Science and Mathematics Education Centre

Engineering Lecturers' and Students' Perceptions About Teaching and Learning Practices in a South African University of Technology

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DECLARATION

The thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature:

Date: 28/4/2011

ABSTRACT

This thesis investigated engineering lecturers' and students' perceptions about teaching and learning practices in the Faculty of Engineering at a South African University of Technology. The Faculty of Engineering had experienced low student success rates in many of its programmes and courses over a long time. This study was premised upon the concern that the teaching knowledge competencies of the engineering lecturers might be inadequate to facilitate meaningful learning and to motivate their students to learn better and achieve excellent success rates. The overarching construct of investigation was the lecturers' teaching knowledge. The teaching and learning theories of constructivism and pedagogical content knowledge were used as the main frameworks which guided the study. The teaching knowledge domains investigated in this study were instructional repertoire, representational repertoire, subject matter knowledge, and knowledge of student understanding. Sources of the lecturers' teaching knowledge professional development were also investigated.

The study was approached from two perspectives – the students' and lecturers' views on teaching and learning. Three research questions guided this study.

1. What are students' perceptions of their lecturers' teaching knowledge in their engineering classrooms?
2. What are the lecturers' perceptions of their own teaching knowledge in engineering classrooms?
3. What are the lecturers' perceptions of their own professional development?

A mixed methods design incorporated qualitative and quantitative approaches and techniques to collect and analyse data. Students completed the Students' Perceptions of Teacher Knowledge (SPOTK) questionnaire. Lecturers completed the Teachers' Beliefs about Teaching and Learning in Engineering Questionnaire (TBTLE). Data from 450 completed students questionnaires and 24 completed lecturers questionnaires and interviews with nine lecturers were used to provide answers to the three research questions. The SPOTK and TBTLE questionnaires were found to be both valid and reliable instruments in this higher education context.

The main findings from the study: Students and lecturers perceived teaching knowledge in their classrooms both positively and negatively. Teacher–centred teaching approaches and strategies were still predominantly used in many of the classrooms. Many lecturers had limited knowledge about teaching. Both students and lecturers raised concerns about the ineffectiveness of teaching methodologies and assessment practices to facilitate meaningful learning. Lecturers perceived their teaching approaches and students' attitude towards learning as possible causes of low success rates. The findings confirmed that teaching and learning approaches used by lecturers were not consistent with the teaching and learning theories supported by constructivism and pedagogical content knowledge principles. Lecturers' participation in teaching professional development was based on personal choices. The most predominant sources of professional development were associated with advancement of disciplinary knowledge as opposed to collegiality and attendance of teaching and learning development courses. In addition, both lecturers and students raised dissatisfaction with the some aspects of the engineering curriculum structure and psychosocial factors of an affective nature as possible causes of teaching and learning difficulties.

This study has successfully identified limitations in lecturers' knowledge of teaching. The information has implications for the conceptualisation of teaching knowledge in professional development for engineering lecturers. The findings have the potential to influence curriculum reform in engineering in South Africa. Therefore curriculum design, planning and implementation by decision makers may benefit from the use of these findings.

In conclusion, the study has revealed that the SPOTK and TBTLE questionnaires, used for the first time in a higher education environment, were successful in eliciting students' and lecturers' perceptions about teaching and learning practices in engineering classrooms. This finding adds to the body of knowledge in the use of these tools in teaching knowledge studies.

DEDICATION

This thesis is dedicated to my sons, Shoabute and Molebogeng, granddaughter, Tshegofatso and my late parents and brother, Mr Shoabute Selepe (1929-2007), Mrs Mamogudi Selepe (1932-1998) and Mr Mapale Selepe (1973-2007). Their passion for education continued to inspire me to date.

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It has always been a dream for me to obtain a doctoral degree from an offshore institution of credibility. Coming to Curtin to further my dream has never in any way made me regret it. The journey towards getting the doctorate degree was interesting and also brought satisfaction and fulfilment. I am thankful to the professional support and encouragement of Professor David Treagust, my supervisor, without his help I would never have managed to finish the journey. I would like to thank the staff at SMEC, especially Mrs Rosalie Wood and Ms Petrina Beeton for their kindness and assistance in every respect, especially the caring attitude they had towards me during my brief visit to Curtin University.

The data for this study was collected in 2004 while registered as a part-time offshore student. Following the data collection period, I was able to work on my study consistently. However, since 2005 semester 2 to 2010, personal circumstances precluded me from completing my study. I would like to acknowledge South African National Research Foundation and my employer Tshwane University of Technology for providing me with time and financial resources to allow me to complete this study.

I would like to thank all the students and lecturers in the Faculty of Engineering at Tshwane University of Technology for accepting to participate in the study and to willingly provide me with data. I am grateful to the support and encouragement of my colleagues in the Directorate of Quality Promotion and friends for encouragement and support when I thought the journey will never come to an end

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CHAPTER 1

Background and Rationale

1.1 Introduction

My interest in undertaking this study starts from personal observation while working as an academic development practitioner in the Faculty of Engineering at Tshwane University of Technology (TUT), Soshanguve campus, Pretoria. I observed during senate meetings, Faculty boards and listening to lecturers talking about teaching and learning and students' poor performance issues in their classrooms that they could be an academic tension between the teaching and learning expectations of the lecturers versus those of students. An exemplary extract from a departmental meeting report on semester 1, 2002 examination results stated:

> Chemistry 1 did not however provide an exception to our good results with only 32, 24% of the students achieving passes in the subject. ... It must be emphasised that most of these lecturers have extensive experience in Chemistry. (Head of Department, Department of Chemistry Semester 1 Report, p. 3)

An investigation was immediately carried out and a list of causes to the problem was drawn. This investigation in the Chemistry Department did not even consider scrutinising the lecturers' teaching knowledge as a possible cause of the high failure rate. The head of the department was confident that his lecturers were good teachers. Therefore, the cause of the problem was always blamed on students. None of the remedial measures which had been taken involved investigation and enhancement of teaching knowledge and skills of lecturers.

I also listened to the students talking about their experiences of classroom teaching. Their views were different to that of lecturers. Furthermore, I observed that lecturers were not interested in attending official staff development seminars and workshops on teaching and learning development. I became concerned that lecturers in engineering probably had limited knowledge about good pedagogical principles and strategies to motivate their students to learn better and achieve excellent results. These concerns encouraged the conception of this study**.**

Searching the literature relevant to this kind of problems led me to into the field of learning environments research studies. Extensive work has been done on research in the learning environments. Reviewing the different learning environment studies guided me into the studies on teaching knowledge, pedagogical content knowledge and teaching efficacy.

1.2   Background to Study

As a staff development practitioner I have observed that many educators in higher education complain regularly about students' poor performance in tests and examinations as well as communicate poorly about their subject content. Through my work, I have experienced that this type of concern usually leads to emotional discomfort and confusion among educators. My main concern as a staff development professional was whether the educators themselves do know and understand the learning styles that their students use in order to understand or make sense of the content taught in the lectures. The literature revealed that in vocational or career focussed tertiary institutions such as the technical universities and colleges, the lecturers saw themselves as technical trainers in their subject fields, and were sometimes less concerned about using best practices in teaching (Brent & Felder, 2003; Coetzee-Van Rooy, 2002).

The reality is that in most Technikons (now classified as Universities of Technology in South Africa) lecturers' practice in the classroom is still teacher-centred. As such, lectures are used as the most predominant teaching approach to impart knowledge. The lecture method, though it may be relevant for teaching certain topics, has been found not to always yield good learning because in most classrooms the teaching approach is still teacher- centred, while students remain passive during the rest of the lecture. Previous studies (Aguire, Haggery, & Linder, 1990; Allie et al., 2009; Brent & Felder, 2003; Veldman, De Wet, Mokhele, & Bouwer, 2008; Waghid, 2000; Weimer, 2007) revealed that the traditional teaching practice paradigm was equated with transmitting information to the empty minds of the students.

The predominant use of lectures with the purpose of disseminating information and applying or checking knowledge and understanding conflicts with the role of a

lecturer as a facilitator of student learning and a student support provider (Murray & Macdonald, 1997). Teacher-centred classroom practice therefore reduces the chances that students could effectively integrate knowledge and skills, thus leading to effective learning and good performance. Under alternative educational practice paradigms such as constructivism, science and technology teachers are encouraged to teach in ways that actively engage students in the teaching and learning process (Yager, 2000).

1.2.1 Equity of access and equity of success in Science Engineering and Technology education in public higher education institutions (HEIs) in South Africa

In its mission, TUT endeavours to improve access, retention and success of students in the science, engineering and technology (SET) fields. Though the university was able to reach its target in the last five years, in terms of providing access to diversity of students, including the previously marginalised people, faced a challenge regarding the high failure rate amongst students in engineering. The success, retention and throughput rates in the Faculty of Engineering have decreased over a number of years. The lecturers as well as the external agencies such as the Higher Education Ministry, Engineering Council of South Africa (ECSA) were very concerned about the rate at which engineering students were failing. The high failure rate was found not to be a unique situation to TUT, but a nationwide challenge in engineering education (Department of Education, 2001; DoHET, 2011; Jawitz, 1998; Scott, Yeld, & Hendry, 2007).

Since the onset of democracy in South Africa, the new policies on education encouraged an increase in access to higher education (Department of Education, 1997, 2001). In response, higher education institutions (HEIs) experienced high enrolments even in programmes such as SET which previously experienced low enrolments. However, though access to HEIs has improved dramatically, the HEIs in the last decade have experienced low graduation rates in the SET fields. The rate of enrolments did not show positive correlation with the success and graduation rates. Low graduation rates suggest that schools of engineering would be unable to supply the growing South African economy with adequate engineers and technologists. The Engineering Council of South Africa (ECSA) also acknowledged

the challenges of engineering education and supply of professionals in the engineering fields.

The engineering industry in South Africa also raised concerns about the poor performance of new engineering graduates in terms of their knowledge and skills. Similar concerns were reported elsewhere internationally. According to Seggie (2011), ECSA considered the low success rates and the time taken to complete engineering diplomas or degrees at local HEIs as unsatisfactory. The situation at universities of technology was reported to be even worse, where only 15% of the students enrolled in the three year National Diplomas completed on time.

Though there could be many myriad causal factors for the low success and graduation rates in SET, a number of questions could be raised regarding the quality of teaching knowledge and skills amongst the teaching staff in relation to matching the diversity and profile of the students entering the higher education system in masses. It is common knowledge in South Africa today, that the majority of students enrolling for the first time in SET fields in the HEIs in South Africa did not have the required fundamental competences to cope with the demands of the curricula in the mathematics, science and technology disciplines. The Minister of Higher Education in South Africa also acknowledged the underlying problems, bottlenecks and barriers caused by the post-apartheid school education system that the country is currently facing (DoHET, 2011).

The question that arises from this reality of the poor quality of entering students was the level of preparedness of the engineering lecturing staff in HEIs with regard to their teaching knowledge, especially pedagogical content knowledge. Suitable knowledge and skills in teaching, specifically suitable to science and engineering disciplines, I would argue, could eventually ensure that the students' success and graduation rates in SET education in South Africa would improve. The researcher's view on how teaching and learning in engineering could be improved is shared by ECSA.

ECSA claim that a greater success of engineering education may be achieved through more efficient teaching and learning processes at higher education level rather than only through increasing students' numbers (Seggie, 2011). Accordingly,

the strategy should include use of improved teaching methodologies and techniques. In addition, the strategy should ensure that lecturers are better prepared to deal with teaching and learning challenges in the classroom. A platform where lecturers can share teaching experiences was also suggested.

Most of the teachers in the Faculty of Engineering at the university are recruited from industry, and thus lack teaching qualifications and teaching experience. Their recruitment is usually based on their expertise in subject knowledge and industrial experience. It is assumed that because they are experts in their fields, they will automatically become experts in teaching. According to De Jong (2003), an educator, who is knowledgeable about the subject content, may not necessarily be knowledgeable about pedagogical content. If such a teacher is not made aware about this dichotomy, he or she may be frustrated by the poor performance of the students.

1.3   Theoretical Background

The literature indicates that some tertiary education teachers do not have a clear understanding of how their students learn. Such awareness necessitates the need for professional development of lecturers on pedagogical knowledge issues such as teaching strategies, instructional styles, student learning styles and alternative teaching strategies other than traditional lectures (Coetzee-Van Rooy, 2002; Gallagher, 1989). Identifying beliefs about teaching knowledge from the perspectives of the engineering educators and their students in higher education institutions is crucial if faculty intends to improve student learning experiences and outcomes.

1.3.1   Teaching Knowledge and Pedagogical Content Knowledge

Modern engineering lecturers ought to be empowered to understand and to integrate pedagogical knowledge domains with engineering content in teaching practice. Pedagogical Content Knowledge (PCK) is an important construct within the field of teaching knowledge which could serve as a source of empowerment for engineering lecturers. As a construct, PCK is value-laden both conceptually and practically in the teaching and learning environments. Shulman (1986, 1987) conceptualised PCK to

be knowledge transformed from other knowledge domains, thus making it a very powerful construct in terms of improving teaching practice from a specific subject field. Tuan, Chang, Wang, & Treagust (2000) argue that PCK integrates seven domain of pedagogical knowledge which has relevance to content knowledge. In view of the descriptions of PCK provided by Shulman (1986, 1987) and Tuan, et al. (2000), it could therefore be argued that PCK bridges the gap between the engineering educators as subject specialist and their role as educators. Jang (2011) argues that it is essential that university lecturers should acquire PCK because it serves as part of the knowledge base for teaching, especially for those who want to grow as professional teachers within their disciplines.

According to De Jong, Korthagen and Wubbles (1998) teachers' insufficient knowledge of students' conceptions can be explained as a position of teachers as experts in the subject matter or discipline content knowledge. Because of this difference, teachers' subject expertise tends to be a source of difficulties regarding teaching and consequently revealing teachers' lack of awareness of pedagogical content knowledge. Science, mathematics and technology teaching are specialised teaching disciplines. Therefore, teachers in these fields require specific or context-based approaches to their professional development. PCK therefore provides teachers with an opportunity to examine areas of their teaching in which there are identified deficiencies, and then seek assistance for improvement. This study assumes that there is a gap with respect to teaching knowledge among the engineering lecturers at TUT, hence the tension between the lecturers' expectation and that of their students in terms of students' learning experiences and achievement.

My experience of working with science and engineering educators is that these teachers dislike any educational theory that does not relate directly to their work, thus PCK principles and components will sound more appealing and relevant to their teaching practice.

1.3.2   Research on Students' Perceptions of Teacher Knowledge

This study was conducted within the context of identifying and evaluating perceptions about teachers' knowledge in the engineering classrooms using students' views or beliefs. According to Felder and Brent (1999), students at universities want

a variety of different and often contradictory things. Some students want teaching that emphasises the concrete and practical over the abstract and theoretical knowledge that will prepare them for their chosen professions. Others want rigorous education that will prepare them for graduate schools. Some like working in teams, other hate it. These diverse needs of students pose a major challenge for educators to choose diverse teaching strategies to meet the variety of learning styles which students bring to class.

Knowledge of students learning styles helps the teacher to select appropriate teaching approaches for transforming the tacit engineering content held by expert educators into explicit knowledge for successful student learning (Allie, et al. 2009). In addition, Tuan, et al. (2000) suggest that the results of surveys about students perceptions of teacher knowledge can assist teachers to identify those aspects of their teaching that need to be improved in order to match the students' needs and expectations. Therefore investigating students' perceptions of their lecturers' teaching knowledge could become useful in assisting the engineering lecturers to choose teaching strategies which accommodate their students' needs and learning styles.

1.3.3   Teacher Beliefs about Teaching and Learning

Knowledge about beliefs of teachers with regard to their teaching practices and classroom experience is very important in attempting to resolve challenges associated with poor student performance. A number of studies regarding teachers' beliefs about their teaching efficacy were conducted with pre-service and in-service science teachers in the elementary and secondary schools throughout the world (Bleicher, 2004; Gibson & Dembo, 1984; Kiviet, 1996; Riggs & Enochs, 1990; Thair, 1999). In these studies, the construct of teacher efficacy and its implications on classroom teaching and student achievement was thoroughly investigated. However, similar studies on teacher efficacy beliefs in higher education institutions have not yet been published. Hence, this study attempted to investigate lecturers' perceptions of teaching efficacy and beliefs about teaching and learning in their engineering classrooms within a university of technology.

1.3.4 The need for relevant Professional Development for Engineering Educators

In order for engineering educators to address their lack of educational skills as indicated by Jawitz (1998), good pedagogical knowledge linked with subject content knowledge, is required. It would be wrong to assume that industrial experience plus subject content knowledge has equipped lecturers to have good educational practice skills. The engineering lecturers' development of competence on PCK will not only enhance their teaching practice, but will be useful in preparation for accreditation processes by the Engineering Council of South Africa (ECSA) and Higher Education Quality Committee. Improving teaching requires identifying problems with the existing educational and professional development practices and then applying a combination of sound educational and psychological principles to devise a better approach (Felder & Brent, 1999).

1.3.5 Research in Engineering Education in South Africa

A number of studies in engineering education have been conducted in South Africa, with a focus on student academic development interventions to improve students' success rates(Allie, et al., 2009; Case, 2001; Combrinck, 2003; Horak & du Toit, 2003; Maytham & Martin, 2004; Potter, Van der Merwe, Kaufman, & Delacour, 2006; Swart, 2010). However, research has been conducted and reported about the perceptions of students and lecturers on teaching knowledge and professional development in HEIs engineering classrooms across the world. It was therefore imperative to explore the perceptions of the students and their lecturers about teaching knowledge in their engineering classrooms.

1.4 Significance of the Study

This study is significant in many ways. It is the first study in South African higher education to focus on the perceptions of students and lecturers about teaching knowledge in the engineering classrooms. The findings of the study will contribute to the body of knowledge of how teaching knowledge is perceived by both students and lecturers in engineering classrooms in South Africa. The theory generated from findings will contribute to the perceptions databases about teaching and learning in engineering and also contribute to building significant knowledge about views on teaching knowledge in higher education

It was the first time that the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire (Appendix 3), the two teaching efficacy scales from the Science Teaching Efficacy Beliefs Inventory (STEBI) questionnaire and a teaching professional development scale used to compile Teacher's Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire (Appendix 4), were used with students and lecturers respectively in a South African higher education environment. Previously these instruments were validated and used in elementary and secondary schools science classrooms across the world. The study will add to the body knowledge relating to use of these instruments not only in engineering education but within higher education sector.

It is important to ensure that teaching and learning in higher education institutions in South Africa is of good quality. Therefore, studies of perceptions of teaching knowledge are of utmost importance with a view of using the findings of studies like this one for improving the quality of teaching and learning. The findings of the study will provide engineering education curriculum developers, quality assurance practitioners and academics with a basis to understand the implications of curriculum review in South Africa.

Knowledge of engineering students' views and lecturers' beliefs do make a difference in classroom teaching practice. The findings of this study could help engineering educators to reflect on how they teach, identify their short comings in terms of teaching knowledge and skills. Subsequently they may decide to do something to change their teaching based on a new knowledge gained from their students.

1.5   Purpose of the Study

The purpose of this study was to investigate the engineering students' and lecturers' perceptions about teaching knowledge as they experience it in their classrooms.

1.5.1 Research Objectives

The research objectives for this study were generated from the concerns generated from personal experience of the researcher and also from literature regarding

perceptions of teaching knowledge and professional development in engineering classrooms of higher education institutions.

1. Investigate the perceptions of students about teaching and learning in their engineering classrooms
2. Investigate the perceptions of lecturers about teaching and learning in their engineering classrooms
3. Investigate opportunities available for teaching professional development of engineering lecturers in the institution

Consequently, with information from the research questions, the study will be able to provide recommendations from the findings and its implications professional development of engineering lecturers with a view to improve teaching and learning in the Faculty of Engineering at Tshwane University of Technology. In order to have a clear action plan, objectives were converted into research questions.

1.5.2 Research Questions

This study was designed to answer the three main questions. In order to guide the research process, the research questions were divided into sub-questions.

Research Question 1: What are students' perceptions of their lecturers' teaching knowledge within their engineering classrooms?

    1.1   Is the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire reliable for use in a higher education institution to explore perceptions of students about teaching knowledge of their lecturers?

    1.2   What are the perceptions of students from various engineering programmes on each teaching knowledge repertoire evaluated by the SPOTK questionnaire?

Research Question 2: What are the lecturers' perceptions of their own teaching knowledge in engineering classrooms?

2.1 Are the personal teaching efficacy and teaching outcomes expectancy efficacy scales reliable for use in a higher education institution to explore perceptions of engineering lecturers on own teaching knowledge?

2.2 Is there a relationship between lecturers' personal teaching efficacy beliefs and the qualifications the lecturers taught, the highest qualification the lecturers held and the period of participation in teaching professional development activities?

2.3 Is there a relationship between the lecturers' teaching outcome expectancy efficacy and the qualifications the lecturers taught, the highest qualification the lecturers held and the period of participation in teaching professional development activities?

2.4 What were the most predominant perceptions of the lecturers about their teaching knowledge?

Research Question 3: What are the lecturers' perceptions of their professional development?

3.1 Is the professional development scale reliable for use in a higher education institution to explore the perceptions of engineering lecturers on their professional development?

3.2 Is there a relationship between the professional development scale and the qualifications the lecturers taught, the highest qualifications held by lecturers and the period of participation in professional development activities?

3.3 What were the most predominant opinions about sources of professional development the lecturers preferred to participate in?

1.6   Overview of the Thesis

The thesis is divided into eight chapters. The first chapter introduced the thesis by explaining the purpose of the study, its objectives and associated research questions.

In addition, a brief overview of the rationale, significance and research methodology were described.

Chapter 2 describes review of literature related to the theoretical and conceptual framework for the study, studies about students' and teachers' perceptions of teaching knowledge, teaching efficacy beliefs and outcomes expectancy efficacy, engineering education and professional development.

In Chapter 3, a detailed description of the research methodology used to address the research questions is provided. The study used a combination of research methods. A broad range of issues related to use of qualitative and quantitative research approaches is outlined. Furthermore, a historical perspective on the development of the data collection instruments is described. Selection of participants, data collection methods and data analysis techniques used for the output of results is outlined.

In Chapter 4, the analysis of data, results and findings of the students' questionnaire, SPOTK, are discussed. Both the quantitative and qualitative results are discussed in detail. The discussion in this chapter is aimed at addressing Research Question 1 regarding the perceptions of students on the teaching knowledge of their lecturers.

Chapter 5 reports on the data analysis, results and findings of the lecturers' perceptions of their teaching knowledge using the two teaching efficacy scales. The quantitative results and interpretations are discussed in detail with the purpose of addressing Research Question 2.

Chapter 6 reports on the quantitative data analysis, results and finding for Research Question 3. The focus of the chapter is about the lecturers' perceptions on professional development sources and activities they frequently engage in for enhancement of their teaching knowledge.

In Chapter 7, the analysis of the qualitative data and results generated through the interviews with the eight lecturers are presented. A synthesis of the relationship between the findings from chapter 4, 5 and 6 is given.

Chapter 8, the final chapter of the thesis provides an overview of the study, summary of results and major findings in terms of the three research questions. A discussion on the limitations of the study, recommendations for future research and implications for teaching and learning practice in engineering education concludes the chapter.

