces which a learner traverses during her/his WIL orientation and practice and also refers to the authentic laboratory experiences at university.

The triple helix knowledge ecosystem is a model of knowledge sharing which includes industry, academia and regulatory agencies in intertwining relationships where convergences provide opportunities for dialogue, debate and the design of new collaborations to address the problems of knowledge production, transfer and application. Sharing professional knowledge through the intersecting worlds of industry, academia and regulatory agencies is best exemplified by the image of the spiralling triple helix. While each strand dances independently, they all converge at several points during the dance. It is these intersecting nodal spaces that carry the potential for actors to develop solutions to the problems they experience as knowledge silos. It is envisaged that WIL and other knowledge platforms will serve as opportunities to come together in new and robust formations to address professional issues affecting the three agencies in question. An image of the triple helix and a list of a few of its characteristics are presented below.

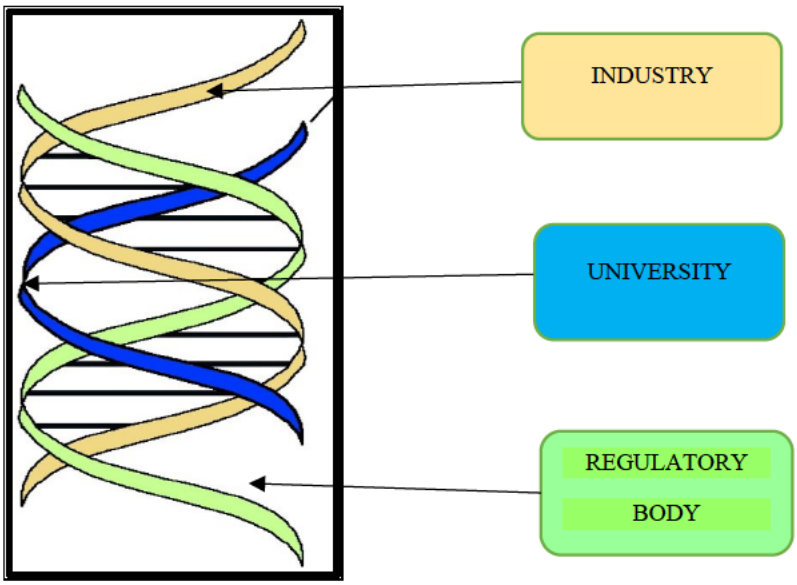


Figure 11: Triple helix (Adapted from Siedman and Galzer, 2003)

Characteristics of the triple helix

- Distributed – evolves at different times in different spaces depending on the needs of each entity.
- In the new relationship, there is no central organising framework. Instead, there are nodal points which are created by the needs of the three entities in the triple helix relationship.

- Non-linear, non-hierarchic – No single entity dominates. Instead, expertise and understanding will be shared across the systems.
- Multiple geometries and levels – conveys the idea of fluidity of space; of traversing different learning contexts without the hindrance of boundaries.
- Functions across spaces and hierarchy.
- Nomadic – it is not subject to time. It can cross boundaries.

Since professional knowledge has come to be seen as dialogical, embodied, democratic and contested, a migratory professionalism allows for a less fragmented vision of knowledge transfer from university to industry. I believe that more transparent and robust collaboration is required in order to make the transition far more meaningful and effective. This will entail the following features:

1. Allowing student voices to be heard in the triple helix configuration.
2. Each strand of the triple helix, namely, industry, university and the regulatory agency must be heavily invested in the new alliance; for example, experts from all three sectors need to be retrained in curriculum construction and pedagogy. These experts will lead the transformation of relationships.
3. The relationship will be based on each partner bringing their strengths to it instead of using one's power to dominate; power could be used to assist, uplift and transform creatively. While this may seem idealistic, it needs to be acknowledged that all stakeholders have different kinds of power in the relationship and will need to use it differently. Of course, more vibrant and better-resourced organisations may use their size and prestige to bulldoze or dominate. There is a need to guard against a situation where the economic imperative guiding transformation overshadows the importance of exploring academic and professional knowledge. Universities must maintain their identities as producers of knowledge in as much as they serve to prepare graduates for profit-making industry.
4. A dialogical space should be created in which the third space for this initiative can be adequately theorised. It is in this third space that a renegotiation of the partners' identities can occur and in which merged identities can be inscribed.
5. Embracing the critical role played by regulatory bodies as a third component of the traditional WIL relationship.

Chief Executive Officer of Universities South Africa Ahmed Bawa (2017), proposes a new architecture to describe the university and its envisaged multi-site engagement with industry:

> Just as universities are specifically designed for research and teaching/learning, they must be designed for engagement with multiple dynamic interfaces where the intersections of humanity, its poetry, its technologies and nature are re-imagined by multiple partners on an ongoing basis. The need for porous boundaries that are physical,

> intellectual and sociological in nature is vital for the university as a social institution to be home to different modes of research and teaching/learning and to permit for free, unhindered flow of people, ideas, methodologies and technologies and through which multiple ways of knowing may interact with each other (Bawa, 2017, p. 10).

Where previously boundaries were the source of limitations, they need to be transformed into spaces of creative engagement and potential for innovation. The structure and architecture allow for new ways of knowing and newer conceptions of knowledge that circulate seamlessly in a single system.

Imagine a scenario where the old WIL is history and in its place is a radically different configuration for training graduates for industry. How will this architecture look? What forms of knowledge will circulate within this system? Clearly, an Aristotelian influence in the form of phronesis needs to be the guiding influence on all forms of knowledge fusions and relationships. This could not only link the relationship with classical tradition but could also ensure that both practical wisdom and ethics are critical to notions of professional knowledge.

Will these be driven by pedagogy and assessment? Which spaces will students and their mentors need to traverse in enacting learning? What will the new syllabi look like? Will these be different for different industries or one single system? Will epistemic knowledge be taught separately or will it be conjoined with techne as in the old dispensation[9]? Will the current problems be addressed to create newer ways of engaging with theoretical knowledge in the workplace?

In a migrant professionalism, higher education teaching will be undertaken by both academics and industry specialists in spaces where technology and other artefacts of learning are available for use by all. Opportunities to participate in the rituals of practice must be shared by all. If the domains of academia and industry decide to isolate themselves in their citadels of knowledge, they may risk producing graduates without the requisite skills that industry demands. All the while these domains exercise jurisdiction in their knowledge boundaries to ensure their survival, they doom themselves to remain ossified in past frozen relationships. Some of these UOT-industry partnerships were dictatorial and unidirectional, with agendas set by captains of industry to create a servile labour force instead of the creation of dialogical spaces of learning.

Regulatory bodies like ECSA can play a critical role in the relationship between academia and the workplace by ensuring that universities capacitate students to deal with the messiness and uncertainties of practice. They could also ensure that all students find placement at relevant companies for their in-service training. Their role in the professional development of personnel could also be enhanced by

[9] Traditionally techne or craft knowledge was taught to students either in a laboratory setting at university or as a work-integrated sojourn for a period of time in a workplace setting.

finding ways of collaborating with universities to create opportunities for transfer of staff from one sector to another as part of their professional development.

Table 12

Characteristics of a migratory education system

Mode	Old	New
Teaching/ Pedagogy	**Academics teach codified knowledge in the university space**	**Engineers and academics teach collaboratively either in the triple helix or traverse their traditional spaces**
Lab work	**Academics work in labs with limited resources; as a result, students have to share**	**Academics work in resource-rich sites or in the workplace with authentic materials and objects**
Theoretical knowledge	**Codified knowledge at university**	**Students consult industry experts and lecturers in the same consultation either collaboratively in workshops or individually, where theoretical knowledge is discussed in tandem with practice**
Movement	**Restricted boundaries: movement of students and staff limited by bureaucracy**	**Porous boundaries, unrestricted movement of staff across academic and work places**
Curriculum C Planning	**Curriculum construction rigid codified and bounded**	**Knowledge systems shared among university planners, students, and industry teachers as well as government representatives and outside stakeholders, consultants and experts**

10.3 Section Three: Contributions of the study

This section explores the study's theoretical, methodological and contextual contributions. The theoretical dimension focuses on the way knowledge is produced and circulates in the envisaged knowledge ecosystem. In terms of methodological contributions, I highlight the study's innovative use of the transect methodology to generate data. Finally, I discuss the study's contextual contribution and explore three broad domains of action, namely, between the university, industry and regulatory agencies in terms of theoretical, and practical sources of knowledge.

10.3.1 Theoretical contribution

This study contributes to the literature on professional knowledge. It focuses on how academic and industry personnel understand how knowledge is produced, generated and circulated in three domains, namely, the UOT and the workplace, and mediated by regulatory bodies. It further clarifies sources of knowledge in the environments as well as raises questions about the drivers of these conceptions. These were the key questions of the research project.

Not many studies have focused on the relationship between work and academia and how the two are connected in terms of the knowledge that is produced in each. The study explores how learning takes place within and across these sectors. The field of study is chemical engineering; it thus contributes to the body of knowledge in chemical engineering education. There are also few studies on UoTs and industry with regard to the ways in which professional knowledge is conceived. The study is unique in the sense that it provides perspectives from both novices and managers as well as middle management and senior personnel. Obtaining a more holistic snapshot of the organisational viewpoints at different levels is fairly unique. The study also compares conceptions across the UOT sector.

A key issue that I raise is whether universities tend to fixate on codified formal knowledge to the extent that hardly any space is left for reflection of personal experiential knowledge. This obsession with disciplinary knowledge suggests that they may view their programmes not as professional education but as academic training in codified knowledge. One way of overcoming the lack of balance between the ways in which different knowledge is treated could be for departments at universities to look to other programmes like teacher education. Within the field of professionalisation of prospective teachers, there is well-established respect for life-history research, narrative inquiry, and self-study as a form of teacher development. Professional higher education could remain in a silo if it does not explore adopting the practices and learning from other professional education spaces in academia. The contribution of this study lies in its provocative declaration that various disciplines that engage in professional education can learn from one another and not remain ossified in their current outmoded structures.

Curriculum construction

This study throws light on the way in which universities prepare students for the workplace. It also provides deep insight into how industry personnel and academics view this process. The thesis articulates the research gap as differential understanding of professional knowledge and its enactment in practice. There are differences and convergences in knowledge conceptions across the two sectors. The findings showed that wide differences may impact not only how syllabi are designed. For example, the period of WIL preparation has been shown to be inadequate. Students do not have sufficient time to engage meaningfully in the field. They will not gain diverse experience in the field as some projects to which they may be attached are time-consuming. Some universities have experimented with breaking the WIL programme into shorter but more frequent periods so that the student gains experience over the three or four-year period. The more recent notion of doing away with the WIL component is shown to be a mistake as most participants see it as a crucial part of the preparation of graduates for the workplace.

Syllabus changes could be made in the areas of communication and opportunities for practice as well as skills such as leadership and teamwork. The thesis also calls for a reconfiguration of the traditional relationship between academia and industry that is not limited to the WIL component. It regards the role of regulatory agencies as critical to the triple helix process. A more robust relationship and an overhaul of the current relationship between the two sectors is suggested. The thesis identifies several areas in the curriculum that need focus:
Increasing opportunities to practice in authentic places and contexts

- Strengthening the teaching of communication skills
- Making novices aware of sources of knowledge in varying contexts (in academia and the world of work)
- Exploring the role of regulatory bodies
- Opportunities to practice

Although the syllabi make provision for occupational practice either in laboratories or in the institutions themselves, how much of this actually translates into effective learning needs to be investigated. The participants clearly indicated the need for more significant opportunities to explore the workplace context more thoroughly in terms of the range of practices in which they could engage. The issue of assessment is another major theme highlighted by students and this is linked to the lack of commitment from mentors. Formal assessment of the WIL programme varies greatly from institution to institution. It appears that personnel's commitment to this process is critical in ensuring that students receive appropriate feedback.

Communication skills

Both industry and academia emphasise the importance of communication skills. Clearly, the UoTs need to build more time into their curricula to devote to communication skills. These include listening skills as well report writing. Other skills identified as important by the participants are leadership skills, team work, and creative thinking. A critical component that emerged from the study is the role of communication and soft skills in the preparation of the engineer. The ability to communicate in both oral and written form was seen as necessary for a professional. The ability to listen and follow instructions is valued, as is the ability to write a cogent report and summarise its findings.

Sources of knowledge

Sources of knowledge identified in the study were older and experienced members of the organisation. Old-timers were regarded as libraries of information or tanks of knowledge in both university and industry contexts. Developing good relations with mentors was identified as necessary for sharing lessons. The personal attributes of the learner were also seen as crucial to her/his success in the

company. Graduate attributes like humility and willingness to learn were regarded as significant. Practice knowledge in the form of oral and physical reports were archived in codified forms in the company library.

Driving conceptions: regulatory bodies

This research confirms that regulatory bodies play a critical role in shaping conceptions of professional knowledge. These regulatory bodies drive conceptions as their presence is all-pervasive in the audit regimes carried out in the UoTs. Fear of regulatory bodies seems to be common, as does a desire to seek their knowledge and blessing during audit regimes at universities. Regulatory bodies also affect how professionals progress in their professional lives as registration is required for professional certification. The study shows that despite fear of and reliance on the regulatory body, their roles have been mandated by government agencies. It also argues that certification councils that exercise their power through controlling graduates' access to the workplace may well be serving the interests of powerful forces who wish to maintain the agendas of the past regime and who refuse to accede to the dictates of the new state structure. In contrast, this study expands the notion of regulation by viewing their role as phronetic.

10.3.2 Contextual contribution

This study provides unique insight into conceptions of professional knowledge from a range of perspectives. Firstly, it engaged with participants in two different sectors, namely, universities and industry. Secondly, within each site, participants were drawn from a range of different levels of power comprising the novice, a mentor, a curriculum developer or trainer and a manager or dean. The varied perspectives were compared and contrasted across sites as well as across levels within and across the institutions. The findings highlighted the different goals and perspectives of the two sectors explored. They also revealed differences within the sectors. Conceptions across the two industry sites could be attributed to the nature of these organisations. While one, located in the water sector, was essentially engaged in serving surrounding communities with water and other products, the second site was part of the petro-chemical industry whose main aim was making profit. In fleshing out the conceptions of professional knowledge across the sectors, the study was also able to identify the unique goals /features/ perspectives, and priorities of the sending and receiving organisations concerned.

10.3.3 Methodological contribution

Three different methods were used to collect data, namely, semi-structured interviews, transect walks and document analysis.

The semi-structured interviews provided biographical narratives of the participants and data on their workplace experiences. The study confirmed findings on the suitability of semi-structured interviews to provide a range of biographical information as well as information related to what participants think about various issues. The flexibility of this method enables one to probe issues on both a conscious and unconscious level.

The transect walk was initially envisaged as a physical walk in the sites with selected participants. This did not materialise as planned. Access to certain sites was restricted as they contained highly sensitive technology essential to the country's economy. Hence, it was decided to limit the transect walk to a virtual one that would obviate the need to physically tour the sites.

The transect walk prompted much discussion on the ways in which organisations were structured and the sources of information and knowledge within each of their parts. The participants created maps which showed how each part related to the others. Discussions on these maps were dominated by the senior partner of the teams selected for the virtual walks. At the end of these discussions, a holistic picture of the organisation was created and the participants articulated their roles and contexts of interactions in the diagrams created.

The transect walk methodology holds great promise for those who seek a contextual understanding of the sites of their investigation. It also locates participants and their roles in the companies selected. The transect walk allows for a snapshot of where crucial resources can be located in terms of the company's knowledge resources. This methodology could prove very useful in higher education studies as it enables researchers to get a "feel" for the site of research. This is significant because it can convey contextual understandings of the phenomenon to be studied.

The document analysis included perusing and analysing the online histories and magazines of the four sites explored. Student workbooks for WIL were also scrutinised as well as the companies' training manuals. These resources provided deep insight into the material used for professional development of novice engineers and staff.

10.4 Section Four: Limitations of the study

The study focuses on academics in UoTs. Deeper insight could have been gained if traditional universities had been included. This would have allowed for broader comparison within the tertiary sector in South Africa. Furthermore, the UoTs selected are both located in the province of KwaZulu-Natal. Including UoTs in other provinces would have allowed for broader comparisons.

The selection of industries in KwaZulu-Natal was also limited. Another company in the petrochemical industry would have provided useful insights as would the addition of a company from another sector.

This would have highlighted the role of varied specific company contexts in shaping notions of professional knowledge.