CHAPTER 2

Literature Review

2.1   Introduction

This chapter provides a review of literature related to perceptions about teaching and learning knowledge. The scope of the literature reviewed includes studies in pedagogical content knowledge, students' perceptions of teacher's knowledge, and teachers' beliefs about their own teaching knowledge and professional development. Exemplary studies on improvement of student learning in engineering were also reviewed. Since literature on perceptions about teacher's knowledge in engineering education is limited, literature relating to science and technology teaching and learning was also used to provide theoretical perspectives and research framework for this study. The chapter also provides a distinctive brief review of the state of engineering education in South Africa.

Teaching knowledge forms the heart of every curriculum and learning programme respectively. Any shortcomings on any of the domains of teaching knowledge would impact negatively on the implementation of the curriculum and overall academic outcomes and student achievement in any discipline. Educators require a good grasp of teaching knowledge and skills in order to implement the curriculum aims and to provide students with good learning experiences. A starting point in gathering an understanding of the status of a teacher's teaching knowledge base would be to identify teachers' believes about their own teaching. In addition, students are able to provide valuable information about their experiences of their teachers' teaching knowledge. Studies conducted on learning environments (Fraser, in press) indicate that information about teachers' and students' perceptions of learning environments is important in identifying possible shortcomings in pedagogical practices. Consequently, the information could be used to address the teacher's limitations in teaching knowledge. Therefore the conception of this study to investigate perceptions about teaching knowledge in the engineering classrooms was influenced by previous studies conducted in learning environments (Fraser, in press), teacher knowledge, and pedagogical content knowledge (De Jong, 2003; Gess-Newsome *&*

Lederman, 1999; Grossman, 1990; Shulman, 1987; Tuan, et al. 2000). In order to gather a broader understanding of what teachers believed about their teaching knowledge and the expectations they had about their students' achievement in engineering, the construct of science teaching self-efficacy beliefs (Bandura, 1997; Bleicher, 2004; Kiviet, 1996; Riggs & Enochs, 1990; Thair, 1999) was also reviewed.

2.2 Theoretical and Conceptual Framework for the study

This study is guided by two main theoretical constructs on teaching and learning, namely, constructivism and teaching knowledge. First and foremost are the frameworks on social constructivism and how they provide guidance on effective teaching and learning. Secondly, teaching knowledge as a framework provides guidance and understanding about competences required by teachers in order to facilitate meaningful learning in their classrooms. Within the teaching knowledge theoretical framework, pedagogical content knowledge was selected as a special teaching knowledge domain associated with providing sound principles for effective teaching and meaningful learning within a discipline.

The two theoretical frameworks were selected because of their possible influence on the improvements in engineering teaching and learning practices. Most of the knowledge generated from research on science teaching and learning today, gained their conceptual frameworks from social constructivism and pedagogical content knowledge. Therefore, for the purpose of this study, my review of literature regarding teaching knowledge placed special emphasis on pedagogical content knowledge, (PCK). These two theoretical frameworks support the argument of why this study was significant in investigating perceptions about teaching knowledge of engineering lecturers in a South African institution of higher learning.

2.2.1 Constructivism

Constructivism as a theory of teaching and learning has its roots in the developmental theories of cognition and social constructivism. Constructivists' view meaningful learning as a cognitive process in which individuals make sense of the

world in relation to the experience and knowledge which they had already constructed and the sense making process involves active negotiation and consensus (Fraser, in press). In reviewing literature, Treagust, Duit and Fraser (1996) describe constructivism as a teaching and learning framework which consists of two principles, one psychological and the second epistemological. Emphasises are based on the fact that knowledge cannot be separated from the process of knowing. The first principle states that knowledge is not received passively but it is build up by the cognizing subjects. In other words, it is not possible to transfer ideas into students' heads intact; rather, students construct their own meaning from the words or visual images they see. Consequently, when engaging in this construction of meaning, what the learner knows already is of central importance. The third principle states that although individuals have to construct their own meaning of a new phenomenon or idea, the process on constructing meaning is always embedded within the social setting of which the individual is a part (Prince & Felder, 2006; Terhart, 2003; Treagust, Duit, & Fraser, 1996)

Constructivism, as a theory of teaching and learning, provides educators with an alternative model to positivist educational principles and approaches (Prince & Felder, 2006). Furthermore, Prince and Felder (2006) argue that constructivism serves as a foundation for inductive teaching and learning. In the heart of constructivism there is a notion that individuals actively construct and reconstruct their own reality in an effort to make sense of their own experience. New information is filtered through mental structures that incorporate the students' prior knowledge, beliefs, preconceptions and misconceptions, prejudices and fears. If the new information is consistent with the student's mental structures, it may be integrated into them as new meaningful learning. However, if the new information is contradictory, the students may memorise it (rote learn) for examination purposes only. The student may decide never to use such new information in circumstances and situations beyond the assessment and collection of grades, (Prince & Felder, 2006).

Constructivism is embedded in the belief that knowledge is constructed in the mind of the learner in an interactive way. Treagust et al. (1996) argue that if the constructivist approaches are to be implemented effectively, teachers' traditional

beliefs about transmission approaches to teaching and absorptionist' views of learning need to be challenged. Therefore, this challenge about implementation of constructivist approaches in the classroom provides a conceptual framework as to why the study of beliefs about teaching and learning practice in engineering classrooms is important, especially in view of the suggestions that learner-centred teaching approaches be introduced in many teaching and learning environments in South Africa. Learner-centred teaching and learning approaches are mainly embedded in constructivism.

Constructivist's teaching and learning environments become a reality if teachers employ teaching practices that promote learners' conceptual change and learner-centeredness. According to the constructivist approach, teaching methods are selected according to the learning outcomes envisaged. Prince and Felder (2006) summarised the constructivists' principles of effective teaching and learning thus:

- Instruction should start with content and experiences the students are likely to be familiar with. New teaching and learning materials should be presented in context to the real-world applications and its relationship to the other areas of knowledge. New materials should not be taught in an abstract way and out of context

- Learning materials should not be presented in a manner that requires students to alter their cognitive models abruptly and drastically. Teaching should be 'spirally organised' to allow students to reflect critically and continually revisit concepts until their cognitive models have been improved.

- Instructional approaches and strategies should challenge students to fill in gaps and extrapolate materials presented by the instructor. The goal should be to wean the students from dependency on the teacher as a primary source of information and encourage them to become self-directed learners.

- Instructional strategies should involve students to work together in collaborative and cooperative learning groups

In reviewing literature, Mills and Treagust (2003) summarised the role of constructivism principles in assisting the lecturers to set up learning opportunities in a university engineering environment thus:

- Anchor all learning activities to a large task or problem

- Support the learner in developing ownership for the overall problem or task
- Design an authentic task
- Design the task and the learning environment to reflect the complexity of the environment they should be able to function in at the end of the learning
- Give the learner ownership of the process used to develop the solution
- Design the learning environment to support and challenge the learner's thinking
- Encourage testing ideas against alternative views and alternative contexts
- Provide opportunity for and support reflection on both the content learnt and the process of learning

Prince and Felder (2006) argue that simply adopting inductive teaching approaches such as constructivism will not automatically lead to meaningful learning and satisfied students. Just like any other teaching approach, inductive teaching can be done well or poorly. The outcomes are dependent on the teacher's knowledge, skill and care with which it is implemented. Furthermore, Prince and Felder (2006) suggest that teachers should be aware that some students might be resistant to any type of teaching approach that makes them become more responsible and accountable for their own learning. Some students may develop hostile characteristics towards learning tasks thereby producing poor learning outcomes and providing evaluations. Teachers are expected to provide guidance and support in order to motivate the learners persistently.

The framework on teaching and learning approaches in constructivism provide a basis on which the researcher could understand and interpret the findings regarding the views of students and engineering lecturers about teaching knowledge. By implication, the teaching and learning principles founded on constructivism may mean that to succeed in implementing the constructivist approaches to teaching and learning, teachers should have adequate teaching knowledge and skills to be able to select relevant instructional repertoires and relevant assessment strategies to support inductive and learner-centred educational practices. This condition on teaching competence further provides a challenge to teachers, who may want to make their

classrooms interesting and meaningful, to be initiated into constructivism by first identifying and understanding the needs for their own professional development.

The assumption held by the researcher, prior to the development of this study, was that engineering educators at Tshwane University of Technology did not employ constructivist teaching approaches, and hence, there were many complaints that learners were failing because they did not have basic knowledge needed from secondary schools to understand engineering at tertiary level. The blame was always on learners and never on the methods of teaching used in the classrooms. These lecturers probably did not know that when presenting lectures, no matter how good they may look, learners would experience them differently to the lecturers' intentions. This view is also shared by Mills (2002) in her observations of the engineering education environments in South Australia. Mills observed that;

- Different students prefer different learning styles, almost no students learn successfully by attending lectures
- No matter how entertaining a lecturer might be, lectures can be boring for both lecturer and students.
- No matter how well the concept is presumed to have been taught during a lecture, the majority of students will at best only partly understand it until they have been asked to apply it by tutorials or a design project
- Some students who strive for and demonstrate conceptual understanding during a course are unable to demonstrate this understanding through examinations.

Therefore, for the engineering lecturers who never reflect on their teaching practice against the teaching and learning framework provided by constructivism, I would argue, may find it difficult to understand why students fail to achieve better in their studies according to their teachers 'expectations.

2.2.2 Teaching Knowledge

Teaching, just like any occupation, irrespective of where the teacher is practising, has got its own principles and pillars of quality. One of the pillars of quality in teaching and learning is teacher's competence in teaching knowledge and skills.

According to Shulman (1987) teaching begins with the teachers' understanding of what is to be learned and how it should be taught. The second stage involves selection of learning activities and opportunities for students by the teacher. The last stage involves comprehension of the teaching ends by both the learner and the teacher. However, Shulman's initial view of teaching had short comings since it presented teaching as if it was only about what is to be learned. Teaching is a complex process which encompasses a variety of processes. The teaching processes ought to be understood and undertaken by the teacher and the learners in a meticulous way (Shulman, 1986, 1987).

In an attempt to unravel the complexity of understanding the processes of teaching knowledge, a number of studies on teaching knowledge were conducted and various models of good teaching knowledge bases were proposed. The most prominent scholarly work recognised as a foundation in teaching knowledge bases today, is the work done by Shulman and his colleagues. Shulman (1987) conceptualised the teaching knowledge base to be comprised of seven categories, namely:

- Content knowledge
- General pedagogical knowledge which it encompasses broad principles and strategies for classroom management and organisation
- Curriculum knowledge, which include materials and programmes that serve as tools of the trade for teachers
- Knowledge of the learners and their characteristics including processes of learning
- Knowledge of educational contexts of schooling which would include factors such as school and local communities of interest culture, philosophies, governance and finances
- Knowledge of educational ends such as purpose, goals and objectives, values and outcomes
- Pedagogical content knowledge, a special category which focuses on combination of disciplinary subject matter content and pedagogy. It is unique to area of expertise of the teacher and the teacher's own special form of professional understanding

  (Shulman, 1987)

Though Shulman's work was acknowledged as ground breaking in an attempt to understand teacher knowledge bases, his model received various criticisms from teaching knowledge scholars. In an attempt to improve Shulman's model of teaching knowledge, Grossman (1990), suggested that teacher knowledge was formed by four general pillars of knowledge base which are, general pedagogical knowledge, subject matter knowledge, knowledge of context and pedagogical content knowledge. Most scholars agreed with Grossmans' four categories of teaching knowledge base (Grossman, 1990). Shulman's work and that of Grossman contributed extensively towards paradigm shifts on how teaching was to be understood and teachers were to be developed.

Many studies have reported on the importance of teaching knowledge in facilitating meaningful learning to ensure that teaching outcomes and student achievement are of good quality. Studies on how teachers acquire teaching knowledge in specific subjects were mostly conducted with the primary and secondary schools teachers. There is a need in the university teaching and learning environments for lecturers to acquire teaching knowledge and skills. Even though the university lecturers are not expected to have formal qualifications in teacher education, awareness about the values of teaching knowledge would go a long way in ensuring that university teachers realise the importance of teaching knowledge if they want to become effective teachers. Research has shown that many novice and some experienced university teachers have substantial knowledge of the subject matter but did not know how to teach effectively (Jang, 2011; Tuan, et al. 2000; Waghid, 2000; Weimer, 2007). A good teaching knowledge base is therefore essential even for university lecturers if they want to be recognised as professional teachers.

2.2.3 Pedagogical Content Knowledge

The uniqueness of pedagogical content knowledge (PCK) as a category in teaching knowledge which is more relevant to discipline based teaching approach was identified in this study, as a teaching knowledge category of importance worth extensive review. PCK is a powerful construct which could serves as a foundation for effective teaching in the engineering classrooms. Shulman conceptualised pedagogical content knowledge (PCK) to be knowledge transformed from other

general pedagogical knowledge domains, thus making it a very powerful construct in terms of improving teaching practice from a specific subject field. Pedagogical content knowledge was therefore defined by Shulman (1987) as:

> *"Pedagogical content knowledge identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and adapted to diverse interests and abilities of learners and presented for instruction it is a category most likely to distinguish the understanding of the content specialised from that of the pedagogue."* [Shulman, 1987. p8]

According to Shulman (1986, 1987), PCK is a teaching and learning framework comprising of powerful analogies, illustrations, examples, explanations, demonstrations which a teacher could use to facilitate content knowledge in a way that is comprehensible and meaningful to others. PCK is a special teaching knowledge base which differentiates the subject matter expert with a teacher (Shulman, 1987). In addition to Shulman's model of PCK, Grossman (1990) added four more pillars or categories to the model. Grossmans' (1990) additional categories included:

- Knowledge and beliefs about the purpose of teaching a subject
- Knowledge of students' understanding, conceptions, misconceptions of particular topics of the subject matter. Knowledge of misconceptions is essential in assisting the teacher to select the most appropriate explanations and representations to address the misconceptions.
- Curricular knowledge. This category includes knowledge of the curriculum in terms of what students have studied in the past and what they are likely to learn in the future.
- Knowledge of instructional strategies and representations for teaching particular topics. This means that a teacher with adequate knowledge of PCK would demonstrate rich repertoires of metaphors, experiments, activities or explanations which are particularly relevant to teach certain topics.

The models presented by Shulman (1987) and Grossman (1990) elevate PCK as a construct and theoretical framework to study and understand teacher knowledge for both experienced and new teachers. In addition, it provides a good framework for researchers in teacher knowledge and student learning to understand complexities in teaching and learning. Furthermore, Shulman's and Grossman's scholarly work shows that PCK goes beyond knowledge of subject matter because it explains the relationship between the dimensions of pedagogical knowledge and subject matter knowledge thus making it a very powerful construct in terms of improving teaching practice from a specific subject field. Therefore, PCK bridges the gap between the subject specialist and the general educators (Gess-Newsome & Lederman, 1999).

Research interest in science teaching and pedagogical content knowledge (PCK) following Shulman's and Grossman's work grew very strongly in the last two decades. Many studies were conducted with pre-service and in-service teachers for example, Magnusson, et al. (1999) model of PCK shows a relationship among domains of teacher knowledge also known as the components of PCK, namely: orientations towards teaching science, knowledge of science curricula, knowledge of students understanding of science, knowledge of students' assessments in science and knowledge of instructional strategies. According to this representational model of PCK, effective teachers need to develop knowledge with respect to all aspects of PCK and also with respect to all the topics they teach.

Though there are various conceptions and models developed since Schulman's and Grossman's work, (Gess-Newsome & Lederman, 1999) suggest that there seems to be an agreement among the science teaching scholars that the conceptualisation of PCK is guided by the following intertwined elements:

- Knowledge of presentations of subject matter for teaching
- Knowledge of instructional strategies incorporating these representations
- Knowledge of specific student conceptions
- Knowledge of specific student learning difficulties

De Jong (2003) and Magnusson, et al. (1999) suggest that all the elements of PCK function as a unit. If a teacher master's only one element of PCK, there is no

guaranteeing that his/her teaching will improve. This argument has major implications for teacher professional development programmes. It means that the professional development models need to be approached from a holistic view, incorporating all aspects of PCK. Therefore, it is imperative that teachers' prior beliefs and knowledge about pedagogical practice are elicited, identified and ultimately incorporated into the professional development programme. The teachers' insufficient knowledge of students' conceptions can be explained as a position of teachers as experts in the subject matter or discipline content knowledge. The experts tend to think and reason from a different level (abstract) while their students think from a novice level of reference. Because of this difference, teachers' subject expertise tend to be a source of difficulties regarding teaching and consequently revealing teachers' lack of awareness of pedagogical content knowledge, (De Jong, et al. 1998; Jang, 2011). This observation was also reported by Allie, et al. (2009) where engineering educators were reported to have experienced difficulties in making the tacit knowledge (that knowledge held by the subject experts) explicit (what learners need to understand) to their students.

Recently, there have been a number of studies conducted regarding the further conceptualisation of PCK in terms of its value in science education following the literature review by Gess-Newsome & Lederman in the late nineties. Tuan, et al. (2000) suggested that PCK in science teaching should integrate seven domain of teaching knowledge, viz. Pedagogical knowledge, representational knowledge, subject matter knowledge, curriculum knowledge, assessment knowledge, student knowledge and context and social knowledge. Jang (2011) added categories of pedagogical techniques, knowledge of what makes science concepts difficult to learn, knowledge of students prior knowledge and theories of epistemology.

These new perspectives, further strengthens the use of PCK as a relevant framework for teaching and in science classrooms. The question arising from these theoretical arguments is whether PCK is contributing positively in making a teacher understand the principles and perspectives of successful teaching and thus develop into a competent teacher? PCK as a construct is value-laden both conceptually and practically. The researcher's experience with science and engineering educators is that these teachers dislike any educational theory that does not relate directly to their

work, thus PCK principles and components should sound more interesting and relevant to their teaching practice and professional development needs.

Though the field of investigating teacher knowledge has grown quickly in the natural sciences, less has been done regarding research about teaching and pedagogical content knowledge within higher education in engineering classrooms. In addition, many of the research studies on PCK were conducted with science pre-service and in-service teachers at primary and secondary schools and a gap thus exists regarding the research literature on PCK studies with higher education teachers, especially in science and engineering disciplines.

This study adopted the teaching knowledge models proposed by Shulman (1987) and Grossman (1990). The models have many characteristics of a good model to provide theoretical framework for the study. In addition the PCK model has provided a new framework for research on teacher cognition and the importance of subject matter and its transformation for science teaching (Gess-Newsome, 1999). However, the researcher is aware of the reported weaknesses of the PCK models in terms of the degree of precision and heuristic power to discriminate the construct associated with the model with regard to the relationship among constructs and the matching of the research data (Gess-Newsome, 1999). In addition, Gess-Newsome (1999) argues that although the PCK model creates a unique framework for studying knowledge held by teachers, identifying instances of PCK is not an easy task. Accordingly, some researchers had reported that PCK boundaries with other teaching knowledge domains were fuzzy (Carlsen, 1999). This made categorisation of data into PCK constructs difficult. However, Gess-Newsome (1999) suggested that researchers could use ephemeral clarity to assign and categorise knowledge to PCK and its related constructs.

2.2.4 Sources of Teaching Knowledge

According to Shulman (1987) an individual's teaching knowledge base develops through a variety of sources such as scholarship in content discipline, materials and setting of institutional education policies and processes, research on schooling,

learning from other teachers, teaching development and other cultural phenomena which affect teachers in their practice and wisdom of practice.

The source of scholarship takes into account that subject matter content develops through scholarship in the nature of knowledge within a discipline. The teacher has to show deep understanding of concepts and principles of the subject matter content and how to communicate the subject matter in a meaningful way to students. This view puts the responsibility on the teacher to have a deep understanding of the subject matter and how students are to learn the content (Shulman, 1987). Formal educational scholarship as a source of teaching knowledge provides the teacher with the opportunity to engage in scholarly work on teaching and learning. The last source of teaching knowledge is the educational materials and structures of teaching and learning. Teachers' engagement with curricula, assessment issues and institutional policies on teaching and learning provide a good opportunity to develop teaching knowledge (Shulman, 1987).

Jang (2011) argues that since PCK relies a lot on dynamic relationship between various areas of teaching knowledge, it is very much dependent on the practice of the content to be taught. The development of PCK is reported to be personal, contextualised and influenced by the interaction of the teacher with many factors in the teaching and learning environment and his or her classroom experience Therefore teaching experience and personal reflection of a teacher about his or her teaching practices were reported to be the greatest influences on the teacher development of PCK (Grossman, 1990). In addition to the experience and reflection, knowledge of students' views about teaching knowledge of their teachers and a formalised professional development programme of collegial nature in PCK was found to yield results in improved teaching practices and student achievement (Jang, 2011).

Jang (2011) argued that professional development in PCK is essential even for university lecturers if they want to grow as professional teachers. A case study conducted by Jang (2011) with a novice university physics teacher revealed that contextualised professional development in PCK could turn a specialist in physics, with little understanding of pedagogical principles into a more effective and

competent teacher. Since PCK serves as an important part of knowledge in teaching, it is essential that university teachers are made aware of its value if they intend to improve their teaching outcomes. Shulman (1987) suggest that teaching knowledge base is not fixed or final but rather continues to be reformed and transformed by teachers and scholars as they engage with the teaching process through evaluation and reflection.

2.2.5 Teaching Efficacy

The literature review in this section was intended to position the teaching efficacy as a construct associated with conceptions about teaching knowledge. Teaching efficacy is linked to self-efficacy. Interest in studies on self-efficacy is mainly documented from theoretical perspectives championed by Bandura in the seventies and eighties. According to Bandura (1997), human behaviours are influenced by the individuals' beliefs and attitudes regarding efficacy namely the self-efficacy and outcomes expectation efficacy. Self-efficacy refers to a conviction that one has the ability to succeed fully to execute the behaviour required to produce an outcome. The outcomes expectation efficacy refers to the expectation that a given behaviour will yield certain outcomes. Bandura (1997) further argued that people with high self-efficacy and outcomes expectancy would demonstrate the confidence to act and behave in a decisive way. When Bandura's theory of self-efficacy is applied to the teaching and learning contexts, it would imply that a teacher with a high self-efficacy would display high level of confidence that he or she is capable of providing excellent teaching opportunities to the learners, possess competencies to execute teaching tasks and thus his or her actions would produce positive and excellent student academic outcomes (Gibson & Dembo, 1984). In pedagogy, confidence could be linked to creativity, passion and excellent content knowledge and strategies to deliver it within a specific subject matter discipline (Enochs & Riggs, 1990). Personal teaching efficacy assesses perceptions about teaching competences in terms of instructional approaches and strategies, assessment, subject matter and knowledge of student understanding (Goddard, Hoy, & Woolfolk-Hoy, 2000). In addition teachers with high efficacy tend to experiment more with methods of teaching to better meet their students' needs (Henson, Kogan, & Vacha-Haase, 2001).

Gibson and Dembo (1984) contend that Bandura's definition of teaching efficacy and outcomes expectancy were too limited to provide a clear understanding of the broad and complex dynamics of educational practice (teaching and learning processes). Self-efficacy is a complex multidimensional concept which consists of more than two dimensions as defined by Bandura (Gibson & Dembo, 1984). The teaching and learning process is affected by many other variables such as the teachers' personal characteristics such as gender, academic qualifications and preparation for the teaching job and teaching experience. Gibson and Dembo (1984) suggested that in order to understand the effect of self-efficacy on teaching and learning processes, an investigation about the relationship between the teachers' characteristics or profile and teaching efficacy should be considered.