Although the study explores academics' conceptions, video-taping of lessons and analysis thereof by industry personnel in focus groups could have provided useful insight into curriculum design and pedagogy since conceptions and beliefs tend to influence what and how we teach. Other more exploratory methods, such as a metaphor study, could be employed to yield conceptions.

A further limitation is that, as noted above, two UoTs were selected from a single province. Future studies could explore conceptions of knowledge across a greater range of UoTs as well as traditional universities. A more diverse sample may provide deeper insight into how different contexts are implicated in conceptions of professional knowledge. This will require a more comprehensive project. Finally, the study was limited to analysing the intended curriculum rather than the enacted one.

While the thesis appears to celebrate the role of the engineering council (ECSA), as a critical agency in bringing the worlds of the university and industry together in a dialogical partnership, it may be argued in further studies that professional councils seek to adhere to more conservative agendas of the past in the name of protecting standards. Perhaps, the tensions between these conservative forces and the other regulatory forces in the broader political and social system may provide a ripe area of research for future studies.

10.5 Implications of this thesis

While a technical view of communication as simply encoding, transmitting and decoding is beginning to give way to a more nuanced and contextual understanding, communication is now increasingly regarded as a complex negotiation that is shaped and reshaped by social, political and cultural contexts. This understanding has implications for the way in which communication issues are configured in engineering education and practice. Problem-solving as a pedagogical method must account for authentic practice situations which are messy rather than easily solved like textbook examples. Greater focus in the communication class should be placed on graphical and visual communication reflecting the authentic communication practices of engineers. In the present COVID environment (which were not the framing context at the time of data production) there is a greater urgency for using technological communication platforms. This has future implications for the development of engineering education to include technological communicative expertise. Moreover, engineering education should seek to assist in developing a professional engineering identity which views the engineer as ethical and using wise judgment in dealing with real-world problems. A greater focus should be placed in teaching a range of genres for a wide stakeholdership. Communication experts and disciplinary experts in faculties to collaborate on curriculum reconstruction while stand-alone communication courses to embed core concepts to facilitate transfer.

10.6 Section Six: Suggestions for further research

There is a need for further research on the relationship between industry and the university and in particular, how knowledge transfers from one to another at the micro-level. This will require careful selection of participants and a more detailed exploration of specific features of professional knowledge that may be foregrounded, integrated or silenced as the transfer occurs.

Curriculum and pedagogical studies need to be encouraged to explore notions of professional knowledge across professional domains. Working in silos may be helpful, but it offers very little in terms of how knowledge is conveyed from one site to another.

Another area that warrants attention is the role of power and its insidious effects on the learning that takes place across professional domains. Who determines what kinds of knowledge and how that knowledge needs to be activated are issues that need to be interrogated. Also critical will be analysing the asymmetries of power in existing and future partnerships. An analysis of the exercise of power within the interactions amongst employees of these companies also needs exploration.

10.7 Section Seven: Concluding thoughts

As my concluding remarks, I offer brief responses to the key questions raised by the thesis. Firstly, what is professional knowledge, and how is it activated? Secondly, why is professional knowledge conceived in the way that it is? Professional knowledge is a highly complex and multifaceted term. In enacting practice, the practitioner invokes a range of different knowledge forms, namely, personal, cultural, regulatory, theoretical and practical knowledge to address societal problems in an ethical manner. Forms of professional knowledge activated in practice encounters are guided by its relational, dialogic, embodied and phronetic characteristics.

Professional knowledge conceptions at play in the worlds of university, industry and other domains can be attributed to the legacy of past practitioners, current reformulations and the impact of globalisation. The issue of the nature and shape of professional knowledge is intimately linked to the survival of institutional structures in society. For example, universities' survival is currently under threat as workplaces seem to be taking over their job of producing knowledge. Higher education maintains the jurisdiction of its territory to ensure survival. The same holds for industry; it produces goods and services and will therefore exercise intellectual property rights over the knowledge it produces. Maintaining boundaries allows for continuity and this agenda seemingly drives the university enterprise. However, it could be argued that universities are turning too far inward to reflect and protect their educational edifices. The effect is to ossify into relatively rigid entities despite rapid globalisation and changes in the wider world.

Stakeholders in the triple helix need to recognise one another's importance in their relationships as well as the need to evolve such a nexus to another level. I am confident that such realisations will spur new understandings of how professional knowledge is produced, circulated and activated in inter-professional settings

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LIST OF APPENDICES

APPENDIX 1: SCHEDULE OF INTERVIEW QUESTIONS

Newly qualified workers/Lecturers	Trainers/ Curriculum planners	Mentors/Mentors	Managers/Deans
1.Can you describe your career thus far. Tell me your story from the time you entered university.	1.Can you describe your career thus far. Tell me your story from the time you entered university.	1.Can you describe your career thus far. Tell me your story from the time you entered university.	1.Can you describe your career thus far. Tell me your story from the time you entered university.
2. How do you feel about being an engineer? is it a status job? in what ways is it different from other jobs? Do you have to have special skills or perhaps an inclination or interest in the subject?	2. How do you feel about being an engineer? is it a status job? in what ways is it different from other jobs? Do you have to have special skills or perhaps an inclination or interest in the subject?	2. How do you feel about being an engineer? is it a status job? in what ways is it different from other jobs? Do you have to have special skills or perhaps an inclination or interest in the subject?	2. How do you feel about being an engineer? is it a status job? in what ways is it different from other jobs? Do you have to have special skills or perhaps an inclination or interest in the subject?
3. Can you describe your most memorable/rewarding activities at work?	3. Can you describe your most memorable/rewarding activities at work?	3. Can you describe your most memorable/rewarding activities at work?	3. Can you describe your most memorable/rewarding activities at work?
4. What were the seminal experiences that made you select engineering as a career?	4. What were the seminal experiences that made you select engineering as a career?	4. What were the seminal experiences that made you select engineering as a career?	4. What were the seminal experiences that made you select engineering as a career?
5. What kinds of knowledge do you need to perform successfully as an engineer/technician?	5. What kinds of knowledge do you need to perform successfully as an engineer/technician?	5. What kinds of knowledge do you need to perform successfully as an engineer/technician?	5. What kinds of knowledge do you need to perform successfully as an engineer/technician?
6. What has influenced you the most about how engineers should think and act?	6. What has influenced you the most about how engineers should think and act?	6. What has influenced you the most about how engineers should think and act?	6. What has influenced you the most about how engineers should think and act?

APPENDIX 1: SCHEDULE OF INTERVIEW QUESTIONS

Newly qualified workers/Lecturers	Trainers/ Curriculum planners	Mentors/Mentors	Managers/Deans
7.Describe a perfect graduate from your place of work in terms of knowledge, skills and values.	7.Does the current curriculum adequately prepare students for the workplace?	7.What role does WIL play in preparing the future engineer.	7.Do you think the mergers have affected the universities in terms of their offerings?
8.What do you think our graduates strengths and weaknesses?	8.What do you think our graduates strengths and weaknesses?	8.Are the students sufficiently prepared when they go into industry?	8.Has globalisation affected the way we do things as engineers?
9.Why do you think industry complains about our graduates?	9. Are graduates sent for professional development? Explain.	9. In what areas of their knowledge are students strong or weak?	9.Should the relationship between industry and the institution be strengthened. Explain.
10.What kinds of professional knowledge should you teach?	10. How do you think universities and industry can collaborate to improve graduate knowledge?	10.What do industry complain about in our students.	10.State the role played by ECSA and other bodies in preparing the future engineer?
11.What kinds of knowledge does an academic need to teach prepare novice engineers for their occupations?	11.Are you aware of the curriculum of universities?.	11.How do you think we can address these shortcomings at the university?	11.How important would you consider training and development?
12.Is there any knowledge that academics lack or could develop to make them more competent?	12.What would you include/change?	12.As a mentor, what do you consider to be your responsibilities to students?	12. As a manager, do you think the WIL programme can be expanded or changed. does it work and why?
13.Do you think ECSA, DOE, OR SAQA and advisory boards play a role in creating an engineer? Explain how?	13.Do you think academics should have industry/teaching experience. Explain your answer?	13. In your interactions with students where do you find the most challenges lie?	13.Can you describe how much of theory should be included in the curriculum and how much of practical?

APPENDIX 1: SCHEDULE OF INTERVIEW QUESTIONS

Newly qualified workers/Lecturers	Trainers/ Curriculum planners	Mentors/Mentors	Managers/Deans
14.Has the university prepared you adequately for the workplace?	14. Is WIL designed into the curriculum. Explain why it is designed in this way?	14. What diff exist amongst students from UoTs and students from traditional universities?	14. Do you academics should go for training on how to teach more effectively?
15.What changes would you make to the curriculum?	15. Is there a need to train newly qualified graduates? in what area do they require training and what format does this take.	15. How are you selected to be a mentor? Are there any training/skills programmes for you?	15. As Deans, do you think we should invite speakers from industry and vice-versa?.
16.How did WIL benefit you?	16. Does professional development at university involve teaching for the workplace? Should it?	16.Wwhat are your specific duties on a daily basis?	
17.Do you think you need any professional development at your workplace?		17. If you had to divide practice and theory what would these percentages be and why?	

APPENDIX 2: VIRTUAL TRANSECT WALK INTERVIEW

Part One: The participant will be expected to draw a map of the organisation or institution, with a particular focus on where knowledge is exchanged, stored and transmitted.

Part Two: The participant will then take the interviewer on a guided tour of the organisation or institution using the map of facilities drawn, highlighting the spaces where he/she thinks learning occurs in terms of knowledge sharing and transmission.

Part Three: Small group discussion of the narrative provided by the participant.

APPENDIX 3: LETTER OF INFORMATION - UNIVERSITY OF TECHNOLOGY

PROJECT TITLE: Academic and industry conceptions of professional knowledge in chemical engineering: convergences and disconnections

PRINCIPAL INVESTIGATOR: M.R. Jamal

Letter of information

Invitation to participate

You are being invited to participate in this research study which is based on conceptions of professional knowledge because you teach/ supervise/mentor and manage students who belong to the Department of Chemical Engineering at a University of Technology.

Purpose of the letter

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

Purpose of this study

The purpose of this study is to explore academic conceptions of professional knowledge in the chemical engineering field.

Study procedures

If you agree to participate, you will be asked to participate in an semi-structured interview of about an hour in length and participation in a virtual transect walk interview.

Possible risks and harms

There are no known or anticipated risks or discomforts associated with participating in this study.

Possible benefits

The possible benefits to participants may be to gain a better understanding of the different knowledges that are required by students for employment.

Compensation

You will not be compensated for your participation in this research.

Voluntary participation

Participation in this study is voluntary. you may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future employment.

Confidentiality

All data collected will remain confidential and accessible only to the investigators of this study. if the results are published, your name will not be used. *if you choose to withdraw from this study, your data will be removed and destroyed from our database.

Contacts for further information

If you require any further information regarding this research project or your participation in the study you may contact:

Publication

If the results of the study are published, your name will not be used.

Principal investigator: M.R. Jamal
telephone (w): 031-9077283
[redacted]
e-mail: jamal@mut.ac.za

Consent

see consent form below:

CONSENT FORM

PROJECT TITLE: Academic and industry conceptions of professional knowledge in chemical engineering: convergences and disconnections

PRINCIPAL INVESTIGATOR: M.R. Jamal

I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant's name (please print): _____

Participant's signature: _____

Date: _____

Person obtaining informed consent (please print): _____

Signature: _____

Date: _____

APPENDIX 4: LETTER OF INFORMATION – INDUSTRY

PROJECT TITLE: Academic and industry conceptions of professional knowledge in chemical engineering: convergences and divergences

PRINCIPAL INVESTIGATOR: M.R. JAMAL

LETTER OF INFORMATION

Invitation to participate

You are being invited to participate in this research study which is based on conceptions of professional knowledge because you work as an engineer/engineering technician/manager in the chemical engineering industry.

Purpose of the letter

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

Purpose of this study

The purpose of this study is to explore academic and industry conceptions of professional knowledge in the chemical engineering field.

Study procedures

If you agree to participate, you will be asked to participate in an semi-structured interview of about an hour in length and participation in a virtual transect walk interview.

Possible risks and harms

There are no known or anticipated risks or discomforts associated with participating in this study.

Possible benefits

The possible benefits to participants may be to gain a better understanding of the different knowledges that are required by students for employment.

Compensation

You will not be compensated for your participation in this research.

Voluntary participation

Participation in this study is voluntary. you may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future employment.

Confidentiality

All data collected will remain confidential and accessible only to the investigators of this study. If the results are published, your name will not be used. If you choose to withdraw from this study, your data will be removed and destroyed from our database.

Publication

If the results of the study are published, your name will not be used.

Contacts for further information

If you require any further information regarding this research project or your participation in the study you may contact:

Principal Investigator: M.R. Jamal
[redacted]
e-mail: jamal@mut.ac.za

Consent

see consent form below:

CONSENT FORM

PROJECT TITLE: Academic and industry conceptions of professional knowledge in chemical engineering: convergences and disconnections

PRINCIPAL INVESTIGATOR: M.R. Jamal

I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant's name (please print): _____

Participant's signature: _____

Date: _____

Person obtaining informed consent (please print): _____

Signature: _____

Date: _____

APPENDIX 5: ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

22 September 2015

Mr Mahomed Rafiq Jamal 901361320
School of Education
Edgewood Campus

Dear Mr Jamal

Protocol reference number: HSS/1209/015D
Project title: Academic and industry conceptions of professional knowledge in Chemical Engineering

Full Approval – Expedited Application

In response to your application received on 20 August 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

.....
Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Prof M Samuel & Dr Marinda Swart
Cc Academic Leader Research: Prof P Morojele
Cc School Administrator: Ms T Khumalo

Humanities & Social Sciences Research Ethics Committee
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Website: www.ukzn.ac.za

APPENDIX 6: TRANSCRIPT: INTERVIEW WITH MANAGER

		Transcript	CODING
I:		Can you describe your career trajectory since the time you were in school and university and your interest in Engineering. How did that story unfold?	
M:		Okay,I think from school- it was in the apartheid era, so it was very difficult to find places to study maths and science so that was the one difficulty. In KZN, there were only two or three schools. Fortunately, there was one opposite Sapref there – Fairvale, So we had to travel two buses everyday. The other one was in Ixopo and the other one, in Eshowe were the only places where Maths and Science were done. So that was what really directed me being at a school that did Maths and Science… My real interest came in this field during those Science what you call Eisteddfod or Science…..	Apartheid – Differentiation in schooling. Science as rare subject Struggle against apartheid Taking two buses
I:		Eisteddfod?	
M:		Yes, where you write some tests – what you call them? Science Olympiads. So we did well in the school and we were two reps from KZN. Two of us from the school. And they took us on a tour of Cape Town of universities and industries and stuff and that's where the sort of penny dropped to say - this is what I want to do. So that exposure through the Science Olympiad winning that … em going on a week exposure in …	Motivators Early exposure to Science Olympiad – theoretical knowledge versus Going to UCT and participating in Olympiad Youth
I:		Into industry.	
M:		Industry and academia, coz we went to UCT and UWC and they showed us engineering and science experiments and physics at quite… a really for us really eye-opening level at that stage and then we went to some industries as well and looked at processes that were happening in industry. A couple of different industries, but that's where I really…. and then took to that. The industrial exposure I've been exposed at different industries and eventually ended up in the water field, in paint ..eh manufacture, eh.. pharmaceuticals, …not pharmaceuticals, insecticides and pesticides and the aluminium industry as well. So those were the three industries. I ended up in the water side really for stability after having exposure there in a	Exposure to UCT and UWC – science experiments /as scholars. Visits to industry Exposure to practice knowledge /as a graduate to many chem eng industries Chose water as it had more advantages for growth and benefits

		sort of operations and that sort of thing but the water industry being quasi-govt was more stable and they offered a housing subsidy. Those are the main reasons I actually moved across because housing was such a critical asset that you needed to acquire at that stage. And, so I actually sacrificed a company vehicle for a housing subsidy. So it forced me to buy a house. I could have stayed. I did not have any financial benefit as such. But it was substituting one for the other. But it forced me to buy a house because you could only use the housing subsidy if you had a house.	Changing jobs provided experience and competence Practical reasons and engineering choices
i:		Al-right. Good decision!	
M:		Yes, it definitely was because I think I had a bakkie with free use and unlimited fuel and stuff. So I think when you young you just want to drive the vehicle and get to places which is going to cost you more.	
I:		A motor vehicle is never an asset while a house is. A good decision.	
M:		Ya, so that's really the exposure and why I ended up in the industry. In terms of my own mentorship, I think I had two very good mentors. So I was fortunate I think in all the places that I worked there -good supervisors/mentors they were not designated as such. They were just supervisors but they played both that roles. So I think in all of them Rentokill, Plaskon, Huletts - they were all good supervisors/managers who played also the mentorship role.	Mentorship is very importamt to his dev as an engineer
I:		Was it something…the initiative - was it something that came from them that they saw you as somebody who was young and needed that kind of exposure and guidance? Did you have to actively seek that guidance?	Mentoring
M:		No, I think in the first two industries, it was mainly supervisory because I think I was younger. When I got to Umgeni, I was married and more settled and mature and I think the people that supervised me – I wonder why? - you ask a good question. Why they would have wanted to play that role cause they could have just ignored you and let you do your job. Eh…. you know a lot has to do with personality. hmm…. ok, one good thing I worked in the pub. (laughter)	Links engineering dev of relationships to Personality – Taking initiative – working in the pub. Communication skills and development of self
I:		It developed your communication skills?	