In addition, there are other environmental factors which may affect the teaching and learning outcomes which the teacher may not have control on. Kiviet (1996) argued that studies on the measurement of teacher's situation specific sense of teaching efficacy could enable the researchers to identify characteristics and factors that contribute to a low sense of teaching efficacy and also enable researchers and educators to assess the effectiveness of strategies designed to overcome a low sense of teaching efficacy. However, a teacher with a high level of teaching efficacy will not be discouraged by negative factors such as heavy teaching load and student high failure rates. Teachers with high levels of efficacy look for solutions to address teaching challenges they face. The low success rate concerns which prompted the conceptualisation of this study can be addressed if the collective efficacy of the lecturers is high enough to persevere in seeking solutions.

Teacher efficacy is also linked to teacher effectiveness which in turn influences students' attitude towards learning, affective growth and overall achievement (Cakiroglu, 2008). Teacher' thoughts that they will be able to influence their learning positively have an influence on the choices that a teacher would have on teaching activities and learning opportunities (Ashton & Webb, 1986). Furthermore, such a teacher would expend all the effort and also persist in facilitating learning so that his or her students could do well in line with his or her expectations. This assertion could mean that if all environmental factors are taken into consideration, teachers with a high self-referent would have a high teaching efficacy and, consequently,

would have high student outcomes expectations (Kiviet, 1996). The teachers views about personal teaching efficacy is an integrating construct which mediates the relationship between teachers' expectations about the efficacy of teaching specific students and teachers' classroom interactions with the students (Ashton & Webb, 1986; Kiviet, 1996)

Goddard, et al. (2000) argue that teaching efficacy does not develop on its own. Teachers need to be exposed to various sources of professional development in order to improve their teaching efficacy. Goddard, et al. (2000) suggest that teachers could learn from their own experiences about successes and failure, through social persuasions such as participation in formal and informal collegial activities like professional development programmes and being able to manage affective factors such as stress and pressure.

2.3 Research on Students' Perceptions of Teacher Knowledge

Students in universities have a variety of expectations from their teachers, which sometimes may vary completely with those of their teachers, further creating a dichotomy in the teaching and learning situation. Jang (2011) argued that students come to class with certain expectations from their teachers about effective teaching when they enrol in a programme. According to Jang (2011), students' perceptions of effective teaching would include a combination of methods, context, students' effort and teacher commitment. According to this view of students, effective teachers would be those that display characteristics such as (i) knowing the subject, (ii) show evidence of thoughtful planning, (iii) use appropriate teaching strategies instructional and representational repertoires and (iv) give adequate structure and directions for learning. Tuan, et al. (2000) also reported similar students' expectations from a study conducted with secondary science students in Australia and Taiwan.

These diverse needs and expectations of students pose a major challenge to university teachers to choose diverse teaching strategies to meet the variety of learning styles which students bring to class. University teachers are also challenged to develop an understanding of the learning styles their students use to make sense of the content. Knowledge of students' learning styles helps the teacher to select

appropriate teaching approaches for transforming the tacit abstract content held by expert educators into explicit knowledge for successful student learning, (Allie, et al. 2009).

Knowledge of students' perceptions about their teachers' pedagogical knowledge at university is therefore very important in the professional development of teachers. A study conducted by Jang (2011) explored the impact of using students perceptions of their Physics teacher's PCK at college level. The study involved collecting student views before and after a professional development intervention programme about PCK of their teacher. The pre-test was used to measure views and identify areas were students were not satisfied with their teacher's performance in class. At this stage, students' perceptions of the teacher were reported to be low. For example, students learning styles did not match the teacher's way of teaching even though the teacher was reported to have good subject knowledge.

An intervention professional development programme was established for the teacher to enhance her pedagogical content knowledge. The context of the professional development programme for PCK was very collegial and involved a lot of reflection by the teacher. The findings revealed that after the intervention programme, students perceptions of their teacher were highly enhanced in all the categories of PCK. In addition, the findings revealed that the PCK workshops and students' perceptions questionnaires helped the teacher to develop an understanding of the pedagogical content and also assisted her to choose appropriate content for students. Furthermore, the PCK workshops helped the teacher to understand students' prior conceptions of the subject matter and learning difficulties. Jang (2011) suggest that using students' perceptions about teaching knowledge is beneficial in the sense that it enables the researchers and teachers to appreciate perceived instructional and environmental influences on students learning process.

Awareness of students' perceptions of teaching combined with personal reflection of own practice, would not only challenge the engineering lecturers in this study to look for opportunities to enhance their knowledge and skills, but would subsequently lead to improved personal teaching efficacy and teaching outcomes.

2.4   Research on Teachers' Perceptions of their own Teaching Knowledge

Teachers' beliefs about the purpose of teaching a specific subject influence their choice of what content to teach and how to teach it. According to Grossman (1990) conceptions of what it means to teach a subject includes teachers' beliefs about the purpose of studying the discipline, the goals and expectations they set for students and beliefs about the nature of the subject. In addition, teachers' beliefs and their pedagogical knowledge base determine the kind of instructional and representational repertoires they would use to teach the subject (Grossman, 1990).

Thair (1999) and Kiviet (1996) argue that teachers' beliefs about teaching should never be ignored because of a possible influence of the beliefs on classroom teaching and consequently influencing students' learning. Thair's argument is based on the notion that if teacher beliefs about science teaching are neglected in professional development initiatives, there is a possibility that instructional strategies and methods used by the teachers may be incompatible with contemporary philosophies of learning such as constructivism and outcomes based education.

Research studies have shown that there is a strong relationship between teacher beliefs and their performance in the classroom. Teachers with low teaching efficacies were found not to have a strong believe that they were able to teach science effectively (Enochs & Riggs, 1990; Kiviet, 1996; Thair, 1999). Enochs and Riggs (1990) suggest that possible causes of low personal teaching efficacy could be that teachers do not have adequate discipline content and teaching knowledge to teach science.

The study conducted by Huibregtse, et al. (1994) investigated physics teachers' conceptions of their own learning and how it affects the way they teach. Their findings confirmed that the way in which teachers want to teach and their goals in teaching were related to their approach and goals in their own learning process. This finding confirms the researcher's thinking that engineering lecturers use their own personal learning experiences as frameworks of the way they teach engineering courses. Thair (1999) and Gess-Newsome (1999) also reported that teachers' life experiences of teaching, from their schooling days through graduate level, have an

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impact on how they teach in class. This experience serves as a foundation for teachers' beliefs and practices in classroom teaching. Therefore, every conceptual change intervention programme has to take teachers' believes and perceptions about teaching seriously, so as to avoid disappointments of implementing unsuccessful outcomes professional development programmes.

A study by De Jong, Korthagen and Wubbles (1998) revealed that the teachers' insufficient knowledge of students' conceptions can be explained as a position of teachers as experts in the subject matter or discipline content knowledge. The experts tend to think and reason from a different level (abstract) while their students think from a novice level of reference. Because of this difference, teachers' subject expertise tends to be a source of difficulties regarding teaching and consequently revealing teachers' lack of awareness of pedagogical content knowledge. In a study conducted with pre-service teachers about the teacher development of PCK, De Jong (2003) reported that even though teachers were taught to identify students learning difficulties (an element of PCK) in certain topics, they found it difficult to identify the relevant models and strategies of teaching modelling. The teachers had limited knowledge which created discrepancies between teaching intentions and teaching practice. It is a common dilemma among engineering teachers at Tshwane University of Technology that their classroom practice does not always yield the intended learning outcomes. The researcher's assumption is that the engineering lecturers' classroom practice does not relate nor link well with their planned teaching outcomes due to an existence of conceptual and practical limitations on PCK.

There is a common belief that exists among many engineering and science educators at universities that their role is to deliver discipline specific content to students. Lectures are therefore the predominant form of teaching. In addition, for an educator who holds this view, completion of a syllabus is practical evidence that he or she has completed his or her job of teaching. Such lecturers are less concerned about how their students learn or make meaning of the content taught. Practical consequences of these beliefs are many and include amongst others, students' high failure, attrition and low graduation rate and loss of interest in the discipline and various types of learning difficulties. According to Gallagher (1996) the "covering of content" belief emanates from some old university's teaching paradigms and cultural beliefs and

practices about science teaching. Gallagher (1996) argued that the lecture method is associated with promotion of rote learning of the science content. The perception associated with a culture of rote learning is that only professors could make sense of the science content whilst the role of the students is to acquire knowledge from the professor. Gallagher (1996) argued that such cultural beliefs can give rise to difficulties in engaging students in meaningful learning in science.

Gallagher (1996) suggested that teachers' beliefs about science teaching can be changed if the intervention programme takes into cognisance the beliefs and culture of science teaching that teachers bring into the programme. The professional development programme's conceptual framework should aim to help teachers to expose, confront and challenge their teaching beliefs in such a way that the teachers will be able to become aware of how their teaching affect how their students learn. Consequently, they will use the available resources to change their beliefs in a practical way. Gallagher (1996) used the Science Teaching Style Inventory to evaluate the teachers' pedagogical content knowledge beliefs before, during and after the programme implementation. The intervention programme was successful in changing teachers' beliefs. The additional benefits of such intervention programmes in changing teachers' beliefs about teaching were reported to go beyond the classroom, to include changing school climates and ultimately improving students learning and attitudes (Gallagher, 1996).

The study conducted by Hand (1996) showed that diagnosis of teacher's knowledge bases and roles about classroom practice prior to implementation of a professional development programme, during and after can help teachers to improve their classroom teaching knowledge. According to Hand (1996) identifying and confronting teachers' knowledge of classroom practice are the initial stages of a successful implementation of a constructivist teaching and learning professional development program. During this initial phase, teachers' beliefs about their own pedagogical content knowledge are defined as a beginning point for change. These beliefs are continually evaluated, during the course. Hand (1996) further suggests that science teachers' knowledge bases be analysed before, during and at the end of a professional development programme using questionnaires addressing both teachers' and students' perceived and preferred views of constructivist' learning environment.

In a study conducted with a university physics lecturer, Jang (2011) revealed that although the lecturer had excellent subject matter knowledge, she was frustrated because her students were not successful as she expected. Participation in a contextualised intervention programme led to improved pedagogical content knowledge base. Consequently, her students experienced the Physics learning environment more positively.

Professional growth of science teachers requires competence in self-appraisal in managing and influencing the science learning environment to produce good student outcomes. Kiviet (1996) suggested that a good teacher preparation and continuing education programs could assist less efficacious teachers to improve their competences in general and personal teaching efficacy.

The literature reviewed in this section showed that studies of PCK and teachers' perceptions of their own teaching knowledge can be a powerful framework to provide teachers with an opportunity to reflect and challenge their conceptions about teaching and learning in their various subjects and disciplines. In addition, understanding and applying pedagogical content knowledge principles in teaching practice could help teachers to facilitate learning in a meaningful way.

2.5   Professional Development in Teaching Knowledge of Engineering Educators

There is a conspicuous absence of research literature on teachers' pedagogical knowledge and professional development of engineering educators. The studies conducted by Felder (1999), Mills (2002), Shepstone (2009) and Veldman, et al. (2008) in USA, Australia, New Zealand and South Africa, respectively, confirm the researcher's observation.

In order to improve the current status of engineering student outcomes, retention, success, throughput and graduation rate in South African higher education institutions, there is a need to investigate and to address the needs of engineering educators in terms of their professional capabilities to teach students of diverse educational needs. Research has indicated that university educators with good teaching knowledge are able to motivate their learners to perform better (Case &

Jawitz, 2003; Council on Higher Education, 2009; Jawitz, 1998; Waghid, 2000; Weimer, 2007; Winberg, 2008). However, Waghid (2000) had raised concerns about the level of teaching competence demonstrated by many engineering educators, which has implications for their teaching professional development.

Various views exist about the need for engineering educators to participate in teaching professional development as opposed to discipline advancement. Research studies (Coetzee-Van Rooy, 2002; Weimer, 2007) have shown that many of the academics teaching in universities think that the only best way to improve their teaching is by developing their content knowledge. Such academics end with sophisticated levels of knowledge, but they only have simplistic instructional methods to convey the material. To imagine that content matters more than the teaching process and mechanisms is like saying that content is more important than all other aspects of a teaching and learning situation (Weimer, 2007). In a teaching process, subject content and the teaching and learning process are interwoven and therefore are very much dependent on each other. Development of content knowledge without improving the teaching knowledge such as instructional approaches and strategies would not always yield effective teaching in terms of improved student outcomes. Weimer (2007) contends that elevating content knowledge at the expense of teaching knowledge creates a mismatch between content knowledge and teaching perspectives and approaches which ought to be used to facilitate learning. Therefore, it is important that marrying the content and the teaching and learning process requires an intimate and sophisticated knowledge of both. Felder et al. (1998), Felder and Brent (2004) and Prince and Felder (2006) also found that content and delivery strategies in the engineering classrooms were not matched and thus suggested strategies to help engineering educators transform their teaching practice.

The challenge posed by the implementation of effective instructional strategies in the classroom is the teachers' level of teaching competence and preparation to teach in diverse classroom environments. For many university teachers in science and engineering, who are traditionally trained experts in their own disciplines, it is a challenge to acquaint themselves with various effective and meaningful approaches to facilitate intellectual development and growth of their students. There is a need for

engineering educators to engage with various and relevant sources of professional development. Waghid (2000) and Case and Jawitz (2001) supported this argument and hence it is for this reason that engineering educators were encouraged to engage in a dialogue about teaching professional development with a view of improving teaching and learning in engineering classrooms in South Africa.

Felder and Brent (1999) argue that improving teaching requires identifying problems with existing academic practices and then applying a combination of sound educational and psychological principles to devise a better approach. A professional development model, founded on a combination of teaching knowledge domain such as the pedagogical content knowledge, could lead to effective teaching and learning experiences and consequently improved student outcomes. However, change requires a paradigm shift in terms of the approaches and models used in the teaching professional development of engineering educators (Shepstone, 2009).

Professional development approaches and models may vary from institution to institution, depending on the culture and vision of academia in terms of their views on teaching, learning and research. Furthermore, the selection of professional development approaches could be influenced by the individual lecturers' needs in terms of how they intend to interact with their students to improve learning and academic outcomes in their classrooms. However, each source of professional development opportunity had its own merits and demerits in terms of assisting academic staff to improve their teaching knowledge. For practising engineering educators variety of potential approaches and sources for teaching knowledge professional development exists and thus require rigorous exploitation. Amongst the variety of sources available, Thair (1999) and Goddard et al. (2000) suggest that engagement in collegiality with colleagues, personal reflection on practice and participation in formal and informal but context specific programmes was amongst the most effective professional development approaches.

Collegiality through various forms of partnerships within the departments, across faculties and external to universities is important in enhancing professional identity in teaching. Burn (2007) suggests that academic collegial partnerships have significant potential to improve the teaching knowledge of new teachers whilst the

mentors are also expected to learn from the process thus playing a major role in the construction of new professional identities for all role players.

The study conducted by Winberg (2008) has shown that if engineering academics participate in a formal professional development programme designed to expose discipline specialist to pedagogical content knowledge in engineering, academics would shift to new identities as educators. Winberg (2008) contended that through a well-designed collaborative professional development programme which attempts to understand the formation of discursive identities in various engineering communities, engineering academics can shift from being engineers to engineering educators. In the case of Winberg's study, a small group of engineering educators at a university of technology negotiated their change in academic identities by enrolling in a formal professional development programme, a Master Degree in Engineering Education. The findings revealed that formation of academic identities, even among staff members teaching in a single engineering discipline, is flexible, multilayered and susceptible to different degrees of change. Furthermore, the results had shown that the participants experienced similar stages of growth in the process of shifting from engineering experts to engineering educators' identities (Winberg, 2008).

In a study conducted by Veldman, De Wet, Mokhele, & Bouwer (2008) in another university of technology in South Africa aimed to transform didactical approaches in engineering, the findings showed that academic staff can achieve exceptional high level of alignment of teaching practices when using teaching approaches such as problem-based learning (PBL) as a didactical approach and a source of teaching knowledge. Therefore, the curriculum reform process serves as good sources of reflection on teaching practice and also provides valuable skills in improving teaching knowledge.

Establishing a good and customised staff development program has the potential to enhance lecturing staff teaching skills and thus encourage them to improve their teaching practice and hopefully improving the quality of learning and throughput rate in the engineering programmes (Case & Jawitz, 2003; Jawitz, 1998; Weimer, 2007; Winberg, 2008).

2.6   Engineering Education in South Africa: A Brief Overview

South Africa, as a developing country post-apartheid era, is experiencing strong economic growth; however, the country is experiencing a serious skills shortage, especially in scarce skills such as science, engineering and technology. Any country in the world, for it to experience success in terms of its economy, requires a highly skilled workforce. The current question that arises in South Africa is what is the status of engineering education and why are the institutions failing to address the problem of skills shortage in the engineering industry?

Some of the reported challenges (Allie, et al., 2009; DoHET, 2011; Jawitz, 1998; Potter, et al., 2006; Swart, 2010; Veldman, et al., 2008; Winberg, 2008) facing the country and higher education institutions (HEIs) with regards to engineering education are:
- inadequate and articulation of post school engineering education
- equity of access and success of black students to appropriate diplomas and degrees at university and college
- low academic achievement of school leavers enrolled in science, engineering and technology programmes
- low student retention, success, throughput and graduation rates
- the general quality of teaching and learning

According to Case and Jawitz (2003), historically higher education in South Africa had its origin on supporting the colonial and apartheid social order. Almost all the higher education institutions offering the engineering programmes at the time served white communities, which is approximately 10% of the total population of the country. Due to the racial discriminatory laws of the country at the time, the academic participants in these institutions were white staff and students respectively. However, the enrolment demographics in the institutions started changing in the eighties, more previously disadvantaged racial groups enrolled into the engineering programmes at the previously white institutions. With the onset of democracy in South Africa, the new policies on education encouraged an increase in access to higher education (Department of Education, 1997, 2001). In response, HEIs

experienced high enrolments even in programmes such as Science, Engineering and Technology (SET) which experienced previously low enrolments.

Although access to HEIs has improved dramatically, the HEIs have historically, and now more especially in the last decade, experienced low graduation rates in the Science, Engineering and Technology fields. The rate of enrolments did not correlate with the success and graduation rates. The HEIs are experiencing challenges in teaching and learning success in SET because students do not achieve their academic outcomes and thus do not graduate within the minimum period (Council on Higher Education, 2009).

Table 2.1 The SET enrolments and graduations at all public institutions in South Africa between 2004 and 2007

Year	Enrolments	Graduations	Graduation Rate
2004	202,552	30,383	15%
2005	210,707	33.506	15,9%
2006	211,595	34,478	16,3%
2007	209,985	35,257	17.0%

Source: Higher Education Monitor No. 8, 2009

Table 2.1 shows the public higher education institutions' low success and graduation rates could have negative impact on producing the required skill and knowledge capacity required by the vigorously developing economy of the country. In addition, these data show that the higher education public system is unable to provide the industry and the economy with the appropriate skilled and adequate SET workforce to match the national needs.

The Department of Higher Education and Training (DoHET) in South Africa, in its latest drive to improve education, training and development of citizens, has stressed the need to develop a skilled and capable workforce to address skills available in the labour market and increase access, articulation and success in occupationally directed programmes such as engineering. However, the Ministry also acknowledged the underlying problems, bottlenecks and barriers with the post- school education system that the country in currently facing.

The Engineering Council of South Africa (ECSA) also acknowledged the challenges raised by the Ministry, especially with respect to the low success rates and the time taken to complete engineering diplomas or degrees at local HEIs (Seggie, 2011).

Furthermore, ECSA suggests that a greater success may be achieved through more efficient teaching and learning processes at HEIs. The strategy should include better teaching methodologies and techniques by better prepared academic staff to deal with large classes and by creating a platform where teachers can share teaching experiences.

According to Waghid (2000), engineering education in South Africa does not comply with the eclectic approaches to teaching and learning. Waghid (2000) argued that most engineering educators were still using teaching methods that were not motivating their students enough to learn better. Though Waghid acknowledged that the results of his analysis of engineering education conference proceedings showed that the educators used variety of teaching strategies supported by the mix of behaviourist, interpretive and critical reflection educational frameworks, he argued that there was generally a disconnect in engineering practice between "knowing how" and "knowing that" because engineering teaching was still predominantly focused on providing factual content knowledge. Waghid defines "knowing that" as knowing that is linked to facts while "knowing how" is linked to skills acquisition. His contention is that eclectic approach is required in engineering education so that both facts "knowing that" and skills "knowing how" acquisition and application become the rationale which would enhance and expand engineering teaching and knowledge beyond the present reduction to factual and technical content.

Waghid (2000) further argued that introducing eclectic didactical approach to develop engineering curricula and improve practice is not enough without being shaped by dialogical agape pedagogy. Waghid (2000) describes dialogical pedagogy as a notion in teaching and learning process which allows mutual dialogue between the students and lecturers in a safe, caring and loving learning environment. The dialogical agape pedagogy learning environment is characterised by a dialogue which allows students to engage in critical thinking, action and skills while they construct and reconstruct subject matter to make it meaningful. According to Waghid (2000), dialogical agape pedagogy in engineering education means that learning content should bring the educator and the student in a joint search for knowledge and skills. Learning environments which foster dialogical agape support students to be able to deal with unpredictable moments in their learning by constructing knowledge

and ways of knowing that exceeds dialogue. This would in turn, improve students' ability to learn better. Furthermore, the moral notions of dialogical agape is that there should also be a feeling of trust, respect and understanding between the educator and the students. Felder (2004) also emphasised the importance of psychosocial relations between engineering educators with their students.

Waghid (2000) argued that the role of transformative learning and moral aspects in engineering education in South Africa seems to be missing or rather not being taken seriously within higher education institutions. This view is supported by Case and Jawitz (2003) who agree with Waghid on the issues raised regarding lack of transformation in learning and the inclusion of dialogical agape in engineering curricula and classrooms.

According to the South African Council on Higher Education (2009), the teaching staff in universities are now continually under pressure to improve teaching, deal with the need to deal with rapidly changing student body and pressure to transform the curricula and teaching practice. In light of these challenges that teaching staff in universities are facing, this study becomes more significant for the teaching staff in the Faculty of Engineering at Tshwane University of Technology. Knowledge about their own perceptions and that of their students about teaching and learning could lead to establishment of intervention programmes to improve teaching and learning practices and consequently improving the success and graduation rates in the various engineering programmes.

A number of exemplary studies were conducted by various researchers with the intention of improving student learning in engineering. In South Africa, a number of these studies and intervention programmes (Allie, et al. 2009; Potter, et al., 2006; Scott, et al., 2007; Swart, 2010) were established to improve the quality of teaching and learning with special focus directed at addressing students' learning problems. Very few research studies were reported regarding interventions on addressing teaching knowledge of engineering educators in South Africa. Selected engineering education studies conducted in South Africa and are presented in the following paragraphs.

Many studies in South Africa were conducted to investigate the learning difficulties experienced by students in the engineering classrooms. In addition, most of these studies introduced innovative intervention initiatives geared at improving students learning difficulties in various disciplines in engineering education (Allie, et al., 2009; Potter, et al., 2006; Swart, 2010; Veldman, et al., 2008; Waghid, 2000; Winberg, 2008). However, most of these studies were focussed on identifying and resolving the learning problems experienced by students only. Such studies were mostly grounded on the belief that students, mostly from disadvantaged science and mathematics school background, were unable to succeed in engineering education due to their learning problems. Hence efforts, According to Case and Jawitz (2003) academic development initiatives such as foundation programmes, bridging programmes and many others were initiated by various engineering departments across the institutions to help students to improve on their quality of learning.