M:		Yes, yes… so (laughter) I met a lot of people at a higher level. Every Friday afternoon I managed the pub.	Meeting with management. Role of informal communication SOFT SKILLS
I: … ..		Right – was it local at your…..	
M:		In Pietermaritzburg, at our head office.	
I:		At the head office?	
M:		Yes, so I really met from the CEO, two or three levels above me. So you actually learn to communicate and get on with people and I think that ability to be able to converse and speak to people at different levels. But they… I think they also definitely had an interest in developing people. You know some people who can do it and some don't. I have fellow colleagues and managers who just get the job done and are not interested in the people's development whereas people like Dean , myself we take a lot of pride in seeing people grow and develop.	Communication across hierarchy and exposure. learn to communicate and get on with people and I think that ability to be able to converse and speak to people at different levels. Pride in seeing people grow
I:		That's wonderful!	
M:		It's, it's just innate sort of …one of those senses or comfort that you get from seeing people go from being there to there…. eh… so… it's not everyone who is like that some even as managers are just interested in their own careers or in just getting the job done.	Personal fulfilment versus selfish motives of others
I:		Right.	
M:		So you have to go the extra step to do the mentorship. My managers at that stage did that. You know they could have sat back and said job's done, that's it. So it was a matter of introducing you to the key role players in the industry. I clearly remember ……said ….drop what you are doing today….– please come there's certain people from Water Research Commission or whoever (he) introduced me to who they are had lunch with them whatever. those key points things like that made a difference. And I've also tried to apply some of the same things … specific meeting like Ayanda's young. He has got to go to certain meeting tomorrow	Speaks of things not fomalised – tacit ways of doing things of learning Empowerment of workers

		for certain exposures. It is not required in his work. Sometimes I have to bulldoze my way into why is he here or what's he doing here? It is for part of his development programme. So, yah those sort of things are not formalised.	Reflecting the behaviour of his mentors with Ayanda's exposure to management strategies – understands the building of tacit knowledge
I: .		But, they so important for somebody's development. Ok, that's great! So you will attribute learning that took place from mentors that you had.	
M:		Yah, some at least 50% of it, where I saw one of my main mentors. Actually he is in England and he came out late last year on holiday in a wheelchair and he wanted to see me and he's 80 something.	Self – Mentor relationshsip Mentor from England
M:		And he made effort to contact me and I had to go see him …… get him out his car with a wheelchair, help him but he made the effort to come and see me. So it was mentorship and a relationship but also business. You still had to deliver from both sides.	Strong, lasting relationships Importance of delivery – show of commitment – characteristic of expertise?
I:		It's, it's difficult for me to imagine an Engineer or a person brought up in a strict engineering ethic to be so humanistic. We in the social sciences think that people in the hard sciences are extremely business-like; do their jobs, get on with it.	
M:		No, no there's lots that's actually required of that as well. But as I said not everyone. There are people as I've said that are just …they are only interested in themselves and they are not interested in anyone else but they get the job done.	Hybrid managers
I:		What would you say would be your most memorable or rewarding activity /experience at work?	
		I think mine is when I see people get appointed into some senior position - their growth and going from a graduate. Eh, what made me very proud, I think there's two or three of them that have gone in the last 10 years - have gone on from bursary student the whole hog - bursary student, graduate trainee, back work here, getting a job and then getting promoted in the organisation and then being a manager today.	Identifies career trajectory of worker and professional development in the company and his role in that

I		To see how they developed over time.	
M		Ya into managers	
I		What kinds of knowledge do you think you need to perform as Engineers? If we look at the two ladies who have gone through a whole gamut of experience from the beginning to where they are now. Along the way what kinds of knowledge would you need?	
M		Besides the theoretical and academic training whether it's a diploma or engineering degree or something that is a no go assuming you got that, you then have to apply that knowledge and the application of that knowledge eh… takes quite a eh eh…lot for the supervisor and the individual to relate the two and link the theoretical knowledge to practical work sometimes. So, yes, you need the ability as the trainee and a supervisor to be able to link those two cos you could finish the academic and often they faced with a problem and they can't see the connection to some theoretical concept that they were taught in the 2nd and 3rd yr at university. So that's really a skill and an art that comes with experience to say – yes, this is the connection do you remember that equation you remember that concept take that adapt it and apply it here now.	Making a connection between theoretical concepts and practical work Speaks of academic training – rather than prof education Practice knowledge Supervisor – ability to connect the two forms of knowledge Comes with experience/tacit
	I	Right	
		Cos, sometimes the example of the way you are taught - it is totally not linked to the problem you faced with today, and you got to be able to interpret the…the nuances of what was being done there and apply it in this and sometimes you are applying only 5 or10% of that theoretical concept into the problem you face today. So that's a big part in the sort of graduate going across and applying his theoretical knowledge. And he only applies 5-10% of what he learnt in the degree and it is not a lot, cos the engineers learn a wide variety of concepts and theories and 10% is even a lot of what they'll apply. But besides the Maths and being able to do all that all sort of thing but the theoretical things	Pedagogy **** Definiton of Professional Engineer and knowledge From theory to interpret nuances of what you learnt and apply. Complexity. Theory/Practice divide between university and the workplace The way you taught does not allow one to see the engineering problem

		yes its not a lot eh…so you linking the two to that and keep going back to that and the softer. After that you can be an expert in whatever you want. Then there is the softer skills that you need to learn - the stuff that I am saying I want to take Ayanda to tomorrow – it's a strategy meeting, its exposure what is business planning, what is strategy they don't get that training and they can be very deficient in it eh eh so we have to do that on the job that part of it exposure and then they also do some post-graduate work MDP or something emerging management programme where they introduced to theoretical concepts of planning, and business strategy and that sort of thing eh..but then taking it and applying it in the work environment they don't have that so that's what I try and do sometimes just to expose them I look back on my own and say where did I learn to do these things and then I try to apply them back to the younger people to say this is what. Sometimes I can't explain everything and I say I they should go to a certain meeting or you should attend that or I don't have the time to tell them	Core skills -Speaks of Maths and theory and softer skills – being an Expert! Soft skills like the following strategy meeting, its exposure what is business planning, what is strategy they don't get that training and they can be very deficient in it eh eh so we have to do that on the job that part of it exposure and then HYBRID ROLE OF THE MANAGER AS A DEVELOPER /MENTOR Post graduate – prof development Tacit Knowledge above –not being able to explain everything to them.
	I	Right	
		But I do have a deliberate purpose for sending them there and I might be short on explaining to them why eh but I think they know me well enough now to say if I have invited them tio a meeting its not just to sit there its some learning I am expecting them to go through.	Tacit knowledge
	I	They very fortunate to have a person like you guiding them like this in a structured way or with purpose. In terms of the theoretical knowledge and practical knowledge you said that its probably 5-10% which you would reflect back on some of that knowledge. Which one would you consider more important? The theoretical bits or the situated knowledge.	
		You cannot do the experiential without the theoretical. So it's not a matter of importance its that plus this. It's just how much of it you use. Some people might use more 30% some use only 5% just depending on what job they do where they end up. If you in an academic environment and you go on to teach Engineering. You gonna use lots	Sees both kinds of knowledge as crucial. Identifies the context whether its academic or situational use of one or more.

		more but you still will be confined to a certain discipline. An interesting person to speak to about that is Lakesh. You might have to have a separate discussion to answer that question for you specifically because he has academic exposure and he has on-site experience and you could just ask him about that that question. What does he think about.....what amount of what you done in you base degree do you apply in your work environment and what does he think is the importance of it. A good question to pose to him.	Community of practice
	I	What would make a successful Engineer in terms of knowledge?	Definition of Engineer
		I think if I look at the definition and what is required of a engineer is to take that knowledge and apply it to solving problems. So eh to me I what makes a good engineer in this field and a bad one is that ability to link that Theory and to apply it in your daily work and add the other extras to it to see what the gaps are that when I come out of the Univ even if I got certain experience that I'll still have some deficiencies. You know that I am not the complete product yet nor will I ever be but to understand that I need more. Cos the biggest mistake I think is the guy that come out who goit a four yr degree or took five years to do his degree or whatever and then thinks he knows it all nose in the air that. Number one no one will teach that guy that's guaranteed and it happens under the surface. It happens without anyone saying anything. No one gravitates to him nobody wants to teach you nobody wants to assist you. It kind of It creates that barriers if you came with that attitude. And actually Rabi[10] sat somebody down last year and told them that he came with that attitude and he was supposed to see me for a short discussion cos we were giving him a job that was not an advertised job because we were appointing him but we wanted to see what his skill was but he came with this totally arrogant degree person an wasn't an Engineering because we do Scientists and Engineers in this section so he was a science degree and Rabi told him and said "Look my boy if you going to use the next two years for your benefit in the graduation training programme sort	Problem solving This is linked to persons personality- Gaps in knowledge from university Add the extras – soft skills etc? Your whole attitude and your behaviour are critical to you going further and learn further. Nose in the air will prevent – arrogance as soft skill will prevent growth Effects of arrogance 1. No one will teach 2. Assist or gravitate 3. Creates barriers

[10] Use of pseudonym

		these problems out first. Nobody is going to teach you anything nobody will help you". The attitude is the biggest thing. Your whole attitude and your behaviour are critical to you going further and learn further. You probably can get through with an arrogant attitude but it take you double the time to learn and he did change immediately he is very impressive today when I look at him f/5 months later in terms of his ability and his demeanour and his behaviour	
	I	But that is so important eh for someone to tell you otherwise in a sense he would have been blinded by his own arrogance and he would have lost so much	
		Ya, he would have yah but I think he had the balls to actually tell him that because he could take it very differently as well or he could not have taken the advice this is off the record and I want to tell you certain things and if you going to come with this attitude you will still get the job but you not going to learn much you will not be assisted no one will gravitate to you to say this is a vacuum that needs to be filled or a sponge that needs to be filled with knowledge. Cos you create the perception that I know it all I'm full I can't add any more to this person and it's not written anywhere it's not maybe it is I'm not sure but that attitude is critical to becoming successful because it influences your dealings with people because you are fundamentally you got to solve problems if you can't solve problems you are not being successful. To solve the problem you need the right attitude right behaviour cos you need to understand the persons problem that you are trying to solve so communicating with them understanding cos 90% of what they tell you is not the problem is the peripheral issues around the problem and you need to get to the 10% and say so here's the real problem but your ability to list and pick out the issue or the area of concern that you need to solve cos you might then work on the wrong problem the wrong part of the problem or the problem statement so that ability to listen and relate to people is also important. There are some Engineers and maybe the Scientists who are more the loner who kind of here's yr problem and he will solve it for you.	Advises the Novice on the importance of being part of the community of practice. Refers to problem solving and the importance of senior personnel to guide one.
	I	Right	
	M	He writes a report and is finished. But when you take it from the scientist to the engineer he has to	Describe the ritual of reporting problems via a report.

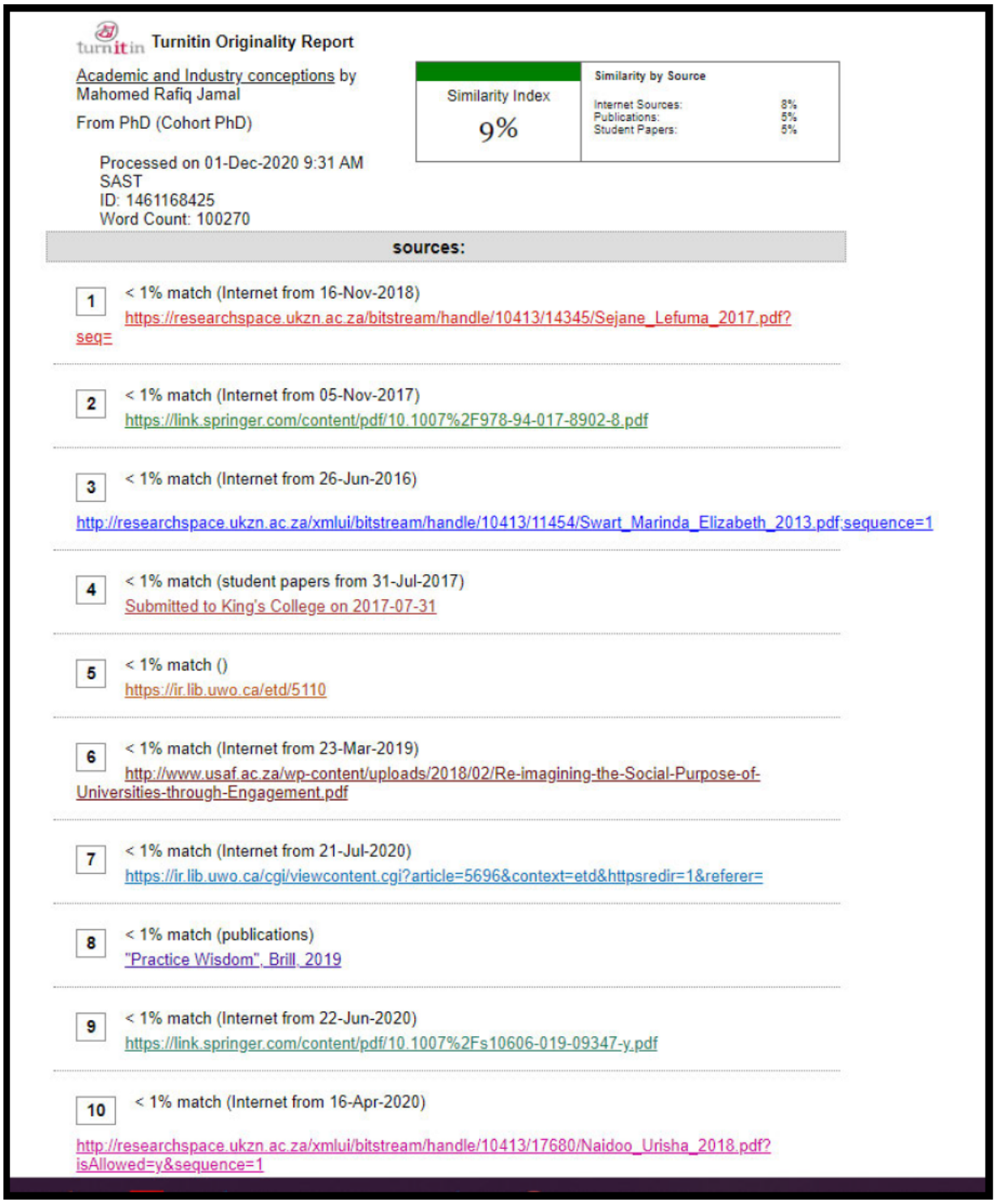
		go and implement the solution which means dealing with the people.	
	I	Interacting?	
		Interacting commissioning handed over to them. The customer who is the person with the problem will not accept it as the solution if you not able to do show him in a report or theoretically or whatever that is now solved cos you could still see it and we have that all the time you got to learn to actually know what that person is what triggers them what they are actually looking for sometimes they give you a problem thats not the real problem. The problem could be something else in their environment. So you need to understand the person who has got the problem what their environment is sometimes it is their manager sometimes it is the employee who is below them who are actually the problem and You might go engineer a solution which is not appropriate. Yeh, because this morning we've decided to send two technicians to a site to spend two weeks there to really understand the problem because we think its human inability of the operators of the plant to listen for them to follow instructions and for them to implement the instructions once we leave.	Describes the relationship with stakeholders Describes the problems one can experience in the field. Problem might be the employee rather than anything else. Enviromental safety / teaching of ethics? Listening skills
	I	So it's a process kind of …..	
		They running a plant in Ixopo but its not performing it keeps failing there is issues with it. The quality of the product is not our standard. Its still drinkable butt its not our standard but on our first sort of high level investigation its not so much the equipment that is the problem which is the eng part of it its around the hr the people operating the equipment so we give them instruction and say do this try this do that implement that give me feedback two days later to say what happened with my instructions so I can cause an effect or that type of thing and they not able to do that so by us going there now for two weeks day shift night shift we will be able to firstly prove that is not an equipment thing and that it can be run as it is and produce acceptable product. And then we will need to also understand the capability of the people where is their problem? why do they not understand instructions? why do they not take instructions why don't they implement them? Why don't they work on shift and every shift seems to be doing their own thing. So night shift does something day shift does something else.	IMPORTANCE OF UNDERSTANDING OTHER PEOPLE Following instructions
	I	Two ships in the night	