A longitudinal study, spanning over 24 years, conducted by Potter, et al. (2006) on student difficulties with engineering graphics revealed increased pass rates from 64% to 77% after the first year students and staff participated in an intervention programme. The invention programme involved amongst others, introduction of a learner-centred teaching methodology and relevant learning materials. However, the researchers observed that certain students, and more especially females, continued to experience learning problems with engineering graphics past their first year of study. For this reason, many students still required academic support in subsequent year levels within mechanical engineering programmes. They also found that learning difficulties in engineering graphics were related to broader cultural and gender issues, involving a complex connection between social factors and cognitive ability. The researchers concluded that the three dimensional spatial perception and academic performance improved in response to instructional techniques designed to increase the ability to model, copy, sketch, visualise and represent objects in three dimensions.

In view of the latter findings by Potter, et al. (2006), it becomes evident that engineering educators who do not have a deeper understanding of the learning problems their students bring to class and respond accordingly by adopting and

applying relevant instructional repertoires to motivate their students, would experience poor success rates in their courses.

Allie, et al. (2009) conducted an exploratory study on improving student learning in selected engineering programmes across three institutions in the Western Cape region of South Africa. Their study was prompted by the need to address challenges, assumptions and their experiences within engineering community in South Africa. Amongst the challenges they reported were an increased need of engineers in the economy, decline in the quality of students intake, poorly prepared school leavers entering engineering programmes in tertiary institutions, student diversity in the classrooms and the use of pedagogical theories which promoted acquisition of knowledge more than active learning were not suited to the understanding of the situation associated with the challenges at hand in most of the engineering learning environments.

Engineering and technology education in South Africa has been reported to be very much behaviourist in nature (Waghid, 2000). In response to these challenges, Allie and colleagues (2009) felt the need to explore better ways of understanding student learning in engineering education. Furthermore, they felt that knowledge of student learning would equip the engineering educators with context sensitive effective teaching methodologies.

Allie, et al. (2009) premised their study on two intertwined perspectives of learning, participation in the community and discursive identity perspectives. Their contention was that participation view of learning was better than acquisition of knowledge perspective. Participation perspective views learning as an ongoing process of participation of becoming a member of the community and therefore of developing a particular identity with that community. From this participative perspective, the goal of learning is that the learner should be able to act in a particular specialist discourse of a particular environment and community (Allie, et al., 2009). The social and academic background of the students, the communities they come from and where they intend to function and the workplace community in which graduates will be employed are also regarded in this perspective as important ingredients of a successful teaching and learning process. The authors define 'community' in the

context of engineering education learning environments, as participation through authentic classroom activities which emulate the engineering industry the student will ultimately engage with when they graduate. Furthermore, the authors argue that such authentic activities need to be productive to enable meaningful participation.

The second theoretical perspective adopted by Allie and colleagues is called discursive identity. Accordingly, discursive identity comes from the concept of discourse, which refers to certain ways of using language, acting, interacting, behaving, believing, using tools, and systems amongst others by members of a certain community (Allie, et al. 2009). Therefore, in engineering community, discourse would include practice of design to solve real-life problems. In turn, problem solving is reported to include actions such as collecting and analysing data, use of empirical laws, doing mathematical calculations, modelling and reporting and presenting the results to the relevant audience.

In addition to discourse participation, Allie and colleagues (2009) introduced the notion of identity. Identity, in their view, means being able to participate as an individual in a discursive community. Therefore, the close relationship between the concepts of discourse participation in a community and the identity of its members, led to the emergence of the concept of discursive identity. The notion of discursive identity takes into account that students use discourse with full awareness that others will use it as an indication of their membership of a particular community. As students engage with the engineering discourse, the authors argue that new identities will emerge. The dynamics of the learning process involved in discursive identity, may be equated with the constructivist notion that learners critically engages with curriculum content actively in order to construct meaning and consequently building good understanding. Both these perspectives of learning involve iterative processes where students engage in a discourse of a particular course. The engineering classrooms are therefore regarded by Allie, et al. (2009) as good starting points to engage with discursive identities. The authors further argue that engaging in discursive identity activities is better than sitting passively in a lecture room while trying to acquire as much factual technical content as possible from the lecturer.

Allie, et al. (2009) assert that many engineering programmes seem to represent a relatively narrow set of discursive identities in research and academic activities. They further suggest that classroom participation in discursive identities as an approach to learning could lead to educational success in engineering since students would be afforded the opportunity to demonstrate the ability to use relevant discourse to participate in a workplace. In addition, one other strength of adopting discursive identities as a teaching approach is that the engineering educators would be able to elicit and identify multiple social and academic identities that their learners bring to class. Multiple identities here may be equated to the constructivist view that learners bring intuitive knowledge to class and that learning and teaching process should engage the learners to confront their intuitive knowledge as they grabble with various learning opportunities provided by teachers.

Allie and colleagues acknowledge that engineering educators are mostly immersed in the discourse and hence it may be difficult to make tacit knowledge explicit to students. It is for this reason that they suggest collaborative teaching between experts in and outside the field so that tacit knowledge could be made explicit for successful learning purposes. In order to explore the perspectives on discursive identity through participation in a community as learning and teaching approach, a group of academics, including the authors, across the three institutions established and participated in student learning project. In institution A the whole faculty of engineering was involved, whilst in institution B, the department of physics adopted the approach. In institution C, only the department of chemical engineering was involved. A variety of teaching and learning opportunities guided by the principles of discursive identities and participation in a community were employed in the engineering classrooms. The teaching and learning strategies included amongst others establishment of collaborative teaching partnerships between engineering educators and academic development practitioners, collaborative development of course materials, incorporating verbal, pictorials, physical, graphical and mathematical representations in learning activities, replacing traditional lectures with workshop-style classes, students cooperative learning groups, quasi-authentic and investigation based practicals, guest lectures by industry specialists, interactive tutorials and conversations with practising engineers.

In all the three cases, the authors argued that the project broadened their perspectives on authentic learning. However, the paper was short of reporting whether the interventions brought about improvements in pass, success and throughput rates in their programmes. Nevertheless, even though their project was exploratory in nature and the results could not be generalised, I am confident that subsequent projects of this nature, if conducted on a mandatory and massive scale, the results may be so significant to impact positively on challenges affecting engineering education in South Africa.

A good engineering education is about the process of learning how to think and act like engineer. Therefore, engineering education is much more than prescription of the content and acquisition of technical knowledge by students. Engineering teaching required simultaneous use of theory and practice in class so that students could emulate the real engineers in the workplace. Engineering curriculum must therefore allow students to experience being an engineer through use of teaching approaches such as problem-based learning, which infuse theory and real world practice (Swart, 2010).

In a study aimed at exposing students to the work of the engineers, Swart (2010) infused theory and practice in a radio engineering third year course. The findings revealed that fusing what a person 'knows' with what a person 'does' in a curriculum, resulted in a better-qualified engineering students. Furthermore, students' performance in the infused course also increased as opposed to performance in the course taught by traditional approach. The approaches adopted by Swart (2010), on engineering education, is supported by the views on use of eclectic teaching approaches by Waghid (2000) and Allie, et al. (2009) in terms of using discursive identities and participation in a community as an educational perspective for exposing students to the real world of work. Both these researchers believe that using approaches that allow students to construct and apply knowledge at the same time in class, could lead to improved learning outcomes. However, this new approach to teaching in engineering according to Swart (2010) has implications for curriculum development, the choice and selection of relevant educational theoretical perspectives and teaching methods. The knowledge and skills of the lecturers to implement such innovative teaching and learning approaches may require some

enhancement through contextualised professional development programme. Furthermore, it may require a paradigm in terms of the lecturers' views on engineering teaching and learning process.

The various educational theoretical perspectives and student learning difficulties and approaches reviewed in this section, creates an argument that identifying and understanding the perceptions of teaching knowledge as viewed by members of the discursive engineering community, the engineering educators and their students could further enhance teaching and learning, particularly in the environments were constructivist and critical thinking educational perspectives are not yet part of the educational practice and culture of the institution.

2.8   Historical Development of Instruments Used in this Study

In an attempt to answer the research questions in this study, three types of instruments developed and validated in previous studies on teacher's knowledge and professional development were identified from literature. This section provides a review of literature on the development of the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire, two teaching efficacy scales from the Science Teacher Efficacy Belief Inventory (STEBI) questionnaire and the professional development scale.

2.8.1 Student Perceptions of Teachers' Knowledge (SPOTK) Questionnaire

The Student Perceptions of Teachers' Knowledge (SPOTK) was developed by Tuan, et al. (2000) in order to respond to the lack of relevant scales to measure teachers' pedagogical content knowledge from the available suite of learning environments instruments. The SPOTK accommodated teaching knowledge aspects associated with the contemporary constructivist's teaching and learning approaches.

The instrument is structured according to the four scales addressing teaching knowledge. The Instructional Repertoire scale refers to students' perceptions of the extent to which the teacher uses variety of teaching strategies to enhance science content learning. The Representational Repertoire scale refers to students' perceptions of the extent to which the teacher uses representational repertoire that

challenges students' previous conceptions. The Subject Matter Knowledge scale refers to students' perceptions how the teacher demonstrates knowledge of the subject matter and how it relates to different ideas and purposes within the field. Knowledge of Student Understanding scale refers to students' perceptions about evaluation and assessment practices of their teacher during lessons and at the end of a unit.

SPOTK was developed through a large multinational education development project on learning environments between Australia and Taiwan. These two countries have different social and educational cultures, which enriched the process of validating the instrument so that the end product is of significant value for use in different environments across the world. The questionnaire was designed in English and Chinese versions. The responses are recorded on a 5-point Likert-scale type. A scoring of 5 was allocated to the most positive statement receiving response level of almost always whereas 1 was allocated to the almost never.

The instrument was vigorously validated during development to ensure that the items in the four scales measured exactly the teachers' knowledge constructs the instrument was intended to investigate. From the main study, Tuan et al. (2000) reported sound factorial validity and internal consistency reliability results with a sample of 1879 Taiwanese and 1081 Australian junior high school students. The final instrument consisted of 28 items. Cronbach's alpha coefficient values for all four scales for group and individuals students were between .86 and .97 for Australian participants while the Taiwanese participants responses gave values of between .82 and .97 respectively.

The results of the final version of instrument showed that SPOTK could be used in any environment to evaluate the teachers' knowledge. Consequently, teachers may use the results to improve their teaching skills by participating in professional development programmes. The instrument was found useful in that it has features of pedagogical content knowledge which formed the conceptual framework of this study. In addition, SPOTK was chosen because of its unique design to measures science teachers' pedagogical content knowledge perceptions from the perspective of individual students.

2.8.2 Science Teaching Efficacy Belief Inventory (STEBI) questionnaire

The investigation into teacher beliefs is very important in providing an opportunity to understand in more depth, the behaviour of teachers towards teaching in the various fields of expertise (Riggs & Enochs, 1990). The need to explore and understand the elementary school science teachers' efficacy beliefs about teaching science compelled Riggs and Enochs (1990) to look for the most appropriate instruments.

The original teaching efficacy instrument to measure self-efficacy and outcomes expectancy was developed by Gibson and Dembo (1984). However, Riggs and Enochs (1990) noticed that science teaching in elementary schools was not receiving the research attention it deserved. Lack of relevant science teaching efficacy instruments led Riggs and Enochs (1990) to modify Gibson and Dembo's (1984) original version of the teaching efficacy instrument into Science Teacher Efficacy Beliefs Inventory (STEBI). The modification process included contextualising the items to the elementary school science teaching and learning environment.

The STEBI questionnaire consists of two scales. The Personal Science Teaching Efficacy Belief scale measures teachers' beliefs about their capabilities to teach science. The Science Teaching Outcome Expectancy Efficacy scale measures teachers' beliefs about their expected possible student outcomes as a result of their science teaching effort. The response and scoring format for each of the two scales utilised a 5-point Likert-scale with response categories of 'strongly agree', 'agree', 'uncertain', 'disagree' and 'strongly agree'. Scoring was accomplished by assigning a score to each of the responses categories. A score of five was allocated to the most positive response, 'strongly agree' and so on. Negatively worded items were also used and they were scored in the opposite direction.

The two STEBI scales were subjected by Riggs and Enochs (1990) to rigorous validation and reliability statistical tests which led to the final version of the instrument found highly reliable and valid for measuring teachers' beliefs towards science teaching. The final version was administered to 331 rural and urban practising elementary school science teachers. After several factor loading exercises 13 items were confirmed for personal science teaching efficacy belief scale. Total

Cronbach's alpha coefficient value for science teaching efficacy scale was found to be 0.92, confirming strong internal consistency. The scale on Science Teaching Outcomes Expectancy had a total of 12 items. Cronbach's alpha coefficient value for this scale was found to be 0.77 confirming acceptable level of consistency.

The correlations between the two dimensions were not very high. However, the patterns of relations between the scales and individual scale items further indicated acceptable levels of homogeneity of items between each scale and the distinctiveness between the two scales. Riggs and Enochs (1990) found that the lower Cronbach's alpha coefficient values of the outcomes expectancy scale was consistent with past research efforts in which this construct was found to be most difficult to define and measure. The lower reliability was also reported to be attributed by the multiple variables contributing to the construct as defined by the set of items in the scale. Riggs and Enochs (1990) suggest that multiple variables beyond the control of the teacher such as teacher's science background, inadequacy of students' science background; low-motivated students which could affect the lower reliability coefficient values of the OE.

Subsequent use of the two STEBI scales in various studies further validated the STEBI for use in multiple science learning environments. Thair (1999) used STEBI in a multinational project with Australian and Indonesian secondary school science teachers. Kiviet (1996) used it with South African primary and secondary school science teachers. In all these studies, acceptable validity and reliability results were revealed. Bleicher (2004) conducted a revalidation study of the two STEBI scales with pre-service elementary science teachers in the USA. Acceptable validity and reliability results of both scales were revealed in the main study. In line with previous studies, the Science Teaching Outcomes Expectancy Scale produced Cronbach's reliability alpha coefficient values lower than the Personal Science Teaching Efficacy scale.

Riggs and Enochs (1990) suggest that the STEBI could be used in identifying the professional development needs of the science teachers, based on their performance on the responses on each of the two scales respectively. Using the STEBI scales in any science or technology education learning environments, including higher

education institutions, would assist in creating awareness by both teaching staff and professional development practitioners. It is therefore these salient features of STEBI scales which made it an appropriate tool in this study to examine engineering lecturers' perceptions about their own teaching knowledge with a view of identifying those areas where they had limited knowledge and skills about engineering teaching.

2.8.3 The Professional Development Scale

In the quest to understand the impact of professional development programme on Australian and Indonesian science teachers, Thair (1999) developed a scale to measure their views. Thair's scale was based on the previous professional development studies by Bell (1993). The scale focused on the sources of teaching knowledge development of teachers. The sources covered by the scale included collegiality activities with other teachers, external sources to the school environment and use of student feedback, individual teacher's reflection and review of teaching and learning materials, reading of literature in educational practice and participating in courses in teaching knowledge. The design and format of responses followed the Likert type scale. Participants had to respond by indicating level of agreement or disagreement. A score of 5 was allocated to items receiving a strongly agree response, a score of 4 to agree, 3 allocated to midpoint, 2 to disagree and 1 for strongly disagree. Following rigorous validation, the final scale was composed of 22 items which identified sources of professional development. The scale yielded high Cronbach's alpha coefficient values of .88 with Indonesian and .90 with Australian teachers. The reliability results confirmed a strong internal consistency of the items within the scale.

The scale was found useful in identifying and differentiating teachers' preferences for sources of professional development, with item on collegial activities being the most predominant choices of professional development sources for teachers. Goddard, et al. (2000) suggest that collegiality activities such as social persuasions, talks and discussions among teachers and sharing of resources can serve as sources for teaching efficacy and teaching competence development. In addition, the sources were reported to increase teachers' strengths about their convictions that their capabilities can help them to achieve their goals. Based on the good features of the

scale to measure teachers' preferences on sources of professional development, especially participation on collegiality, external sources and reflection on own practice; the researcher adopted the professional development scale for this study.

2.9   Summary of Chapter

This chapter provided a brief review of literature on teaching and learning knowledge to support this study. Reviewing theories on constructivism and pedagogical content knowledge provided a good conceptual framework for the study. In addition, the various perspectives in which teaching knowledge was previously studied provided an insight into the complexities of investigating teaching knowledge. The most interesting perspectives of studying teaching knowledge of importance to this study were the two different perspectives of investigating teaching knowledge from the both students and lecturers within specific disciplines. A brief review of studies in engineering education in relation to knowledge about teaching and learning was conducted. Most studies conducted addressed students' learning difficulties in engineering. Though significant studies on teaching knowledge were conducted in science education, it was evident from the literature reviewed that research in engineering education has not been given much attention on the pedagogical content knowledge of engineering educators. The chapter concludes with a brief historical development of the instruments adopted in the study. Reviewing the selected studies and the scarcity of literature on teaching knowledge and professional development of engineering educators has highlighted the need for the investigating engineering teaching knowledge and their sources of professional development of engineering lecturers in this study.

CHAPTER 3

Research Design and Methodology

3.1 Introduction

In the quest to understand teacher knowledge beliefs in science teaching, various research design and methodology such as qualitative and quantitative approaches were used. Different tools were also developed for example, for students Tuan and colleagues developed a teacher knowledge questionnaire Tuan, et al. (2000) and for teachers Riggs and Enochs (1990) developed a science teacher efficacy beliefs inventory questionnaire. Each research design, approach and instruments were developed by researchers to address different educational and research purposes on different categories of teacher knowledge and pedagogical content knowledge in science education.

Gess-Newsome and Lederman (1999) reviewed various research methodologies and approaches used in previous PCK studies. They acknowledged that the methodologies selected and chosen by researchers in this field were guided by the research questions and the context and educational purpose for which the research in pedagogical content knowledge was conducted. Furthermore, a review of assessment and measurements tools used in pedagogical content knowledge (PCK) studies reported by Baxter and Lederman (1999) shows that no instrument so far has been found to measure PCK of teachers holistically. A variety of tools such as pencil and paper, concept maps and pictorial representations, and multi-methods evaluations were used by various researchers. Each one of these methods has strengths and weaknesses and biases in identifying PCK among teachers. However, in their critique (Baxter & Lederman, 1999) accept that the use of multi-methods evaluation involving multiple researchers is preferable in minimising bias. Challenges using multiple evaluations as suggested by Gess-Newsome and Lederman (1999) are among others, economical issues. Single researchers, with time and financial constrains will not be able to use multiple evaluations as extensively as research communities in PCK would desire.

PCK is of utmost importance to this study because it informs the researcher about how to understand and link the students and lecturers believes in teaching knowledge and how such views could be used in conceptualising and designing professional development programmes in order to bridge the gap between engineering knowledge and general education principles and practices. The research design and methodology selected for this study was therefore guided by a review of the methodologies used in previous studies. Secondly, it was guided by the need to identify and understand the nature of teaching perceptions, with a goal of using the research outcomes to develop a relevant professional development programme for engineering educators in South Africa. This study therefore used both quantitative and qualitative research approaches.

There has been a significant move in educational research globally to combine qualitative with quantitative methods (Fraser, in press). The rationale for combining qualitative and quantitative research approaches was mainly propagated by the need for research results to be more credible. Studies in learning environments (Fraser, in press) have reported the success of combining quantitative and qualitative research methods. Fraser (in press) argue that one of the merits of using mixed methods in learning environments studies is that the qualitative information complements the quantitative information to clarify patterns and differences between various participants. In this research, the combination of methods was used to demonstrate concurrent validation of the data and findings as well as an attempt to create a deep understanding of the information generated from the results. Research methods authors (Cohen, et al., 2007; Creswell, 2009; Fraenkel & Wallen, 2003) support the research approaches of combining qualitative and quantitative research methodologies since the results emerging from the analysis of the combinations would help the researcher to understand the nature of the perceptions held by participants, by approaching it from a different point of view and angle, and arriving at a more consistent and reliable conclusion (Terre Blanche & Kelly, 2002).

This chapter describes the research framework, design and methodology that were followed to answer the research questions. The chapter is divided into several sections. The first section describes the framework on which the research questions and choice of methodology were formulated. The second section outlines the

selection of participants. This is followed by the research instruments (questionnaires and interviews), how they were selected, modified and used to collect quantitative and qualitative data in relation to the research questions. The fourth section describes how the data were analysed. A summary of the methodology closes the chapter.

3.2   Research Design Framework and Approach

Studying perceptions can be a complex process, especially if the phenomenon is being approached from various perspectives and more than one group of participants is involved. In the case of this study, students who are recipients of education and lecturers who are facilitators of learning were all selected as participants in the investigation of perceptions about teacher knowledge. The participation of these two different groups in studying teacher knowledge brought two types of windows through which the researcher could look at the phenomenon. This prompted the researcher to look at a multiple research design framework such as pragmatism.

Creswell (2009) argue that pragmatism as a research framework is concerned with what works and seeking solutions to the problem. Researchers use all available approaches to solve the problem. According to Creswell (2009) the strength of pragmatism lies in the fact that it opens doors to the use of multiple research methods, different world views and different assumptions. Researchers are free to choose methods and techniques and procedures of research that best suit the needs and purpose of research project. Therefore, the strength and benefits of pragmatism as a research framework and mixed methods as an approach within this framework were found to be appropriate for detangling the complexity of studying perceptions of teaching knowledge from lecturers and students in engineering programmes.

In an effort to ensure that the definition of the mixed methods design becomes as inclusive as possible, researchers (Creswell, 2009; Tashakkori & Teddlie, 2003) argue that mixed methods research involves the investigator collecting and analysing data, integrating the findings and drawing inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry. These authors further argue that the heart of a mixed methods approach is integration and triangulation. Integration of qualitative and quantitative data and findings provide a

comprehensive analysis to the problem. According to Cohen, et al. (2007) triangulation offers strategies for reducing systematic bias and distortion during data analysis. In addition, it increases the credibility and quality of the research by countering the concern that study findings are simply an artefact of a single method or source.

In this study, quantitative based questionnaires were used in surveys with both lecturers and students. In addition, an open ended question was added to the students' questionnaire to collect qualitative data. The surveys were followed by in-depth interviews with nine lecturers. The findings from quantitative and qualitative data were compared for similarities and differences in order to get a comprehensive understanding of the perceptions about teacher knowledge.

3.3   Selection of Study Participants

The research was carried out at Tshwane University of Technology, Soshanguve campus in Pretoria. The participants in this study were engineering lecturers and students enrolled in semester 2 to semester 4 level of study in the Faculty of Engineering.

A purposive method of sampling was used. According to Cohen, et al. (2007) in purposive sampling researchers handpick the cases to be included in the sample on the basis of their judgement. In this way they build up a sample that is satisfactory to the specific needs of the research. The sample for this study was chosen for a specific purpose already outlined in chapter 1. All lecturers and students in each of the engineering programmes, with the exception of semester 1 and first year students were targeted for participation in the study. The first level students were excluded from the study because of their limited time and experience in the tertiary education environment. First year students were still new at the campus and only had 12 weeks of experience in higher education environment at the time of data collection for this study. The researcher assumed that first year's data would provide unreliable results for the purpose of this study.