		Yes, so why is there a break and a distinct difference bet it operating at night and day. Is it the humans who are different or is it the temperature or is it light. We need to understand that. But as I say our conception or perception is maybe that its human inability to take instructions inability to implement instructions so now you as an Engineer are starting to become more involved in human behaviour. And inability to learn or where was the problem? Why were they not taught this in their diploma?	
I:		I am learning a whole lot about Engineers (Laughter), I can tell you that much. Okay thanks for that. Can we move on to the next question?	
M		Mmm	
I		Okay eh how important is the WILprogramme? Should it be expanded changed in some way? Does it work or why does it not?	WIL PROGRAMME
M		The programme?	
I		The work integrated programme where place students with you for an extended period of time and then they go back to graduate.	
M		Yes we have changed it from 1 yr to two yrs but they can graduate after a yr but we offer them two years exposure but we have found that the 1 yr is not enough time to get them em confident enough to go get a job. Its an Umgeni thing I don't know what the other industries are doing. But we have extended all the programmes by a yr from 1 to 2 years. They finish the 1 year they go and graduate but they are still here with us. The actual integration of the programme the detail as to what they doing when they here Naheen is probably best suited to answer.	One yr inadequate – extended it.
I:		Technician	
M		Technician/technologist trainer. So the only other thing that I see as a gap for them to actually get integrated into work there's still a gap even with the two years in that often in our organisation jobs call for a minimum of three years experience. Now what do you do with the one year close it by one year so you will never get into Umgeni Water.	Gap is located in WIL – inadequate time
I		You will have to go somewhere and then come back.	
M		Yes, yes, and that's often what happens so I would say from our point of view you can be selfish and say well I am training people for other industries but you got to put the bigger picture on and the same applies to University programme where they spend two years as a	

		gap so what I have done in the last two or three years is actually to integrate them and make them as the person who interviews is to change the requirements for the job which is quite a big thing it's not done easily.	
I		Okay	
M		To change that I want a junior Engineer but development that it's a development post so I got to change the post into a development post there's a whole lot of admin which I don't need to do. But that is to give me the ability to say I'll only need two years experience and Next year you have these following targets to meet you have to do a post graduate diploma in this you have to do this training course. And you have to meet these targets then youll have the three years experience and then you fully in the post.	
I		Very innovative, and very useful and practical considering that people have problems in employment, and gaining experience will be the biggest problem.	
M		It is yah. So Its just organisational systems are not structured to allow you that flexibility. As I said I've done it I have the support of my senior manager and its been working and then you pay the person a little more as they develop. So it's not just your graduate trainee anymore but its another dev programme that continues some people 18 months, some is 2 years from where they were after we have given them there minimal training that we offer but this is another step. But they have to apply for that as a job as a dev job. And I had it because I was also in training Engineer or a Scientist in training where that's where I went back 20 years. S I said well that was one concept that worked I went through that I had these mentors eh so it … we have to make them apply to open it to anyone within the programme so I can't just say Rafiq yes I'm putting you in that programme there's an application that needs to be filled but at least the requirements are known upfront.to anyone that's not the full Monty that is required in terms of experience I have reduced experience now to….	
I		In terms of eh the diff levels and the institution for which you can go for training is it just relevant for the younger novice less than 5 years kind of person or even as a fully-fledged employee	
M		There's continuous training for the full time employees and they have their own dev plan. I'm just talking now the graduates from the ones with	Continuous training

		no experience. So for the older, even I have a dev programme. So mine for instance is around strategy exposing you to training you to that level and maybe innovation looking at diff ways of doing things. Everyone has as a training programme a dev plan and which is measured every 6 months as to whether you are archiving it or not.	
I		Just another related question should academics go for training?	
M		Yah they have to because academics ask us to ensure they stay up to date and up to speed.so as part of your professional registration you need to have cpd points which is continuous professional development otherwise you lose registration so you can still be an engineer and still register with a prof body which allows you to sign off certain reports, and drawings	Prof dev points – need to sign off on drawings
I		This would be ECSA OR SAICE	
		If would want to go to a court of law, they would treat it with a pinch of salt if you are not professionally registered.	Prof registration with respect
I		From your own understanding of graduates that come into a job. You say they use 10% of what they learn.	
M		There's nothing wrong with that	

APPENDIX 7: TURNITIN CERTIFICATE



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APPENDIX 8: GATEKEEPER'S LETTER – SITE 1

SITE 1

10 July, 2015

Mr. M.R. Jamal

Communications

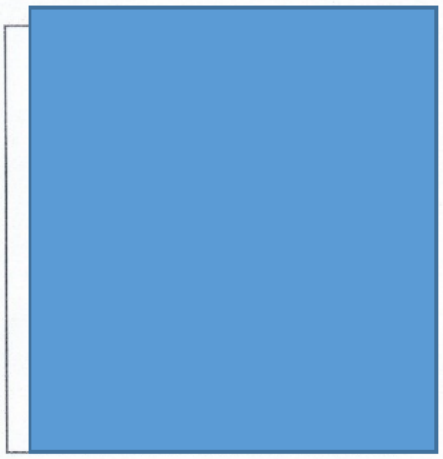
Mr M.R. Jamal

It is my pleasure to inform you that permission to conduct survey titled: "*Academic and industry conceptions of professional knowledge in chemical engineering: Convergences and Divergences*" amongst [ ] staff members was granted.

Permission to conduct the survey is granted on the condition that any changes to the project must be brought to the attention of the [ ] [ ] as soon as possible.

Good luck with your research.

Yours sincerely,



APPENDIX 9: GATEKEEPER'S LETTER – SITE 2

SITE 2

[redacted]

5th May 2015

Mr Jamal Rafiq
c/o School of Education
University of Kwa-Zulu Natal

Dear Mr Rafiq

PERMISSION TO CONDUCT RESEARCH AT [redacted]

Your email correspondence in respect of the above refers. I am pleased to inform you that the [redacted] has granted provisional permission for you to conduct your research "Academic and industry conceptions of chemical engineering professional knowledge" at the [redacted]

Kindly note, that the committee requires you to provide proof of full ethical clearance prior to you commencing with your research at the [redacted]

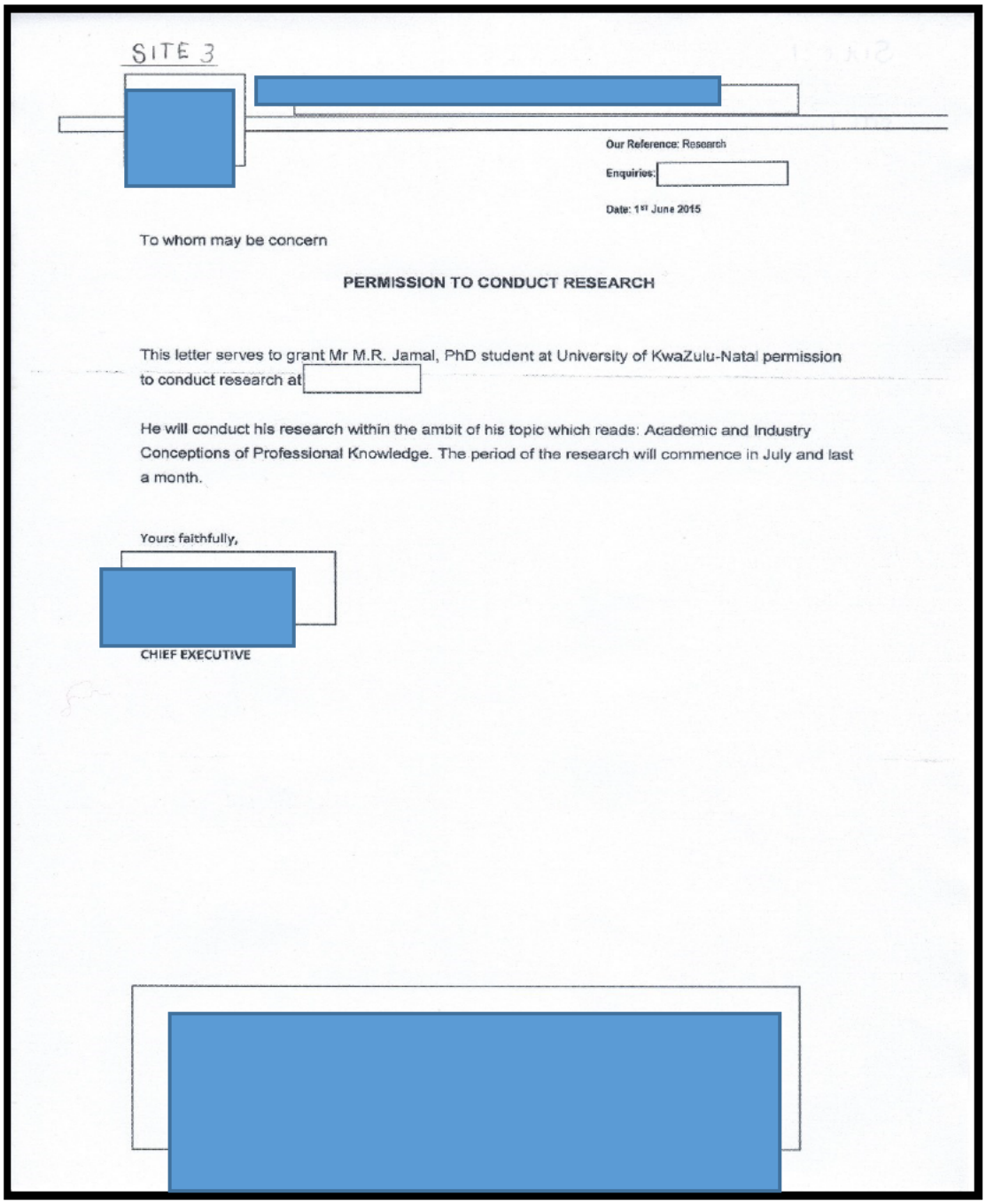
We would be grateful if a summary of your key research findings can be submitted to the [redacted] on completion of your studies.

Kindest regards.
Yours sincerely

[redacted]

DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT

APPENDIX 10: GATEKEEPER'S LETTER – SITE 3



SITE 3

[redacted]

Our Reference: Research

Enquiries: [redacted]

Date: 1st June 2015

To whom may be concern

PERMISSION TO CONDUCT RESEARCH

This letter serves to grant Mr M.R. Jamal, PhD student at University of KwaZulu-Natal permission to conduct research at [redacted]

He will conduct his research within the ambit of his topic which reads: Academic and Industry Conceptions of Professional Knowledge. The period of the research will commence in July and last a month.

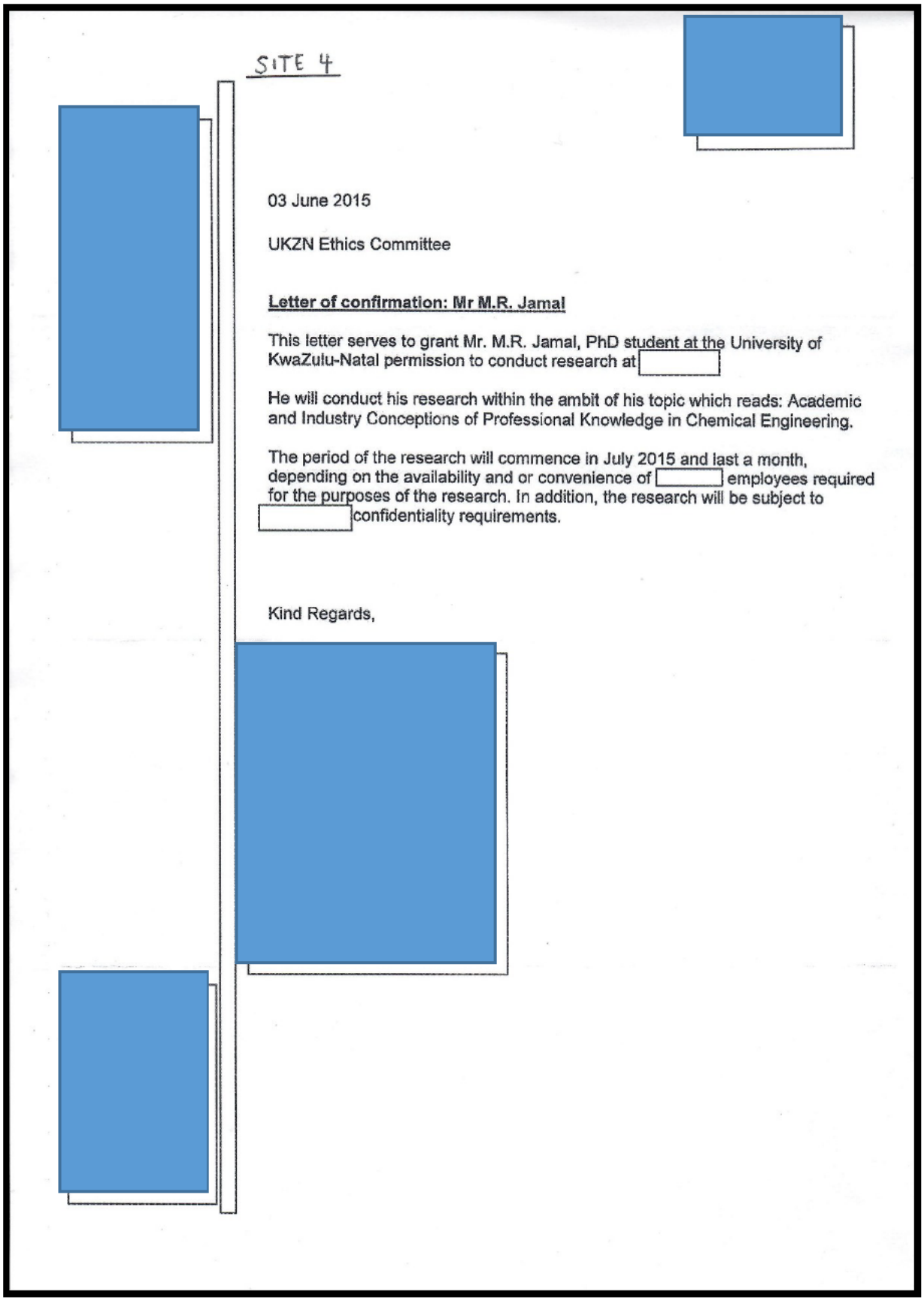
Yours faithfully,

[redacted]

CHIEF EXECUTIVE

[redacted]

APPENDIX 11: GATEKEEPER'S LETTER – SITE 4



SITE 4

[redacted]

[redacted]

03 June 2015

UKZN Ethics Committee

Letter of confirmation: Mr M.R. Jamal

This letter serves to grant Mr. M.R. Jamal, PhD student at the University of KwaZulu-Natal permission to conduct research at [redacted]

He will conduct his research within the ambit of his topic which reads: Academic and Industry Conceptions of Professional Knowledge in Chemical Engineering.

The period of the research will commence in July 2015 and last a month, depending on the availability and or convenience of [redacted] employees required for the purposes of the research. In addition, the research will be subject to [redacted] confidentiality requirements.

Kind Regards,

[redacted]

[redacted]

APPENDIX 12: EDITOR'S CERTIFICATE

62 Ferguson Road
Glenwood
DURBAN 4001
Tel: 072 442 7896
Email: deanne.collins30@gmail.com
Income tax number: 0526066204

25 November 2020

This serves to confirm that I have edited the thesis, "A study of academic and industrial conceptions of professional knowledge", by Mahomed Rafiq Jamal, student number: 901361320.

DISCLAIMER: The editor cannot be held responsible for any errors introduced due to changes being made to the document after the editing is complete (as at 6 October 2020).

Yours sincerely,

[redacted]

(Ms) Deanne Collins (MA)