The researcher was involved with the Faculty of Engineering as an academic development practitioner for staff development; therefore access to the participants was assumed to be easier at the time of planning the research study. The initial discussions to conduct the research took place during the Engineering Faculty board meetings of the erstwhile Technikon Northern Gauteng (now Tshwane University of Technology – Soshanguve Campus) in 2002 and 2003.

Limitations in selecting participants

The final sample of participants for this study did not represent the total number of engineering students and lecturers at Tshwane University of Technology as envisaged. It represented students and staff from only one campus. The researcher had hoped that the merger of the three Technikons in January 2004 to form Tshwane University of Technology would provide more opportunity to have access to more engineering students (about 1500 in total) and lecturers (approximately 150) to participate in the research study. Unfortunately, the request (appendix 1 and 2) to conduct surveys on the Pretoria and eMalahleni campuses of the university where engineering programmes were offered was rejected by some staff members while others agreed. Cohen, et al. (2007) cautions researchers that they should not neglect any possible reason that might prevent access to the sample. In this case, the researcher had never thought that access problems could be encountered; especially that the executive dean of the faculty and some member of the university research ethics committee had approved the request to conduct the research study in the Faculty of Engineering.

At the time of data collection, negative attitudes prevailed on all six campuses of the university. Social cohesion problems existed and staff morale was low due to the merger of the three erstwhile technikons. Like in any change within social environments, staff at all campuses felt very threatened by the merging of the three institutions. The sensitive nature of some of the issues around the merger, led to staff being sceptical and not be trusting of any surveys conducted on campus. Therefore, due to the challenges of access described here, the final sample of participating lecturers was small. This in turn created limitations on statistical analysis of

quantitative data and generalisation of findings to the entire engineering lecturers' population in the Faculty of Engineering.

The final sample of participants

The final sample comprised of a total of 570 second and third year engineering students enrolled for the National Diploma in Building Science, Architecture, Chemical, Civil, Electrical, Mechanical and Surveying at the Soshanguve campus. These students completed the Student Perceptions of Teachers' knowledge (SPOTK) questionnaire (appendix 3).

The Teachers' Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire (appendix 4) was circulated to 59 engineering lecturers teaching in the seven engineering programmes at the Soshanguve campus. The questionnaire was completed and returned by 24 lecturers. Several attempts were taken to encourage the other lecturers to complete the survey and return outstanding questionnaires but nothing more came through. Following the administration of the lecturers' questionnaire, nine lecturers were randomly selected for in-depth interviews.

The two surveys were conducted during the period, March to April 2004. Table 3.1 provides a summary of the final sample of students who completed the survey.

Table 3.1: Summary of the final sample of engineering student surveyed (N=570)

Programme	Number of returned questionnaires	Study levels
Architecture	31	Year 2
		Year 3
Building	26	Year 3
Civil	129	Semester 2
		Semester 3
Chemical	136	Semester 2
		Semester 3
		Semester 4
Electrical	50	Semester 3
		Semester 4
Mechanical	173	Semester 2
		Semester 3
		Semester 4
Surveying	25	Semester 2
		Semester 3

3.4   Tools Used to Collect Data

Three types of tools were used to collect data for this study. The Student Perception of Teacher Knowledge (SPOTK) questionnaire (appendix 3) was used to collect quantitative and qualitative data from students. The Teacher Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire (appendix 4) was used to collect quantitative data from lecturers. In addition, interviews were used to collect qualitative data from nine lecturers. A summary of the tools and its relationship with the research questions is provided in Table 3.2.

The main objective of this study was to identify lecturers' and students' perceptions about teaching and learning practices taking place in their engineering classrooms. Cohen, et al. (2007) describe the value of questionnaires as useful instruments for collecting survey information, providing structured, often numerical data, being able to be administered without the presence of the researcher, and often being comparatively straight forward to analyse. The appropriateness of using questionnaires in this study was primarily their economic value in reaching as many students and lecturers in the Faculty of Engineering as possible. In addition, questionnaires provide a straightforward statistical analysis value and that different variable measured by the questionnaire could be easily manipulated during analysis.

The SPOTK questionnaire and scales in the TBTLE questionnaire used in this study were already developed, validated and used in science teacher knowledge and professional development studies across the world. What was needed to be done in this study was to contextualise the questionnaires for engineering education and check its reliability for use in a higher education institution in South Africa.

An overview of the previous development and preparation of each of the three research tools for use in this study is presented in the next sections.

Table 3.2 Relationship between the research questions and data collection tools

Research Question	Instrument	Items numbers	Form of data
Research Question 1	SPOTK		
Students' perceptions of their lecturers' teaching knowledge	Part A	Background Information	Coded
	Part B	28 items	Likert coded data
	Part C	2 items	Open ended
	TBTLE		
	Part A	Background information	Coded
Research Question 2	Part B	25 items	Likert coded
Lecturers' perceptions about teaching knowledge	Part D	2 items	Open ended
Research Question 3	Part C	20 items	Likert coded
Lecturers' perceptions of professional development			
Research Questions 2 and 3	Teacher interview guide	22 questions	Open ended

3.4.1 Students' Questionnaire

To evaluate students' perceptions about teaching in their classrooms, the adapted version of Students Perceptions of Teacher knowledge (SPOTK) was used to collect data. The SPOTK questionnaire was developed by Tuan, et al. (2000). SPOTK evaluated students' perceptions on four pedagogical content knowledge domains; Instructional Repertoire, Representational Repertoire, Subject Matter Knowledge and Knowledge of Students Understanding.

The main reasons for choosing this instrument, was that the teaching knowledge domains and its associated scales and the content of the items were perceived to be relevant for the teacher knowledge conceptual framework and purpose of this study. No other similar instrument existed at that time.

Secondly, SPOTK was validated in many multicultural schools by large samples of students in Australia and Taiwan. Therefore, even though it was initially developed for high schools, the teacher knowledge constructs and pedagogical principles that

the tool is measuring were assumed to be the same in all formal educational institutions, including universities. In addition, the researcher had identified a gap in the use of this tool in higher education sector especially in engineering education. Therefore, using SPOTK in this research study was also an opportunity to advance research in teacher knowledge by using SPOTK in other different educational systems such as engineering classrooms in higher education.

The SPOTK is a 28 item pencil-and-paper questionnaire which requires students to respond to a five-Point Likert-type scale with a choice of responses; almost never (1), seldom (2), sometimes (3), often (4) and almost always (5). The distribution of items in the four scales was as follows. The Instructional Repertoire (IR) consisted of 8 items, Representational Repertoire (RR) 7 items, Subject Matter Knowledge (SMK) 6 items and Knowledge of Students Understanding (KUS) 7 items respectively. Examples of items in the four scales are shown in Table 3.3.

Table 3.3 Examples of items in the four SPOTK scales

Scale	Item example
Instructional Repertoire	My lecturer's teaching methods keep me interested in engineering
Representational Repertoire	My lecturer uses appropriate diagrams and graphs to explain science and engineering concepts
Subject Matter Knowledge	My knows the content (s)he is teaching
Knowledge of Student Understanding	My lecturer's tests evaluate my understanding of a topic

The version used in this study was composed of three parts. Part A was used to collect background information about the students such as name of programme and the enrolment periods and levels. Part B was used to measure students' perceptions about the four scales in pedagogical content knowledge scales. The purpose of part C was to collect some qualitative data about the students' perceptions of courses they found difficult or easy to learn and why they thought so. It was composed of two open ended questions about difficult and easy courses.

Questionnaire administration

For the main study, SPOTK questionnaire was administered by volunteer lecturers in their classrooms. The researcher collected the questionnaires from the lecturers. A copy of the student questionnaire is included in Appendix 3.

Validity and reliability of SPOTK

Research methods authors such as Cohen, et al. (2007) and Pallant (2011) describe validity of an instrument and its scales as the degree to which it measures what it is supposed to measure. There are various types of validity used in research. Construct validity refers to adequacy with which the measure or scale is sampled from the domain of content. Construct validity involves testing the scale relationship with other theoretically related and unrelated underlying constructs (Pallant, 2011)

In order to ensure that the SPOTK questionnaire was valid and relevant for use with higher education students in South Africa, a pilot study was conducted with 57 second year students enrolled for the National Diploma in Analytical Chemistry in October and November 2002. The pilot study showed that the content and language of the instrument and the relevancy of the items were suitable for the South African English second language speaking students. Secondly, the instrument was used for the first time in Higher Education, thus the level of correctness for this level had to be checked with the science and engineering lecturers and a few heads of departments.

The pilot study results were presented at an international science education conference in January 2003, with the main purpose of getting feedback from peers about the content validity and relevancy of the instrument in higher education. The feedback received showed that the questionnaire content was fine but the use of the term 'science' in the questionnaire made the questionnaire look like it emphasised 'science' classrooms rather than 'engineering'. Consequently, the SPOTK items were modified by changing the word 'science' to 'engineering' in order to give the SPOTK the relevant discipline context. The content of the four scales was not

changed because it was found relevant for the purpose of the study. All the 28 items of the original four scales of SPOTK were retained for the main study.

Pallant (2011) and Creswell (2009) describe reliability of a scale in a questionnaire as an indication of how free it is from random error. In order to test for reliability of scales a number of tests could be done. The most common test is to assess the internal consistency of the items that make up the scale to check if ever they measure the same underlying construct. Pallant (2000) further advises that the most commonly used statistic to measure internal consistency is the Cronbach's alpha coefficient. The higher values, of above .70 indicates a high reliability of a scale. However, Pallant (2011) advises that levels of reliability depend on the nature and purpose of scale.

The items in the original SPOTK questionnaires were reported be valid in terms of content and construct validity in the previous studies conducted in Taiwan and Australia, in secondary schools by Tuan et al. (2000).In subjecting the scales and items to rigorous reliability and factor analysis statistical tests, Tuan et al. (2000) found that the four scales were reliable and the items in each scale had a high internal consistency. Creswell (2009) advises that when one modifies instruments or uses them in different contexts, original validity and reliability may not hold. Since the items were modified to be relevant for higher education engineering classrooms in South Africa, validity and reliability analyses of the scales were performed in this study.

The reliability tests results for this study were found to be consistent with those reported by Tuan, et al. (2000). See Table 3.4 for a summary of comparison of the Cronbach's alpha coefficient values of the original SPOTK as well as in this study.

Content validity was determined through use of peer academics and scholars at a conference described in the preceding section. Determination of the construct validity involved correlation between the four scales. The Pearson correlation coefficients results ranged between .48 and .68. Since these results were all above .40 a high level of inter-scale correlation was confirmed.

Detailed data analysis and results from students' responses on SPOTK items are reported in chapter 4.

Table 3.4 Cronbach's alpha coefficient values for SPOTK scales

| Scales | Tuan et al (2000) | | | | This study |
| | Australia | | Taiwan | | South Africa |
	Class unit N = 50	Individual N = 1081	Class unit N=50	Individual N = 1897	Individual N = 450
Instructional Repertoire	.97	.91	.97	.89	.80
Representational Repertoire	.94	.87	.96	.88	.76
Subject Matter Knowledge	.95	.86	.94	.82	.79
Knowledge of Student Understanding	.95	.89	.95	.86	.84

3.4.2 Lecturers' Questionnaire

The lecturer questionnaire, Teacher Beliefs about Teaching and Learning in Engineering (TBTLE) was used to collect data for answering the research questions 2 and 3.The questionnaire was assembled from components of the various instruments used in previous studies on teacher knowledge and professional development. The questionnaire was made up of four parts, A to D. The questionnaire used the 5-point Likert scale, with lecturers having given a chance to agree or disagree with the statement by choosing 'strongly disagree' 'disagree', 'neither agree nor disagree' 'agree' and 'strongly agree'. Each of the four parts of the questionnaire is briefly described below.

Part A was used to collect data about personal background information of participants such as highest qualification obtained, teaching experience and participation in professional development activities.

Part B consisted of two teaching efficacy scales adopted from the science teaching efficacy beliefs inventory (STEBI) questionnaire developed and validated by Enochs & Riggs (1990), Enochs, Riggs, & Ellis (1993) and Riggs & Enochs (1990). Other researchers used same tool for example Kiviet (1996) with South African primary and secondary schools science teachers. Thair (1999) used the two scales with the Australian and Indonesian participants from various high schools.

The teaching efficacy scales were used to collect data on lecturers' perceptions about teacher knowledge domains such as teaching approaches and strategies, subject matter knowledge, teaching skills, assessment and knowledge of student understanding, learning and achievement and teacher knowledge development. The Personal Teaching Efficacy Belief scale (TE) consisted of 14 items. The Teaching Outcomes Expectancy Efficacy scale (OE) was composed of 11 items. Total items for the STEBI scales were 25. The examples of items in each scale are shown in table 3.5.

Table 3.5 Examples of items in the two STEBI scales in the TBTLE

Scale	Item example
Personal Teaching Efficacy Belief	I am continually finding better ways to teach engineering
	I usually help students who have difficulty in understanding engineering better
Teaching Outcomes Expectancy	Even lecturers with good engineering teaching abilities cannot help some students to learn engineering
	Increased effort in engineering teaching produces little change in some students' achievement

Reliability and validity of STEBI scales in part B of the TBTLE questionnaire

The STEBI scales had never been used in higher education before the commencement of this study. However, the scales and the items in each scale in the previous versions of STEBI were perceived by the researcher to be relevant even for Higher Education classrooms because the scales measured perceptions about teaching and learning knowledge.

During its development process by Briggs and Enochs (1990), STEBI scales and items were subjected to rigorous validity and reliability tests prior to its use in surveys across various contexts and settings in science education environments. In all the settings Riggs and Enochs (1990) found that the Cronbach's alpha reliability coefficients were high, confirming reliability of the two scales. In order to ensure that the original STEBI scales were reliable when used in a different context in South

African higher education environment with engineering lecturers in this study, reliability coefficients of the items and scales were computed. Table 3.6 provide Cronbach's alpha reliability coefficients values of the teaching efficacy scales obtained in this study and those from previous studies.

Table 3.6 The Cronbach's alpha coefficient values of the STEBI scales

Researchers	Personal Teaching Efficacy Beliefs scale	Teaching Outcomes Expectancy Efficacy scale
Riggs &Enochs (1990)	.92	.72
Kiviet (1996)	.87	.82
Thair (1990)	.34*	.19*
	.82**	.79**
This study	.84	.73

*Values attained for Indonesian teachers.   ** values attained for Australian teachers

The Cronbach's alpha coefficient values for this study were found to be consistent with those reported in the previous studies. The researcher concluded that the Personal Teaching Efficacy Belief and Teaching Outcomes Expectancy Efficacy scales' reliability coefficients were acceptable, thus making the STEBI scales reliable for use among the engineering lecturers in this study.

However, the alpha reliability values for the two scales in this study were found to be slightly lower than the values reported by Riggs and Enochs (1990), Kiviet (1996) and Thair (1999) for the Australian respondents. However, the alpha reliability coefficient values of this study were found to be higher than Thair's Indonesian respondents in both scales. The effect of the low response rate of the lecturers could not be ruled out as a cause for the low magnitude of the values of the Cronbach's alpha coefficients. In addition, as Pallant (2011) had advised the magnitude of Cronbach's alpha coefficient is dependent on the nature of the construct being measured. Attitudes and perceptions are sensitive complex personal views which may vary from time to time and therefore tend to have low Cronbach's alpha coefficients.

The researcher accepted the rigorous construct validity tests conducted in previous studies to validate the STEBI scales. Hence no construct validity was conducted

prior to use of the tool in the main study. However, during analysis of the data, construct validity was tested and confirmed. The results of the construct validity tests are described in chapter 6.

Content validity of STEBI scales in this study was verified through qualitative mechanisms rather than quantitative ones. To adapt the STEBI to be appropriate for the engineering education and language context, the research mentor and supervisor (PhD, science education), an international professor in chemical engineering education teaching at a USA university who is renowned for research and development work in engineering education reviewed the questionnaire. In addition, a science education senior lecturer at Tshwane University of Technology and two colleagues from the academic development unit were requested to review the all the parts of the questionnaire including the STEBI scales. Their feedback was incorporated into the final version of the questionnaire prior to collection of data.

Part C of the questionnaire consisted of 20 items addressing views about sources of teaching knowledge professional development. The professional development items were adopted from Thair's (1999) Teacher Development Questionnaire. Examples of the items in the scale are shown in Table 3.7.

Table 3.7 Examples of items in the professional development scale of the TBTLE

Item examples
In my opinion the best teaching development occurs when:
Reading scientific and engineering materials
Getting feedback from other lecturers

The scale was subjected to reliability tests to confirm its satisfactory use in the engineering classrooms. The Cronbach's alpha coefficient value for the scale in this study was found to be consistent with Thair's (1999) study. Table 3.8 provide comparisons of Cronbach's alpha coefficients value of the scale obtained in this study and by Thair (1990). The professional development scale was found to be reliable to use in the engineering classrooms in this study.

Table 3.8 Cronbach's alpha coefficient values for professional development scale

	This study	Thair (1999)
Cronbach's alpha coefficient values	.95	.88 (Indonesian teachers)
		.90 (Australian teachers)

An open ended section was also added to the questionnaire to form part D. Part D was designed to collect data on other teaching related matters which the lecturers wanted to share with the researcher such as a description of teaching styles they were using in their classrooms. The data generated from part D was mostly incomplete in many questionnaires. Therefore for the purpose of this thesis, the data were not analysed. In addition, the list of the subject profile requested in this section of the questionnaire would have exposed the names of the participants, therefore bridging the conditions of anonymity and confidentiality of participants. The absence of the data in section D did not compromise the rigour and reliability of the research study since the two items in this section were used to collect additional background information that was not essential to answer the research questions. Data collected by other parts of the questionnaire were sufficient to answer the research questions.

A copy of the Teacher Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire is included in Appendix 4.

3.4.3 Questionnaire administration and response rate,

The questionnaire was first circulated by email to 59 engineering lecturers on the Soshanguve campus. Few questionnaires were returned after a period of two weeks. The second batch of hard copies was distributed door to door by the researcher. The response improved slightly, but the majority still did not respond. A third letter of reminder was issued a week later. The researcher acknowledges the effect of the threats of the lecturers' poor response rate on external and internal validity with respect to the statistical data analysis on small sample and generalisation of findings from data to the larger population of engineering lecturers. However, in order to deal with this issue, triangulation by means of in-depth interviews was used to offset the threats of validity caused by the small sample. Lack of representativeness of the available target population is regarded by Cohen, et al. (2007) as a threat to external validity to the findings of the research study.

3.4.4 Lecturers' Interviews

Interviewing is one of the major techniques used in qualitative research. Interviews provide an in-depth opportunity to find out more about the beliefs of the participants because participants can verbalise their feelings using their own words. The interview data were used to provide more answers to research questions 2 and 3.

Interviews were introduced in this study to elicit more and deeper conceptions of teaching, learning, assessment and professional development from the lecturers. In this study interviews were used as a triangulation method for eliciting more qualitative responses about the perceptions held by lecturers about teaching and learning and professional development. Interviews were used in conjunction with the quantitative data because the researcher wanted to validate the findings from the two questionnaires data and to also create comparison with the students' responses. Furthermore, qualitative data were used to explore other unique perceptions about teaching knowledge which were not straightforward to identify by the quantitative data.

There are different types of interview approaches described in the research literature. Fraenkel and Wallen (2003) describe four types of interviews, namely: structured, semi-structured, informal and retrospective. Structured and semi-structured interviews are verbal questionnaires and consist of several questions designed to elicit specific answers on the part of the respondents. Often they are used to obtain information that can later be compared and contrasted (Fraenkel & Wallen, 2003). In semi-structured interviews, questions are prepared as a form of schedule to follow with every participant to ensure consistency of asking questions in the interviews. In addition, predetermined questions are designed to guide the participant and researcher in remaining focussed on answering the core questions of research.

Semi-structured interview guide was used because the researcher wanted to ensure content consistency in the questions asked to all the participants. According to Hancock (1998) the benefits of using semi-structured interviews guide includes amongst others, use of open ended questions which are predetermined on a topic of research. Though the topic of research is defined, the interview process allows

flexibility for the researcher and interviewees to probe some topics and responses in a more detailed form. In addition, the semi-structured interview approach allows the interview communication mode to be conversational between the researcher and the interviewee (Hancock, 1998).

Development of the interview guide

The interview question guide was constructed from the interview guide previously used by Thair (1999) and questions from a guide on Challenging Conceptions of Teaching: Some Prompts for Good Practice developed by Higher Education Research and Development Society of Australasia (HERDSA, 2002). This guide was used widely at higher education institutions across the world, especially in the Australasian region, to encourage lecturers to reflect and improve on their practice.

The questions in the interview guide included statements about teaching approaches and strategies, knowledge of students understanding and learning, assessment, students' background. I addition, there were questions which elicited views about how lecturers acquired teaching knowledge and the possible sources of professional development in engineering education. The researcher modified some of the questions to align it with the research questions in this study. The content validity of the guide, in addition to its wide use in higher education institutions, was ensured through sharing the questions with colleagues in the academic development centre across the institution's multiple campuses and senior science and engineering academics. The interview guide is attached as Appendix 5.

How interviews were conducted?

Nine lecturers were interviewed a few days after completing the TBTLE questionnaire. Participation in the interviews was voluntary. Rapport between the researcher and lecturers was already been established before the commencement of the study as outlined in chapter 1.

The interview atmosphere was more conversational. This approach was adopted to create a more relaxing environment for the interviewees. Gratton and Jones (2010)

encourage researchers to use this approach in interview settings because of its power to make interviewees feel relaxed and to be able to engage deeply in issues under discussion, especially if such issues involve personal beliefs of professional nature.

Validity and reliability of the interviews

Validity is described by many researchers as a method of ensuring that the research findings match the reality (Cohen, et al. 2007; Fraenkel & Wallen, 2003). Reliability and validity in qualitative research means consistency of data and dependability of findings. Qualitative researchers want to be consistent in how, over time, they make observations, similar to the idea of stability and reliability. One difficulty is that they start processes that are not stable over time (Neuman, 2003).

Validity in qualitative research methodologies is reported to be difficult to achieve as compared to quantitative research. However there are variety of methods and procedures that qualitative researchers can use. In line with suggestion by qualitative research methods authors such as (Cohen, et al. 2007; Denzin & Lincoln, 1994; Fontana & Frey, 1994; Huberman & Miles, 1994; Kvale, 2007) validity and reliability of interviews was ensured through use of semi-structured interview questions which were asked to all participants, audiotaped to record the conversations with lecturers, writing of notes and personal thoughts during the interview to supplement the audiotapes and also through rigorous and iterative data analysis and reporting process.

Prior to transcription of the tapes, the researcher listened to the audiotape for each interview several times. All transcriptions were done by the researcher. The transcribed responses were shared with the interviewees for correctness. However, not all the interviewees were available to verify the correctness of transcriptions. Some participants had already resigned from the institution and were not easy to trace. However, in order to enhance the correctness of the transcriptions, the researcher conducted quality assurance by reading the transcripts and listening to the tapes twice before full data analysis could commence. During the data analysis process, transcripts were read several times in order to verify the findings against raw data. Additional explanation of quality criteria in qualitative approaches is

presented in section 3.5 and in subsequent results and findings sections in chapters, 4, 5, 6 and 7.

3.4 Analysis of Data

3.5.1 Quantitative Data Analysis

Statistical analysis package (SPSS) version 19.0 (SPSS, 2010) was used to analyse the quantitative data from SPOTK and TBTLE questionnaires. All non-numerical data were coded in numerical form and captured into the Excel spread sheet first. The data were then converted to the SPSS format. Scores of individual respondents were aggregated into different groups of participants for analysis purposes.

Descriptive and inferential statistics were computed in line with responses to each of the research questions and associated sub-questions. Cronbach's alpha coefficients, analysis of variance and means, ranges, percentages and standard deviations were computed for both questionnaires. Correlations of data from all the groups of participants were performed to determine the relationship that existed between the dependent and independent variables of the different groups of participants as well as looking at the emerging patterns and relationships of the students' and lecturers 'perceptions on the domains of Pedagogical Content Knowledge under investigation. Cohen, et al. (2007) describe the value of correlation research as an approach to a fuller understanding of human behaviour that begins with teasing out of relationships between those factors and elements deemed to have some bearing on the phenomenon in question.

The One-way analysis of variance (ANOVA) parametric techniques were used to compare mean scores of the various groups. ANOVA were found to be an appropriate test to ascertain statistical significance among the groups of more than two. ANOVA uses variance of the groups rather than the means to calculate the value that reflects degree of differences in the means. In addition, ANOVA techniques are useful when only one independent variable is used at a time (Pallant, 2011) as is the case in this study.

3.5.2 Qualitative Data Analysis

Qualitative researchers study meaning. Interpretations and meanings are situated. Qualitative research is demonstrably trustworthy and rigorous when the researcher demonstrates that he or she has worked to understand the situated nature of participants' interpretations and meanings. The quality of qualitative data analysis depends on following well thought-out procedures and on ensuring that these procedures reveal the structures of understanding of the participants (Ezzy, 2002).

In order to analyse, interpret and understand the meaning of the qualitative data, approaches to qualitative analysis as suggested by research methods authors were used (Cohen, et al. 2007; Creswell, 2009; Denzin & Lincoln, 1994; Diamantopoulos & Schlegelmilch, 1997; Ezzy, 2002; Fontana & Frey, 1994; Huberman & Miles, 1994; Kvale, 2007). These approaches included an iterative process of mixing deductive and inductive approaches such as content analysis, thematic coding, categorisation, verification of data and interpreting were utilised concurrently to reduce data, generate patterns and categories from data for the purpose of responding to the research questions. Coding in qualitative research methods refers to identification of themes or concepts of interest to the study from the data. Within the context of this study, these approaches were found to be relevant for providing thought-out procedures to ensure that meaningful descriptions of participants were revealed. Ezzy (2002) and Huberman and Miles (1994) argue that a combination of deductive and inductive techniques provide the researcher with an opportunity to analyse data using predetermined themes as well as allowing 'other' emerging themes to be interpreted alongside the predetermined. In addition, the authors argue that the combination provides credibility to the analysis process and findings generated from the data.

According to Ezzy (2002) content analysis uses predetermined themes and categories, it therefore restricts the researcher to analyse the other themes and categories emerging from the data that could add value to the study. Therefore, it is for this reason that content analysis tend to be used concurrently with other inductive techniques such as thematic analysis. Though thematic analysis also requires that general issues of interest to research be determined prior to analysis, it differs with

content analysis in that it allows categories to emerge from data inductively. In this study, issues of interest for analysis were the students' perceptions regarding teaching of difficult and easy courses whilst the lecturers' perceptions analysis focussed mainly on instruction, student learning, assessment and professional development.

Qualitative data in this study were mainly used to triangulate, confirm or contrast results and findings from the quantitative data. Therefore the main themes for data analysis were predetermined. The predetermined themes used for categorising students and lecturers responses were the four scales of SPOTK regarding teacher knowledge, PCK domains and the scales from professional development component of the lecturers' questionnaire. New themes that emerged from data during analysis and could not fit the predetermined themes were classified accordingly into new themes such as curriculum knowledge.

All qualitative data from the students' responses in Part C of the questionnaire and interview transcripts of the lecturers were analysed manually, following techniques and procedures described in this chapter and subsequent chapters 4 and 7 respectively.

3.6   Limitations of Research Design

Cohen, et al. (2007) argue that all research studies designs are subjected to various kinds of threats, biases and limitations. What is important is that the researcher should acknowledge them and take precautions to address them. The most notable threats are associated with reliability and validity of design and methods, data collection tools, analysis, interpretation of results and generalisability of findings. Validity and reliability threats create limitations in research studies. However, though threats can never be completely eradicated there are various techniques and procedures available to assist qualitative and quantitative researchers to minimise the threats (Cohen, et al. 2007; Creswell, 2009).

Various types of validity exist but how that is addressed depends on the nature of the research and the research design paradigms and approaches it belongs to. In this

study, internal validity, external validity and content validity were of critical importance. In quantitative approaches, Cohen, et al. (2007) argue that validity can be improved through careful sampling, use of appropriate instrumentation and appropriate statistical treatments of data. Cohen, et al. (2007) argue that validity in qualitative research can be ensured through honesty, depth, richness and scope of the data achieved, participants approached, extent of triangulation and disinterestedness or objectivity of the researcher. In this study, use of mixed research methods, multiple data sources such as the students' and lecturers' questionnaires and interviews, use two types of sample of participants, triangulation of data, use of multiple techniques to analyse data and interpretation of the results were used to enhance credibility of data, results and findings.

Biases and halo effect from the researcher were described in detail in chapter 1. The researcher has worked with the faculty as a consultant for teaching, learning and curriculum matters. Therefore the researchers' background brings along views and theoretical orientations and interpretations of findings about teaching and learning in this study. However, the various techniques used in collecting, analysing data and interpreting the results and findings were assumed to minimise the bias by being as objective as possible.

Cohen, et al. (2007) describe external validity as a degree to which results could be generalised or used to the wider population. In qualitative research generalizability is interpreted as comparability, transferability and applicability of findings to another situation. Cohen, et al. (2007); Huberman and Miles (1994) and Creswell (2009) suggest that researchers should provide sufficient rich data and thick descriptions about the phenomena so that the readers or users of research findings could determine on their own transferability of findings. In this study, external validity was ensured through rigorous data collection and analysis procedures used, provided rich data and thick descriptions and understanding of the perceptions about teacher knowledge, teaching and learning. Techniques used to address reliability, content validity and construct validity threats were described in detail under each section addressing development and use of each data collection tool and associated methods of analysing the data throughout this thesis.

It should be noted that in this study, the researcher has used all possible suggestions and advice to address the threats and the limitations. However, the greatest limitation which could not be addressed was the poor response rate on the lecturers' questionnaire. The researcher employed all suggestions by research methods scholars but still, due to factors beyond control of the researcher, the response rate could not improve beyond the return of 24 questionnaires.

3.7   Ethical Issues

Ethical approval for this study was granted by Curtin University of Technology during approval of candidacy proposal. For collection of data with the participants in the Faculty of Engineering at Tshwane University of Technology, the researcher forwarded a letter of request together with the two questionnaires for approval by the university research ethics committee, Executive Dean of the faculty. In addition, the researcher had already informed the Faculty board about the intention to conduct the study a year earlier than the period for data collection. Each lecturer and students respectively, received a letter of invitation to participate in the study. Confidentiality and anonymity of participants in any document related to the study was assured to all participants. In the transcription of interview audiotapes, pseudonyms were used to protect the identification of the participants. Furthermore, during data analysis, all pseudonyms and names of departments were replaced with codes. For example P1 represented the code for a participant whereas Department A represented a Department in the Faculty of Engineering. This was done, to further protect the identity of the participants and the departments they came from.

3.8   Summary of Chapter

In the preceding sections, mixed-method research conceptual framework, selection of participants, limitations of access to participants and data collection methods were described. In addition, a brief overview of the three types of data collection instruments used and how they were developed was described. Methods of quantitative and qualitative data analysis and were also described. Limitations, threats to validity and ways of alleviating them were also described. The results of

the data collected from the data sources described in this chapter analysed, interpreted and presented in the next four chapters.

CHAPTER 4

Students' Perceptions of Teacher Knowledge

4.1   Introduction

This chapter report on the analysis of data, results and findings from data collected from students using the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire (Appendix 3) in response to Research Question 1. The chapter is divided into several sections to address research question 1 and its associated sub-questions.

Research Question 1: What are students' perceptions of their lecturers' teaching knowledge within their engineering classrooms?

> *1.3   Is the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire reliable for use in a higher education institution to explore perceptions of students about teaching knowledge of their lecturers?*
>
> *1.4   What are the perceptions of students from various engineering programmes on each teaching knowledge repertoire evaluated by the SPOTK questionnaire?*

The first sections describe the results of the quantitative analyses, followed by the results from qualitative data and finally a summary of the students' perceptions about teacher knowledge is presented.

The students' response data were encoded and analysed using the Statistical Package for Social Sciences, SPSS version 19.0. (SPSS, 2010). Descriptive and inferential statistics techniques were used to organise data and to draw inferences regarding relations and differences amongst the variables, respectively. These statistical tests provided information about the students' response rate, reliability of the data; correlation coefficients were also calculated to determine the relationship between the four scales under investigation. The ability to differentiate between and within the groups of students and descriptive statistical means and standard deviations of

students' perception scores of their lecturers' knowledge on the four scales; Instructional Repertoire, Representational Repertoire, Subject Matter Knowledge and Knowledge of Student Understanding. The scales' means ranged from 1 to 5 on the Likert type scale, with 1 for the most negative that represent 'almost never' and 5 for the most positive perception representing 'almost always', 2 represent 'seldom', 3 'sometimes' and 4 'often'. The interpretation of the results is described according to the research conceptual framework about students' perceptions of their lecturers' knowledge for each of the constructs behind the four scales.

4.2 Questionnaire Response Rate

Five hundred and seventy (570) engineering students returned completed questionnaires. However, due to several respondents not completing all items in the questionnaire, the incomplete questionnaires' data were removed from the data set. Hence, the sample size was reduced to 450 students who responded to all items in the questionnaire, ultimately providing homogeneity of the sample and complete data for statistical analysis purposes. The response rate statistics are provided in Table 4.1.

Table 4.1 Students' response rate statistics for each of the seven engineering programmes (N=570)

Engineering Programmes	No of returned Questionnaires	%	No of questionnaires with complete data	%
Architecture	31	5.4	24	5.3
Building	26	4.6	23	5.1
Civil	129	22.6	94	20.8
Chemical	136	23.8	114	25.3
Electrical	50	8.8	35	7.7
Mechanical	173	30.4	142	31.5
Surveying	25	4.4	18	4.0
Total	570	100	450	100

4.3   Response to Research Question 1.1

Research Question 1.1: Is the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire reliable for use in a higher education institution to explore perceptions of students about teaching knowledge of their lecturers?

In order to ensure that the modified SPOTK scales were reliable and valid to use in a context (country and educational level of students) different to the original version, the data collected from students in all the engineering programmes under investigation were analysed using various techniques to investigate the internal consistency of the items in the questionnaire within the Faculty of Engineering in South Africa. The internal consistency reliability, Cronbach's alpha coefficient values, for all scales were calculated, using individual students' and programme means as the units of analysis. The descriptive statistics and Cronbach's alpha coefficient values results are presented in Table 4.2.

Table 4.2 Descriptive statistics for the four scales of the SPOTK (N=450)

Scale	No of Items	Total programmes Average Item Mean	Standard Deviation	Scale Mean	Standard Deviation	Alpha Reliability
Instructional Repertoire	8	3.74	0.70	29.95	5.56	0.80
Representational Repertoire	7	3.61	0.72	25.24	5.04	0.76
Subject Matter Knowledge	6	4.15	0.65	24.88	3.92	0.79
Knowledge of Student Understanding	7	4.04	0.73	28.29	5.13	0.84

The results in Table 4.2 show that the internal consistency, Cronbach's alpha coefficient estimates for the four scales ranged from 0.76 for the scale on Representational Repertoire to 0.84 for Knowledge of Student Understanding. The magnitude of the alpha coefficients confirms that each of the four scales has got an acceptable degree of internal consistency. Furthermore, this is an indication that the instrument items can be considered to be satisfactorily reliable for use in these South African engineering classrooms. These calculated alpha coefficient results are

comparable to consistency results of the original version of SPOTK which was developed by Tuan et al. (2000) where Cronbach's alpha coefficient values had magnitudes of between 0.86 to 0.91 for Australian students and 0.82 to 0.89 with Taiwanese students, when the individuals were used as units of analysis. The total mean responses across the four scales varied between 24.88 and 29.95, respectively. This indicated that the majority of the scores on events that these scales were measuring occurred between sometimes and often (3.74 and 4.04).

Table 4.3 Pearson correlation coefficients of the four scales in the SPOTK (N=450)

Scale	IR	RR	SMK	KUS
Instructional Repertoire (IR)	1.00	0.68**	0.55**	0.58**
Representational Repertoire (RR)		1.00	0.59**	0.48**
Subject matter knowledge (SMK)			1.00	0.48**
Knowledge of Student Understanding (KUS)				1.00

**Correlation is significant at *p*< 0.01 level (two-tailed)

In order to determine the correlation between the four scales, the Pearson product-moment correlation coefficients were calculated for each scale. Table 4.3 shows the calculated Pearson correlation coefficients (r) values of the four scales. The correlation coefficients values ranged between 0.48 and 0.68. According to Pallant (2011), if r = 0.10 to 0.29 the relationship is small between variables. If r = 0.30 to 0.49 the relationship between the variables is medium. When r = 0.50 to 1.0 the relationship between variables is large. Therefore, in view of the suggestions by Pallant (2011), the r-values in Table 4.3 indicate a medium to large correlation existed between the four scales. The results indicate that IR had a strong correlation with RR, SMK and KUS [r > 0.50]. RR and KUS and SMK and KUS had a medium correlation [r <0.50].

The correlation coefficient according to Cohen, et al. (2007) is an indication of predictability of one variable given the other. Therefore the correlation coefficient values depicted by these results suggest that a relatively strong inter-scale relationship existed between all the four scales. These results established and confirmed that the four scales measured the teacher knowledge construct, thus confirming inter-scale construct validity of the SPOTK.

4.4   Response to Research Question 1.2: Quantitative Results and Findings

Research Question 1.2: What are the perceptions of students from various engineering programmes on each teaching knowledge repertoire evaluated by the SPOTK questionnaire?

Analyses of data and interpretation of the results in this section provide a profile of the students' perceptions of their lecturers' teaching knowledge according to the framework for Research Question 1. Participants were asked to indicate their level of agreement about the rate at which their lecturers were demonstrating knowledge of teaching in the four pedagogical content knowledge domains. Students responded to a total of 28 items, broken down per scale as shown in Table 4.4.The results are described according to the overall perceptions identified in each scale for all the seven programmes as well as a comparison between the programmes.

4.4.1 Analyses and Interpretation of Students' Perceptions

Tables 4.4a and 4.4b shows the descriptive statistics results of the students' perceptions about teacher's knowledge on Instructional Repertoire, Representational Repertoire, Subject Matter Knowledge and Knowledge of Student Understanding. The results in Table 4.4 suggest that all students in the seven programmes perceived their teachers positively in all the four scales. The average item means ranged from 3.53 to 4.38 across the scales. This indicated that students believed that the dimensions on teacher knowledge which the instrument was testing occurred between sometimes-(3) and almost always-(4). The subscale Subject Matter Knowledge received the highest average mean scores of between 4.02 and 4.38 for all seven programmes. This finding suggests that students in all the seven programmes perceived their lecturers to be always knowledgeable about the subject matter. The lowest ranked scale among all the groups was Representational Repertoire with the average mean range of 3.53 to 3.88 across the programmes. These indicates that the events which this subscale was investigating occurred between sometimes-(3) and often-(4), but more closer to often-(4).

Instructional Repertoire: The average mean responses for the Electrical Engineering students (4.15) was the highest among all seven programmes, indicating that the events that this scale was measuring occur between often-(4) and almost always-(5).

The average mean scores of students' responses for the other six programmes ranged between 3.57 and 3.97. The results indicated that the students perceived the events to be taking place between sometimes-(3) and more toward often-(4) in this scale. The results suggest that students thought that their lecturers often used teaching strategies that assisted them to learn content more meaningfully.

Table 4.4a Descriptive statistics of the students' perceptions in the four scales using scale average item means for the seven programmes (N=450)

Scale	Average item mean scores and standard deviations													
	Architecture		Building		Civil		Chemical		Electrical		Mechanical		Surveying	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Instructional repertoire	3.97	(0.75)	3.83	(0.76)	3.68	(0.67)	3.57	(0.69)	4.15	(0.69)	3.76	(0.65)	3.92	(0.76)
Representational repertoire	3.88	(0.80)	3.55	(0.90)	3.54	(0.71)	3.53	(0.74)	3.84	(0.74)	3.59	(0.65)	3.86	(0.76)
Subject matter Knowledge	4.26	(0.66)	4.38	(0.62)	4.10	(0.70)	4.17	(0.65)	4.17	(0.65)	4.02	(0.64)	4.20	(0.55)
Knowledge of student understanding	4.20	(0.57)	4.15	(0.72)	3.84	(0.77)	3.87	(0.69)	3.87	(0.69)	4.21	(0.65)	3.86	(1.07)

Table 4.4b Descriptive statistics of the students 'perceptions in the four scales using individual items average means for all students (N=450)

Scale	Item	Mean	S.D
Instructional repertoire	1 .My lecturer's teaching methods keep me interested in engineering	4.01	0.97
	2. My lecturer provides opportunities for me to express my point of view.	3.88	1.04
	3 My lecturer uses different teaching activities to promote my interest in learning.	3.64	1.10
	4. My lecturer uses appropriate models to help me understand engineering concepts.	3.75	1.12
	5. My lecturer uses interesting methods to teach engineering topics.	3.80	1.01
	6. My lecturer's teaching methods make me think hard.	3.68	1.15
	7 My lecturer uses a variety of teaching approaches to teach different topics.	3.50	1.09
	8. My lecturer shows us activities that I can use to continue my study of a topic.	3.69	1.14
Representational repertoire	9 .My lecturer uses familiar examples to explain engineering concepts.	4.01	0.99
	10. My lecturer uses appropriate diagrams and graphs to explain science and engineering concepts.	4.18	0.97
	11. My lecturer uses demonstrations to show science and engineering concepts.	3.75	1.00
	12. My lecturer uses real objects to help me understand science and engineering concepts.	3.25	1.32
	13. My lecturer uses stories to explain science and engineering ideas.	3.11	1.29
	14. My lecturer uses analogies with which I am familiar to help me understand science and engineering concepts.	3.40	1.08
	15. My lecturer uses familiar events to describe scientific and engineering concepts.	3.54	1.13
Subject matter knowledge	16. My lecturer knows the content (s) he is teaching.	4.58	0.77
	17. My lecturer knows how science theories or principles have been developed.	4.14	0.93
	18. My lecturer knows the answers to questions that we ask about engineering concepts.	4.37	0.82
	19. My lecturer knows how engineering is related to technology.	4.31	0.86
	20. My lecturer knows the history behind engineering discoveries.	3.82	1.03
	21. My lecturer explains the impact of science, engineering and technology on society.	3.65	1.14
Knowledge of students understanding	22. My lecturer's tests evaluate my understanding of a topic.	4.11	1.04
	23. My lecturer's questions evaluate my understanding of a topic.	4.07	0.99
	24. My lecturer's assessment methods evaluate my understanding.	3.92	1.06
	25. My lecturer uses different approaches (questions, discussion, etc.) to find out whether I understand.	3.92	1.08
	26. My lecturer assesses the extent to which I understand the topic.	3.64	1.04
	27. My lecturer uses tests to check that I understand what I have learned.	4.33	1.01
	28. My lecturer's tests allow me to check my understanding of concepts.	4.30	0.99

Representational Repertoire: For this scale, the mean response per programme ranged between 3.53 and 3.88. These results indicate that students perceived the events in this category to be occurring between sometimes-(3) and more towards often-(4). This finding is indicative of satisfaction among students that their lecturers used a variety of representations such as analogies, examples, graphics which challenged students' previous conceptions and also to make new subject matter comprehensible and meaningful.

When the mean scores of Representational Repertoire (RR) were compared across the seven programmes, the results showed that the mean scores of Surveying, Electrical and Architecture where slightly higher than in Building, Civil, Chemical and Mechanical respectively. However, the ANOVA tests showed that there was no statistical significant difference between the groups. This implied that the students in these three programmes did not perceive their lecturers more positively than students in the other programmes.

When students' frequency of responses on the individual items of RR were compared, results showed that option 'always agree' was selected by 48% of students for item 10, followed by 39% for item 9. This finding indicates that a fair percentage of students perceived their teachers to be using diagrams to explain concepts as opposed to stories and real objects in helping the students to understand the engineering content. The items describing other types of Representational Repertoire received low responses of agreement. This finding could be attributed to the fact that in most cases, theory is taught through traditional lectures where lecturers use diagrams presented in class through the data projectors or textbooks. The traditional lecture serves as a dominant teaching methodology in the Faculty of Engineering classrooms. In contrast, models are used during laboratory practical sessions and also when students do experiential learning modules in the industry. Further detailed investigation is required so that more knowledge about students' conceptions regarding the use of other representational repertoires such as models could be generated.

*Subject Matter Knowledge***:** For this scale, the average mean scores for the students' 'responses in all the seven programmes were found to be the highest amongst all the four scales. The average mean scores ranged between 4.02 and 4.38. Building

Science responses produced the highest average mean score whereas Mechanical Engineering received the lowest average mean score. These results indicated that students perceived that the events about their lecturers teaching knowledge occurred more towards often-(4) as opposed to almost always-(5).

Analysis of the percentage frequency results showed that 70% of the students selected items 16, 18 and 19. The statements associated with these items were more familiar to students because they were associated with the dominant teacher centred teaching approach used across the faculty. These results indicate that students strongly believed that their lecturers knew the content being taught. Item 21, which focused on the teachers' explanation about the impact of the society, received only 28% of the responses. This finding implied that students' experiences of knowledge of subject matter was only limited to the teaching of theoretical content. Issues on impact of engineering on society were not addressed through teaching. These findings did not surprise the researcher because teaching in the faculty at the time of data collection was still very much didactical and the curriculum was predominantly theoretical. In addition, since students were not familiar with engineering content, it was therefore reasonable for them to perceive their lecturers' subject matter knowledge more positively than all other three scales.

Knowledge of Students Understanding: The mean scores for this scale were found to be in the range of between 3.84 and 4.21. The results indicate that students perceived the events measured by this scale to be occurring between sometimes-(3) and often-(4). A large cluster of the means was found more towards the option 'often'. Mechanical Engineering registered highest average mean scores than all other programmes. Civil Engineering scores were the lowest within in the range. The finding implied that all students were satisfied that their lecturers assessed and evaluated their understanding of topics and lessons in ways that made learning more meaningful.

However, analysis of scores on individual items within the scale revealed that a higher percentage of students (69% and 57%) selected items 27 and 28. The statements on these items were associated with tests and examinations as tools used in assessment. The items that were associated with other forms of assessing student understanding such as "my lecturer uses different approaches, questions, discussions,

etc. to find out whether I understand "and "my lecturer questions evaluate my understanding" received low responses of agreement from students. This finding was not surprising as assessment in many departments in the faculty and institution wide was still predominantly pencil and paper test and examinations. Therefore, it was not surprising that a large percentage of students selected these two options more than other items within the scale. Students were more familiar with tests and examinations than any other form of assessment and evaluation.

4.4.2 Determination of differentiation between the Engineering Programmes

In order to determine the ability of the SPOTK scales to differentiate between the perceptions of students in the different seven engineering programmes, a one-way analysis of variance (ANOVA) and Scheffe′s post-hoc tests were performed with class membership as an independent variable and the four scales of the SPOTK as dependent variables. The ANOVA tests were found to be more appropriate since it ascertains differences between more than two groups of participants. Furthermore, research methods authors such as Pallant (2011) and Gratton and Jones (2010) suggest this test is relevant since it does not assume that participants have been randomly assigned to each group, as is the case with the students in different engineering programmes in this study. The results of differentiation between the engineering programmes are presented in Table 4.5.

The results in Table 4.5 show that in all the scales, the F value was higher than 1. However responses on only two scales, Instructional Repertoire and Knowledge of Student Understanding were able to be differentiated between programmes at a statistically significant level ($p < 0.05$). The posthoc Scheffe′ comparison showed statistically significant differences between Electrical, Civil and Chemical engineering programmes. Furthermore, the posthoc Scheffe′ comparison test indicated that the statistical significant difference of the mean scores between the seven programmes for the subscale Instructional Repertoire was contributed by differences between the scores from the Chemical and Electrical Engineering students.

Table 4.5 ANOVA results of differentiation of students' perceptions in the seven engineering programmes.

Scale	Sum of squares	df	Mean square	F	Sig.
Instructional Repertoire					
Between groups	11.58	6	1.93	4.16*	0.00
Within groups	205.42	443	0.46		
Total	217.00	449			
Representational Repertoire					
Between groups	6.02	6	1.00	1.95	0.17
Within groups	227.56	443	0.51		
Total	233.57	449			
Subject Matter Knowledge					
Between groups	6.84	6	1.14	2.73	0.13
Within groups	184.72	443	0.42		
Total	191.56	449			
Knowledge of Student Understanding					
between groups	16.58	6	2.76	5.46*	0.00
Within groups	224.18	443	0.51		
Total	240.76	449			

*significant at $p<0.05$

There was no statistically significant difference between the student scores in the other programs. Although the differences between the groups were small, the results seem to show that the students in the three programmes perceived their lecturers' knowledge of student understanding and the instructional repertoire to be more favourable than in the other programmes.

4.5   Response to Research Question 1.2: Qualitative Results and Findings

Research Question 1.2: What are the perceptions of students from various engineering programmes on each teaching knowledge repertoire evaluated by the SPOTK questionnaire?

The results of the qualitative data were used to obtain more insight about students' perceptions of their lecturers' teaching and learning knowledge in their engineering classrooms. This section describes the data analysis and results of the open ended questions. An interesting set of patterns and categories of perceptions emerged from the analysis of students' responses on the two open ended questions in Part C of the SPOTK questionnaire:

Question 1.   Which courses do you find difficult to learn? Give reasons

Question 2.   Which courses do you find easy to learn? Give reasons

4.5.1 Identification, Description of the themes and Data Analysis

In order to identify and analyse student responses to the two open ended questions, the responses were categorised into themes. Several statements or descriptions of the reasons given by the students on their views about courses perceived to be difficult to learn and easy to learn could not be used for data analysis and interpretation. Some of the reasons did not match with the events and characteristics of the teachers' pedagogical knowledge constructs under investigation in this study. Incomplete and ambiguous data were omitted through a rigorous process of data cleaning, editing and clustering following guidelines provided by Diamantopoulos and Schlegelmilch (1997) and Cohen, et al. (2007). Only the responses from representative students who provided useful descriptions for the purpose of this study were selected for the analysis.

Most of the patterns and categories of responses were found to match the four predetermined constructs and themes described in the research conceptual framework. During analysis of responses, a subset of responses emerged which bore no relations to the four predetermined themes. However, because of curriculum knowledge was part of PCK it was decided to adopt the responses under the theme of 'other curriculum issues'.

The students' descriptions of the reasons for difficult and easy courses were coded and clustered according to the linkage or relationship with the four predetermined themes; IR, RR, SMK and KSU on lecturers' teaching knowledge. In the introduction of the findings in the sections below, the teaching and learning theoretical descriptions and meanings of each theme is briefly explained. This is followed by the presentation of results and findings.

Theme 1: Instructional Repertoire (IR). In this theme students' descriptions were clustered according to perceptions about the extent to which the lecturers selected from among a variety of teaching methods, strategies, opportunities to express view points and use of appropriate models that could benefit the students' content learning. Examples of students' descriptions are:

"Lecturers used poor teaching methods and presentation skills"-
[Difficult courses to learn]
"Teaching methods promoted memorisation" – [Difficult courses to
learn]
"Lecturers used a variety of teaching methods to make us understand'
– [Easy courses to learn]
"Lecturers explained concepts well" – [Easy courses to learn]

More examples of students' responses are presented in the tables in section 4.4.3.

Theme 2: Representational Repertoire (RR). In this theme, the students' descriptions were clustered according to the perceptions about the extent to which the lecturer used a variety of representational repertoires to challenge students' previous conceptions. This variety included the use of metaphors, examples, diagrams and graphs, demonstrations, real objects, models, familiar events stories and analogies. Examples of students' descriptions in this theme are:

"Lecturer did not use practical examples, drawings and graphs to
explain concepts"-   [Difficult courses to learn]
"Lecturers use lots of practical examples in class" – [Easy courses to
learn]
"Lecturers use demonstrations and models to make us understand" –
[Easy courses to learn]

Theme 3: Subject Matter Knowledge (SMK). In this theme, the results were clustered according to the extent in which the course was perceived to be easy or difficult to learn due to how the lecturers demonstrated a comprehension of the purpose, ideas and understanding of the discipline content when teaching. Examples of students' descriptions in this theme are:

"Lecturers did not know the subject well"- [Difficult courses to learn]
"Lecturer could not explain concepts, formulae, drawings and graphs
clearly" – [Difficult Courses to learn]
"Lecturer knows the subject very well" – [Easy courses to learn]

Theme 4: Knowledge of Student Understanding (KUS). In this theme, students' descriptions were clustered according to the extent to which the course was

perceived to be easy or difficult to learn based on how the lecturers demonstrated knowledge of various ways of assessing and evaluating students' understanding of the content taught in class. Examples of students' descriptions in this theme are:

> "The teacher marks only the final answer in a mathematical problem, does not give credit to the steps taken in solving the problem" – [Difficult courses to learn]
>
> "Teaching approaches and examples used in class differs with assessments"- [Difficult Courses]
>
> "Tests are set fairly using examples used in the lectures" – [Easy Courses to learn]
>
> "Lecturers always test our understanding after each topic" – [Easy courses to learn]

Theme 5: Other Curriculum Issues. This theme emerged from the analysis of the reasons given to the subjects perceived as either difficult to learn or easy to learn. The students provided a variety of reasons and concerns of why they perceived some courses as difficult to learn or easy to learn. Among the students' descriptions that emerged were concerns about teaching and learning such as: teaching approaches used by lecturers, assessment practices, preferences on learning styles used by students, curriculum design and the syllabus content issues. Examples of students' responses in this theme are:

> "Courses are full of theoretical and abstract factual content" – [Difficult courses to learn]
>
> "Courses are full of mathematical applications" – [Difficult courses to learn]
>
> "Lack of prior knowledge in the basic principles of science and mathematics"
>
> "I like courses that are practical and hands-on" – [Easy courses to learn]
>
> "I like courses that involves calculations"- [Easy courses to learn]

In each theme the researcher looked for patterns of descriptions or comments that matched the events and characteristics defining each theme as described/defined in the next section. For the purpose of analysis in each theme, categories and clusters of responses were identified as either positive or negative perceptions towards difficult

to learn or easy to learn courses. Positive responses refer to categories of perceptions confirming feelings of satisfaction about teaching knowledge used in the classrooms for courses perceived to be easy. Negative responses refer to perceptions which indicated students' dissatisfaction about teaching knowledge as well as some other aspects in teaching and learning styles used in the delivery of perceived difficult courses.

4.5.2 Results and Interpretation for Courses Perceived Difficult and Easy to learn

The sections below provide a brief presentation, interpretation and discussion of the qualitative results for each of the seven engineering programmes. The overall results for each of the programmes are presented in a table format. Only the salient categories were interpreted and discussed in detail.

4.5.2.1 Architecture

The descriptions for the perceived difficult and easy courses in the Architecture programme were collected and analysed from responses provided by second and third year students. Some students did not respond to the open ended questions. A total of the 27 responses from the Architecture group were analysed and the results are presented in Table 4.6.

Table 4.6: Architecture students' responses to courses perceived difficult and easy to learn

Theme	Students' Comments			
	Difficult Courses to learn	*N*	*Easy Courses to learn*	*N*
Instructional Repertoire	Lecturers use poor teaching methods and skills.	9	Lecturers use excellent teaching methods	5
Representational Repertoire	*None*	-	*None*	-
Subject Matter Knowledge	*None*	-	*None*	-
Knowledge of Student Understanding	*None*	-	*None*	-
Other Curriculum issues	Students should just work harder,	3	Students work hard	3
	Subjects requires construction site visit for effective learning,	5	None	
	Curriculum overloaded with too much lecturing.	2	None	

There were no responses for Themes 2, 3 and 4 in both perceived difficult to learn and easy to learn courses. The absence of the meaningful responses on the three

themes created a concern regarding generalisation of the students' attitudes toward teaching and learning within this programme. However, the overall pattern emerging from themes 1 and 5 may be used to improve the ability to generalise the results in this programme.

Theme 1: Instructional Repertoire. In this theme, the nine responses analysed were related to ineffective teaching methods and presentation skills perceived to be used by lecturers in the Architecture classrooms. This finding suggests that students thought that their lecturers lacked competence in teaching and presentation skills to perform their teaching responsibilities effectively. Five students indicated that some courses were easy to learn because lecturers used excellent teaching methods. These perceptions indicate that some students were dissatisfied about the quality of teaching practices in some courses within their programme. The finding imply that the lecturers who taught in the courses perceived to be difficult to learn had limited knowledge of a variety of instructional repertoires they could use to help their students understand difficult concepts. On the contrary, some lecturers in the programme were perceived to have competences in selecting teaching methods and presentation skills which helped students to understand engineering concepts.

Theme 5: Other Curricula Issues. Ten students reported that the courses were perceived to be difficult due to curriculum related issues. The curricular issues were divided into three categories. The first category was about students' reflection about taking own responsibility toward their studies. This response appeared as a perceived reason for finding courses either difficult or easy to learn. The second category was about one of the requirement of the course for students to visit architectural practice sites. The site visits were considered difficult to arrange due to the constraints of time and finances for transport. Therefore, students felt that they missed out on the professional knowledge and skills which could have been learned at the sites.

In the third category, two students perceived curriculum overload to be the cause of learning difficulties in certain courses. Too much lecturing (an overloaded contact timetable) was perceived to be an influential factor on how students experienced teaching and learning in some of the courses in the programme. In addition, the overloaded timetable was believed to cause poor concentration span during lectures. Furthermore, curriculum overload was perceived to have a negative impact on the

allocation of sufficient time to prepare for assessments in all the courses within the programme. There were no other perceptions found to confirm whether or not the Architecture students were satisfied about their lecturers' knowledge of teaching.

4.5.2.2   Building Science

Sixteen students in the third year of study responded to the two questions about perceived difficult to learn and easy to learn courses. A total of thirty five responses were analysed. The results are shown in table 4.7.

Table 4.7: Building Science students' responses on courses perceived difficult and easy to learn

Theme	Students' Comments			
	Difficult Courses to learn	*N*	*Easy Courses to learn*	*N*
Instructional Repertoire	Lecturers use poor teaching methods and presentation skills	6	Lecturers explain concepts very well	3
Representational Repertoire	*None*	-	*Lecturers use demonstrations and stories to make us understand*	*2*
Subject Matter Knowledge	None	-	None	-
Knowledge of Student Understanding	None	-	None	-
Other Curriculum issues	Lack of prior knowledge in the basic principles of science and mathematics	6	Prior knowledge in mathematics and science helped me to understand the content	2
	Courses have difficult and complex formulae, mathematical calculations and applications	6	Motivated by friendly student –lecturer relationships	2
	Course is too theoretical	1	Courses are practical and relevant to professional and everyday life	7

Theme 5 received most of the responses that emerged from both difficult to learn and easy to learn courses. There were no responses for themes 2, 3 and 4 for difficult courses and themes 3 and 4 for easy courses.

Theme 1: Instructional Repertoire. Only one category of responses emerged for the difficult to learn courses. Six students reported that courses were difficult because

lecturers used ineffective teaching methods and skills. Perceptions on ineffective teaching methods and skills implied that lecturers had limited knowledge about the instructional repertoire necessary to assist students to learn with understanding. Only three students indicated that courses were easy because lecturers explained concepts well. However, students did not specify the type of instructional repertoires that were used by lecturers offering difficult to learn or easy to learn courses.

Theme 2: Representational repertoire. Only two students reported that they found some courses were easy to learn because the lecturers used demonstrations and stories to help them understand the concepts in Building Science.

Theme 5: Other curricular issues. Two categories of responses emerged under this theme for difficult to learn courses. In the first category, six students reported the lack of basic prior knowledge in science and mathematics was the source of their learning difficulties. However, their responses did not show whether the lecturers knew about their lack of prior knowledge before the new lessons were taught or not. Since this response was raised by a small number of students, the researcher could not confidently connect the perception with the lecturers' lack of sensitivity towards this learning problem.

The second category related to the level of course difficulty was the complex nature of the curriculum content According to six respondents, the complex formulae, mathematical calculations and applications contributed to making the courses difficulty difficult to learn. Comparison of this finding with the previous one on lack of prior knowledge in mathematics, it became certain that lack of knowledge and generic skills in mathematics and science were the contributing obstacles toward meaningful learning. These findings suggest teaching approaches and methods in the Building Science classrooms environment did not provide students with adequate opportunity to confront their own prior knowledge and weaknesses in mathematical skills and use it to improve their learning of new concepts.

Analysis of seven responses for courses perceived to be easy to learn revealed that the practical nature (curriculum structure) of the course content and its relevance to everyday life and professional practice contributed toward making the course easy to learn. Two other students indicated that some courses were easy to learn because

they could link new knowledge to their foundational prior knowledge in mathematics and science. This finding further confirmed that students who perceived courses to be difficult in this theme did not have good generic or academic skills to cope with subjects that required mathematical applications.

4.5.2.3 Chemical Engineering

Ninety two responses were analysed from data provided by years 2 and 3 Chemical Engineering students on perceived difficult and easy courses. The results are shown in Table 4.8.

Table 4.8 Chemical Engineering students' responses on courses perceived difficult and easy to learn

Theme	Students' Comments			
	Difficult Courses to learn	*N*	*Easy Courses to learn*	*N*
Instructional Repertoire	Lecturers used ineffective and confusing teaching methods that promoted memorisation of facts	33	Lecturers used interactive teaching methods and allowed students to participate in class	27
	Lecturers spoke very fast, leading to difficulties in understanding their lessons	25	Lecturers are patient and dedicated to teaching their students	13
	Lecturers get angry when students ask questions	4	Lecturers assisted students to solve the problems	12
Representational Repertoire	Lecturers did not use practical examples, drawings and graphs to explain concepts	13	Lecturers used plenty of practical examples to help students understand	*12*
Subject Matter Knowledge	Lecturers could not explain concepts, formulae and graphs clearly (meaning with confidence)	9	None	-
Knowledge of Student Understanding	Lecturers used simple examples in class but set difficult tests and examinations	14	None	-
	Teaching approaches differed with assessment styles	18	None	-
Other Curriculum issues	Course syllabi are full of theoretical and abstract content	13	Courses are practical and hands-on	*9*
	I do not like courses with lots of formulae and mathematical calculations	19	I like courses that involves mathematical calculations	*2*
			I like factual theory content that is easy is easy to read without mathematical calculations	13

The results in Table 4.8 show the categories of students' perceptions of the level of difficulty for the chemical engineering courses. A significant number of students provided negative responses to the questions. However, there were students who

perceived teaching and learning to be positive for their courses because they believed that their lecturers' teaching knowledge helped them to understand the chemical engineering content.

Theme 1: Instructional Repertoire. There were a significant number of students who responded positively as well as negatively about factors that contributed to the courses being perceived as either easy or difficult in chemical engineering classes. The response, 'lecturers used interactive teaching methods to explain concepts well' was reported by 27 students as a positive perception to account for why certain courses were easy to learn. However, though this response is positive about the lecturer's teaching knowledge, it did not reveal much about the type of instructional repertoires or approaches that the lecturers used in their classes. In order to understand the instructional repertoire used in this programmes, further intensive investigation is required.

Thirteen of the positive responses were linked to how the lecturers' related personally to students. For example 'Lecturer is patient and dedicated to teaching by using active teaching methods that allowed students to participate in class'. Students in this programme regarded the interpersonal relationship with the lecturers as an important factor toward their success in a course. Responses such as this show the importance of interpersonal relationship between lecturers and students and how the relationship could affect perceptions about the level of difficulty of a course and consequently affecting beliefs about a lecturer's competency in teaching a difficult course. Kember (2004) argued that student-teacher relationships influenced how students perceived subject-content difficulty. In this study, there seemed to be a strong influence of the classroom learning environment on how students viewed the level of difficulty of their course as well as the teaching approaches used by their lecturers. Three main categories of responses regarding beliefs about difficult courses were identified.

    i. Lecturer uses difficult teaching methods to explain concepts thus making the subject too difficult to understand

    ii. Lecturers teach/speak very fast and make it difficult to understand

    iii. Lecturer gets angry when students ask questions/Lecturers did not give us opportunity to express our views

Category (i) relates to teaching methods as a negative factor toward making courses difficult to learn. For example, 'Lecturers expect us to memorise theory concepts, they use difficult teaching methods which promote memorisation'(5 students). However, the students did not specify the difficult teaching methods used by their lecturers consequently teaching practices could not be aligned with any of the instructional repertoires incorporated in the quantitative section of the SPOTK questionnaire.

Category (ii) indicates that students perceived courses to be difficult because their lecturers spoke very quickly. Though for the purpose of clustering, this response was classified as an Instructional Repertoire, it is actually a communication skill rather than an instructional repertoire. However, the response fits well into this category because it exposed 'chalk and talk' as a predominant instructional method in these classrooms. Category (iii) further confirmed that the teaching approach primarily used was actually chalk and talk because some lecturers felt uneasy if students interrupted their lectures by asking questions. The response that lecturers were perceived to be speaking quickly and became angry when students asked questions may be an indication that these lecturers were either unaware of their attitudes and behaviour or how they impacted negatively on teaching and learning. The responses identified in this section demonstrate that some lecturers in Chemical Engineering were not knowledgeable about a variety of good instructional repertoires that could make their course teaching more interesting, understandable and meaningful to their students.

Theme 2: Representational Repertoire. The rate of response in this theme was low. Only one significant category emerged from the responses given by students. Twelve students reported that courses they identified as easy were due to the lecturers' use of practical examples and doing calculations with the students in class. In the theme 'other curriculum issues', complex formulae and calculations were reported as factors contributing toward perceiving courses as difficult. Hence, it was not surprising that students viewed solving engineering problems which required mathematical applications with lecturers in class as a positive factor and important aspect of teaching. Therefore, a lecturer who dedicated much of his or her teaching contact time in assisting students in problem solving was viewed to have knowledge

of representational repertoire and consequently increasing students' positive beliefs about their lecturers' pedagogical content knowledge. This finding could further foster the belief that any lecturer who believes are strong on encouraging self-directed learning by expecting students to solve problems on their own, his teaching practices would be viewed by students as contributing factors towards perceiving courses as difficult.

Only one category of negative responses was identified, namely; "Lecturers did not use practical examples, drawings and graphs to explain concepts". This perception shows that the students believed that their lecturers did not realise the importance of using a variety of representational repertoires such as practical examples, graphs and drawings to help them understand chemical engineering concepts. One would have expected more students to describe the variety of representational repertoires used in their classes but the qualitative results revealed very few responses. This observation contradicts the overwhelming selection of items (with an average item mean of above 3.50) for this scale in the quantitative results presented in this chapter which indicated that students were satisfied that their lecturers used representational repertoires that promoted good understanding of the subject matter.

The findings reported here could imply that lecturers in the chemical engineering programme did not use a variety of representational repertoires because they probably lacked pedagogical content knowledge about the possibility of using and or identifying discipline-based representational repertoires available to challenge the students' prior knowledge and consequently helped them to understand chemical engineering concepts and courses.

Theme 3: Subject Matter Knowledge. Only one category of relevant responses regarding perceptions about difficult courses was identified for reporting purposes in this theme. There were no responses on factors supporting the beliefs about easy to learn courses.

In the case of perceived difficult to learn courses, students reported that their lecturers could not explain concepts clearly using formulae, graphs and drawings. Though some responses showed that some lecturers did attempt to use drawings and graphs in their teaching, on the contrary other students reported that lecturers could

not use the representations to explain concepts clearly and meaningfully. This finding indicates that the lecturers could be experiencing difficulties in relating the content they teach to the representational repertoires they chose or that students could not establish a good understanding of the use of the models in the classrooms. An alternative argument on this finding could be that the students and lecturers may be interpreting the use of graphs, drawings and models in teaching at two different cognitive levels, namely, the levels of the novice and that of the expert. However, any lecturers with a good pedagogical content knowledge in the discipline they teach should be able to know when their students are not interpreting the representations correctly to effect meaningful learning (Magnusson, et al., 1999).

Due to the few responses provided by the students in this theme, the interpretations made are limited to can confidently conclude that students perceived the majority of the courses on Chemical Engineering to be easy to learn because the lecturers had a good knowledge of the subject matter. Perhaps the few responses in this section could be an indication that students were generally satisfied about their lecturers' subject matter knowledge. This observation is further supported by the results in the quantitative section of the SPOTK questionnaire where the majority of the students responded positively to the items in scale with an average item mean score of 4.17. Therefore, it could be concluded that students were generally satisfied that their lecturers in chemical engineering demonstrated a good comprehension of the content and concepts in the discipline. However, it is not known whether the results also indicated that lecturers could answer students' questions competently during the lectures.

*Theme 4: Knowledge of Students Understanding***.** Only two categories of responses were identified for supporting why courses were perceived to be difficult to learn.

      i.   Lecturers used simple examples in class but set difficult test questions

      ii.   Teaching approach differed with assessment practices

The categories (i) and (ii) above indicated an existence of a dual conflict between students' expectations about assessment and the lecturers' assessment practices when compared with teaching approaches used in the classroom. The first conflict relates views about how tests and examination questions are constructed as opposed to the

standards of examples used by lecturers during lessons. The second conflict related to a mismatch between assessment practices and the teaching methods and strategies used by their lecturers. These findings may indicate that the students' held notions that poor performance in courses perceived to be difficult were linked to their lecturers' lack of knowledge about use of relevant repertoires to assess student understanding. Due to lack of response in support of why certain courses were viewed as easy, it was impossible to compare and interpret the reasons behind difficult to learn and easy to learn courses.

Theme 5: Other curriculum issues. Three major categories associated with curriculum issues emerged from the responses about why certain courses were perceived to be difficult to learn.

i. Subjects were full of abstract theory and complex to understand

ii. Have conceptual difficulties in understanding graphs and formulae

iii. Students' preferred learning theoretical content but disliked formulae and calculations due to their weaknesses in problem-solving and mathematical skills

The first category showed that some students found the chemical engineering content overwhelming due to its complexity. These feelings clearly indicate that students lacked academic skills or where not well prepared to cope with the engineering curriculum. The alternative argument that arose from this finding was that lecturers should be able to use their pedagogical content knowledge to identify such students within their classes and recommend extra-curricular remedial programmes. However, if the lecturer does not have the pedagogical knowledge to identify students with this type of problems, it would persist to affect many students in the long term, thus affecting teaching and learning outcomes negatively within courses that are perceived to be difficult to learn.

In the second category students reported that the subjects were difficult to learn for them because they could not understand graphs and formulae. This perception shows that students experiencing this type of learning difficulties indicated that they had academic literacy skills weaknesses in mathematical, computational skills and the interpretation of graphs as representations of the content they are learning. The perception further indicates that students lacked good foundational skills and

knowledge to comprehend the complex nature of engineering content. Prevalence of the perception has implications for the lecturers' instructional presentation styles and use of representational repertoire such as graphs in the lectures.

The third category emerged with a focus on learning difficulties associated with mathematical calculations and problem-solving. However, the perspective of reasoning from students was different from the previous category. Students in category preferred to learn content which did not include mathematical calculations. For example, the response such as 'courses contained abstract theory, involving complex calculations' and ' courses were taught in an uninteresting way' were found to be the most prominent responses. These perceptions indicate that the lecturers' choices of teaching strategies to help students to learn better were probably not compatible with the students learning styles and therefore students continued to view mathematics as abstract and difficult to learn. This finding imply that lecturers who are teaching courses identified as difficult to learn might have little knowledge and understanding about how their students learned the chemical engineering content.

Other general perceptions of interest that emerged in this theme were lack of sufficient learning resources, perceived unfair assessment practices and lecturers rushing through the lessons so that they could finish the syllabus. These findings imply that lecturers had limited pedagogical content knowledge regarding how to assess students' understanding and the use of effective instructional and representational repertoires.

4.5.2.4   Civil Engineering

Twenty eight and fifty responses about easy to learn courses and difficult to learn courses, respectively, were analysed and the results are presented in Table 4.9. A large number of responses for difficult to learn and easy to learn courses were found to be associated with the instructional repertoire and other curriculum issues themes in the difficult to learn courses category when compared with the other three themes in both difficult and easy to learn courses. There were no relevant responses identified for easy to learn courses in themes 2 and 3.

Table 4.9: Civil Engineering students' responses on courses perceived difficult and easy to learn

Theme	Students' Comments			
	Difficult to learn courses	*N*	*Easy to learn courses*	*N*
Instructional Repertoire	Lecturers use ineffective teaching methods which promote memorisation of facts	20	Lecturers use interactive teaching methods	6
Representational Repertoire	None	-	None	-
Subject Matter Knowledge	Lecturers not clear about the subject matter	*2*	None	-
Knowledge of Student Understanding	Lecturers used simple examples in class but set difficult tests and examinations questions	*5*	Lecturers set fair tests which incorporate the examples used in the classroom	*3*
	Teaching approach differed with assessment	1	None	
	Lecturer marks only the final answer in a mathematical problem solving, no credit is given for steps in solving the problem	3	None	
Other Curriculum issues	*Courses* are full of theoretical and abstract content	*8*	Courses are practical and hands-on	*11*
	Courses are full of mathematical applications	5	I like courses that involves calculations	2
	Students' lack of prior knowledge in the subject	4	None	-
	Lack of academic literacy skills to cope with the engineering subjects	4	None	-

Theme 1: Instructional Repertoire. Only one category of students' responses emerged in this theme. The responses were associated with views regarding teaching methods used by the lecturers in classrooms. The responses such as 'lecturers' use ineffective and confusing methods that promoted memorisation' and 'lecturers used interactive teaching methods' indicate that students viewed lecturers' choice of teaching methods as a factor which could either promote or hinder effective learning.

The perceptions that lecturers used poor and confusing teaching methods which promoted memorisation attracted most responses (20) compared to other categories of responses identified in this programme. The existence of this perception shows that lecturers in Civil Engineering used teaching methods that promoted memorisation and regurgitation of facts which the students claimed not to like.

Kember (2004) argued that teaching methods that encourage memorisation of facts promote surface learning. Such teaching methods deny the students the opportunity

to develop a deep approach to learning that subsequently would lead to better understanding. Presumably, the students who held this belief would prefer their lecturers to use teaching methods that promote deep understanding of content rather than memorisation. Six students who responded positively to the courses they found easy to learn support this inference. These students believe that the courses were easy to learn because lecturers used teaching methods that were interactive (student-centred) and subsequently it enhanced their understanding. However, they did not reveal the type of interactive teaching methods that were used in their classes, therefore it was not possible to do a comparison of the teaching methods which either promoted interactive learning as opposed to those that promoted memorisation and subsequently hindered deep approaches to learning.

The findings reported here implied that lecturers viewed by students as using teaching methods which promoted memorisation had limited knowledge of the wide range of instructional repertoires available to assist them to make teaching and learning in their classrooms more meaningful for students.

*Theme 3: Subject Matter Knowledge***:** Only two students indicated that lecturers did not demonstrate knowledge about the subject matter. Fewer responses on this theme may suggest that majority of the students perceived their lecturers have good knowledge of the subject matter.

Theme 4: Knowledge of Student Understanding. Two categories of responses were identified in this theme. In category 1, 5 students reported that lecturers used simple examples during lectures but constructed difficult questions in tests and examinations, a similar comment was found among some students in Chemical Engineering. This finding indicates that the perception about the level of difficulty of the course was influenced by the teaching approaches that were viewed to be in conflict with the assessment practices and the expectations of students about tests and examinations. On the contrary, responses about courses perceived easy to learn showed that the main influences of students' perceptions were fair tests that included exemplary problems used in class. The two perceptions described here further demonstrate that teaching and learning methodologies used in engineering classrooms in this programme promoted rote learning rather than development of skills. Students concerns indicate that they were unable to apply knowledge gained

in class to new unfamiliar problems in the tests and examinations. Hence, students were concerned when lecturers did not repeat examples used in class in the tests and examinations.

Category two had three responses from students who believed that their lecturers' style of marking answers only and ignored the steps followed to reach the answer was thought to be an unfair assessment practice which led to the courses being perceived as difficult. The process of solving a problem is an important variable to assess understanding and provides students with motivation and confidence in learning the subject. Therefore, if the assessment protocols and allocation of marks/grades ignore the importance of this variable for learning, students would be demotivated to learn.

The two categories of findings in this theme has implications on the lecturers' n knowledge and selection of instructional repertoires which would challenge students to think hard and understand concepts in such a way that they could apply the knowledge into new situations with ease. The second category of responses suggests that the lecturers and students' view of the purpose of assessment were different. It is important for both students and lecturers to have a common and shared view of the purpose of assessment and how knowledge of understanding would be evaluated.

Theme 5: Other Curriculum Issues. The analyses of responses in this theme emerged with two categories with descriptions as follows*:*

    i.   Nature of the curriculum structure and students' learning style preferences
    ii   Lack of prior knowledge in the subject and generic analytical skills

Two types of interrelated responses formed category (i). Students viewed the courses to be difficult to learn because the structure of the curriculum was theoretical and abstract in nature. As such, students found it difficult to comprehend many of the engineering concepts. On the contrary, responses about courses perceived to be easy to learn showed that students found the content more practical, hands-on and related to daily life experiences as opposed to theoretical and abstract content. These two findings suggest that students were motivated to learn the engineering content because they could relate it to familiar situations in life. The implication from students' views about difficult to learn courses is that if lecturers' teaching

methodologies fail to turn tacit engineering knowledge into the explicit format, students would find it difficult to understand and thus loose motivation and interest to learn.

The second cluster of perceptions indicated that students used their preferred learning styles to determine whether courses were difficult or easy to learn. Some students preferred more textual content whilst other preferred content with lots of mathematical calculations. These two findings imply that lecturers need to be aware of their students' learning styles and select and use a variety of instructional and representational repertoires to accommodate the diversity of learning styles students used in their classrooms. By so doing, lecturers would create inclusive learning environments for all students to experience learning in a positive way.

Responses in the second category showed that some students blamed the perceived difficulty of courses on their lack of prior knowledge in the subject. For example, the subject Design was perceived difficult to learn because students lacked prior knowledge in it. Many of the students had never done the subject in their high school curriculum. The students' feelings about lack of prior knowledge being a causal factor in perceiving courses to be difficult may suggest that their lecturers did not assess their prior knowledge before introducing new topics in the Civil Engineering classrooms. Fundamental knowledge and skills in a subject is an important feature for facilitating meaningful and successful understanding of new concepts in teaching and learning experiences. The constructivist approach to teaching and learning regards diagnosis of students' level of prior knowledge as a starting point in every lesson (Treagust, et al. 1996). However, diagnosing students' level of prior knowledge is a skill that requires lecturers to have adequate pedagogical content knowledge.

4.5.2.5   Electrical Engineering

Results of students' views about courses perceived to be difficult to learn and easy to learn in the Electrical Engineering programme were generated from 42 responses. The results are presented in Table 4.10. The results displayed in Table 4.10 show that students provided more positive responses (27) about courses perceived to be easy to learn in comparison to the courses perceived to be difficult to learn, which

produced only 15 responses. There was a fair representation of responses in all the four themes analysed for easy courses whilst on the other hand, responses for difficult courses could only be identified and categorised in the three themes only. This finding suggests that students were satisfied that most of the courses offered in the programme were easy to learn. Consequently, it implied that students perceived their lecturers teaching knowledge to be good.

Table 4.10: Electrical Engineering students' responses on courses perceived difficult and easy to learn

Theme	Students' Comments			
	Difficult Courses to learn	*N*	*Easy Courses to learn*	*N*
Instructional Repertoire	Lecturers use poor teaching methods and presentation skills	6	Lecturers use variety of teaching methods to make us understand	2
	None	-	Lecturer explain concepts well	3
Representational Repertoire	*None*	-	Lecturers used lots of practical examples in class	*7*
	None	-	Lecturers use demonstrations and models to make students understand	1
Subject Matter Knowledge	none	-	Lecturer knows the subject well	*1*
Knowledge of Student Understanding	Lecturer work out solutions for problems without explanation	1	Lecturers always test students' understanding after each topic	*1*
	Tests and examinations questions too complex and difficult to understand	1	None	-
Other Curriculum issues	None	-	Prior knowledge in mathematics and science helped students to understand formulae and mathematical calculations in the engineering courses	*4*
	None	-	I like courses which did not have many formulae and mathematical calculations	1
	None	-	factual content is easy to read and learn	1
	Courses too theoretical and have no relevance to daily life	7	Courses are practical and relevant to professional and everyday life	6

Theme 1: Instructional repertoire. The results in Table 4.10 show that students perceived certain courses to be difficult because lecturers used ineffective teaching methods. On the contrary, courses were perceived to be easy to learn because lecturers used a variety of teaching methods and good presentation skills to make

students understand the subject matter. However, as it was the case with other programmes, no specific teaching methodologies were ascribed to their classrooms.

Theme 2: Representational Repertoire. Students attributed perceived use of demonstrations, relevant practicals and models to positive learning in the easy courses. This finding suggest that students believed that their lecturers who taught courses perceived to be easy to learn used a variety of representational repertoires to facilitate learning in their classrooms. There were no responses for courses perceived to be difficult to learn in this theme.

Theme 5: Other curricular Issues. Only one category was identified for courses perceived to be difficult to learn. Seven students attributed the level of difficulty of courses to the theoretical nature of the curriculum. The content was reported to be too abstract and not related to things students were familiar with in their everyday lives. This finding suggest that teaching approaches used in the classrooms failed to help students understand how engineering content was related to societal needs and technological problems which the engineer encounter in their daily professional lives. Allie et al. (2009) argue that teaching and learning approaches used in class should emulate the work of professional engineers so that students could develop a broader and more holistic understanding of the purpose of learning engineering content. The challenge for engineering lecturers lies with their knowledge on selecting appropriate teaching approaches aligned to the level of difficulty of the topics to be taught.

Two categories emerged for the responses about courses perceived to be easy to learn. The first category associated the students' confidence and satisfaction with the quality of their prior knowledge in science and mathematics as a positive factor toward their understanding of engineering content. The second category related students' positive attitude to the practical nature of the curriculum.

The findings in this theme provide useful information for engineering curriculum developers and educators to consider designing the curricula in such a way that the theoretical and abstract nature of the engineering content could be made explicit to students. In addition, selection of appropriate teaching strategies and approaches to

make difficult content more accessible to the cognitive levels of students would provide students with interest and motivation to learn.

4.5.2.6   *Mechanical Engineering*

A total of 184 students' responses on perceptions about difficult and easy to learn courses in Mechanical Engineering were analysed and the results are presented in Table 4.11.

The results in Table 4.11 show that themes 1 and 5 attracted most responses in both perceived difficult and easy courses categories. .

Theme 1: Instructional Repertoire. Most of the responses fell into the category on teaching methods and presentation skills for both perceived difficult and easy courses. About 29 responses revealed that students believed that perceived difficulty to learn in some courses was caused by the lecturers using ineffective (poor) teaching methodologies in the classrooms. On the contrary, 19 responses revealed that students perceived certain courses to be easy to learn because their lecturers used a variety of teaching methods to make them understand the subject matter.

The second category of perceptions was related to lecturers using teaching methodologies perceived to be promoting memorisation of content. This finding suggests that teaching methodologies used by the lecturers in their classes supported rote learning. In contrast, the lecturers' use of variety of teaching methodologies suitable for the learning needs of the students was considered by other students to be a good determinant for positive learning experiences in a course considered to be easy. However, as in the other engineering programmes, these responses did not explain much about the types of teaching methodologies used by the lecturers in both perceived difficult and easy courses. Consequently, one cannot conclude with confidence that the lecturers reported to be using a variety of teaching methods were actually using student- centred teaching methodologies. Furthermore, these results do not confirm that the students were generally satisfied that their lecturers had a good pedagogical content knowledge. A further investigation on the actual teaching methodologies used in the Mechanical Engineering programmes is required.

Table 4.11: Mechanical Engineering students' responses on courses perceived difficult and easy to learn.

Theme	Students' Comments			
	Difficult Courses to learn	*N*	*Easy Courses to learn*	*N*
Instructional Repertoire	Lecturers used poor teaching and presentation methods	29	Lecturers used variety of teaching methods to help the students to understand the lessons	19
	Teaching methods promoted memorisation	2	Teaching methods used in class promoted deep understanding	15
Representational Repertoire	Lecturers did not use practical examples to explain difficult concepts	3	Lecturers used many practical examples in class	*9*
	None	-	Lecturers used demonstrations to make us understand	1
Subject Matter Knowledge	Lecturers did not know the subject well	6	Lecturers knew the subject well	*2*
Knowledge of Student Understanding	Tests and examination questions too complex and difficult for students to understand the assessments	7	Lecturers always use assessment to tests students' understanding	*1*
	Tests and examinations questions are not fair	7	None	-
	Open book assessment is difficult	*5*	*None*	-
Other Curriculum issues	Lack of fundamental prior knowledge in science and mathematics	10	Knowledge of fundamental concepts in mathematics and science helped students to understand formulae and calculations	9
	Courses have difficult and complex formulae, mathematical calculations and applications	13	Prefer courses with factual content that is easy to read from a text book rather than courses with mathematical calculations and applications	12
	Course content too theoretical and not relevant to practical everyday life	7	Courses are practical and relevant to professional and everyday life	19
	Too many subjects to study (curriculum overload)	5	None	-
	Course not integrated/related with other courses in the programme	3	None	-

Theme 2: Representational repertoire. This theme attracted fewer responses from students. Only 3 responses for courses perceived to be difficult to learn and 10 for courses perceived to be easy to learn were noted. In all these responses, the absence

of practical examples in teaching was identified as a contributing factor for perceived difficult courses. In contrast, a determining factor for easy courses was that the lecturers used practical examples and demonstrations to explain the difficult concepts. No other representational repertoires used by lecturers in the class were reported. One can deduce from these responses that lecturers in this programme did not use a variety of teaching approaches and representational repertoires to challenge students' conceptions and to facilitate meaningful learning.

Theme 3: Subject Matter Knowledge. This theme did not attract many responses from students. Only eight students provided responses regarding their perceptions about their lecturers' teaching knowledge relating to the subject matter. Six responses revealed that the lecturers did not demonstrate good knowledge of the subject, thus contributing towards making the course difficult. For example, two of the six students in semester 2 reported that their lecturer struggled to explain difficult concepts and to solve problems in class.

On the contrary, the results for the courses perceived to be easy to learn revealed that two students believed that their lecturers demonstrated better subject matter competence which in turn helped them to learn and perform better in their courses. Due to lack of details and also low response in this theme, the eight responses analysed do not be used to confirm whether the mechanical engineering lecturers demonstrated good comprehension of the purpose, ideas and understanding of the Mechanical Engineering content when teaching.

Theme 4: Knowledge of student understanding. This theme attracted only 14 responses for courses perceived to be difficult whilst only one response was related to easy courses. All the responses received for difficult courses show that students' perceived assessment of learning was a contributing factor towards their experiences of difficult courses. Five students in semesters 2 and 3 reported that open-book assessments were difficult. Even though there seem to be a problem with open-book assessments, students did not specify which aspects of the open-book assessment were perceived to be difficult. The responses are not conclusive to can generate a good interpretation of the finding and implications on teaching and learning. More research is necessary for in-depth investigations regarding perceptions about open-book assessments.

The second category of responses indicate that students perceived assessments (tests and examination questions) to be difficult, complex and unfair because lecturers designed assessment tasks on the work (content) that was not done in class. This perception indicates that teaching is very much teacher-centred and everything that the lecturer said and did in class was regarded by students as assessable. Therefore, any work that was not taught in class was considered to be unfair. The perception may further indicate that the assessment criteria for the perceived difficult courses were not discussed or clarified with the students prior to the administration of assessment tasks. These results may further signify that some lecturers teaching in the Mechanical Engineering diploma programme could have minimal knowledge about the purpose of assessment and also various ways of assessing and evaluating students' understanding of the content they taught in class.

Theme 5: Other Curricular Issues. This theme attracted most of the responses for courses perceived to be difficult and easy to learn. Three main categories of responses emerged during analysis.

    i.   Prior knowledge in generic skills in science and mathematics
    ii.   Course content comprised of either complex formulae, mathematical calculations and applications
    iii.   Courses comprised of either practical or theoretical knowledge

The first category related to difficulties in learning to lack of prior knowledge in the basic principles and skills in science and mathematics. This perception was further confirmed by responses in the perceived easy courses where students thought that their basic knowledge and skills in science and mathematics provided them with an opportunity to do well in their courses that required mathematical skills. As is the case with the other engineering programmes, this findings on perceived difficult courses further show that while students were critical about their lecturers' teaching knowledge, they also reflected their own weaknesses regarding mathematical generic skills required to comprehend the mathematics content inherent in engineering courses.

The second category though closely associated to the previous concern on lack of mathematical skills, the data revealed another causal factor on why courses were

perceived to be difficult to learn. Learning style preferences was a determinant for perceiving courses to be easy of difficult. For example, responses such as ' like courses that did not have calculations and formulae' and 'I like courses that had factual content that is easy to read and learn from textbooks' became evident as contributing to perceiving courses as difficult or easy to learn. The preference for factual content could be associated with rote learning and regurgitation of content in assessment tasks. The findings imply that lecturers need to be aware of their students learning styles and preferences for certain kind of engineering content. Dislike of content associated with mathematical calculations might signal existence of learning difficulties about certain type of engineering content amongst certain students. Such students may require additional support and motivation to learn with success the courses perceived to be difficult. Lecturers with good pedagogical content knowledge would be able to address this issue with ease.

In the third category, the results revealed that many students preferred courses that were practical and relevant to everyday life and professional practice. Seven students reported that courses were difficult because the content was too theoretical and abstract and not related to everyday experiences. These perceptions show that the relevance of the curriculum to students' future professional life plays an important role in motivating students to learning meaningfully.

There were other minor categories that were found interesting for curriculum development purposes, though they did not form part of this study's investigation. These two categories were curriculum overload and lack of subject integration in the programme. These two categories emerged from semester 3 students' responses on difficult courses. This implied that students could not see how the courses were integrated with the rest of the other courses in the curriculum.

The findings reported in this theme may imply that the lecturers' choice, selection and use of instructional and representational repertoires in class did not provide the students with an opportunity to challenge their alternative and prior conceptions about mathematics during teaching. Furthermore, the teaching methods used by lecturers in class probably did not challenge the students to move out of their comfort of zone of preferred learning style in order to accommodate the different types of content (abstract, theoretical, computational and mathematical) presented in

the engineering courses. In addition, the findings further confirm that the Mechanical Engineering lecturers could have limited knowledge in curriculum design which could have assisted them in identifying some of the curriculum design challenges raised by students and addressed them accordingly.

4.5.2.7   Surveying

The data analysed in this programme were collected from seven semester 2 students. Students in the other study year levels did not respond to the questions on perceived difficult and easy to learn courses. There were no relevant responses identified in relation to themes 1, 2, 3 and 4. Due to the low number of responses as well as the absence of responses in the other four themes, only a narrative summary of the results is presented.

Theme 5: Other Curricular issues. Five students considered the subject, Technical Drawing, to be difficult due to their lack of prior fundamental knowledge and skills from the high school curriculum. Indeed, most of the students enrolled in the Surveying and other engineering programmes did not study technical subjects such as Technical Drawing at school level because they followed the academic school curriculum constituted by Mathematics, Science and English as the core subjects. Therefore, this perception poses a challenge for the lecturers to become sensitive about students' lack of prior knowledge and skills by using teaching strategies that may assist students in learning the necessary basic skills to achieve better in subjects such as Technical Drawing.

The second category of responses (one response) related to the 'practical nature of the subjects' which was perceived to be contributing positively to support why certain courses were viewed as easy to learn. This finding indicates that students who held this perception preferred subjects that were exploratory in nature rather than subjects that required more mathematical calculations.

Though fewer responses were generated from the Surveying group due to the small sample size, the findings supported similar views identified in other engineering programmes. Students' responses provided an insight into their perceptions about the nature of the engineering curriculum and how it contributes towards their success or failure to achieve their learning goals. Furthermore, these findings raise concerns

about the teaching knowledge of the lecturing staff in understanding the curriculum design /structure and how it impacts on quality teaching and learning.

The findings further exposed the nature of challenges students experienced in learning courses perceived to be difficult. Consequently the students' challenges necessitates that lecturers identify and implement relevant instructional and representational repertoires that would motivate students to develop a more positive attitude towards subjects perceived to be difficult.

4.5.3 Summary of Students' Perceptions of Courses Perceived Difficult and Easy to learn

In the preceding sections an analysis of students' responses and results on courses perceived to be difficult and easy to learn were presented. The results revealed that students' responses were able to fit well within the parameters of the predetermined teacher knowledge domains of PCK being investigated in this study, namely Instructional Repertoire, Representational Repertoire, Subject Matter Knowledge and Knowledge of Student Understanding. A new theme, also an important feature of PCK, was established to accommodate responses associated with curriculum issues raised by students. This 'good fit' of responses into the four domains of PCK created an opportunity to compare and converge the perceptions of students across all programmes into a summary. In addition, it allowed for easier comparison of the findings from both the quantitative and qualitative data in order to answer research question 1.

This section compares the perceptions held by students in the various engineering programmes. The results revealed some similarities and differences of perceptions about courses perceived to be difficult and easy to learn among the students in the different engineering programmes. The significance of these perceptions on teaching knowledge, together with implications for teaching and learning are integrated in the summary.

Since the analysis and discussion of the results for each programme were reported in detail in the preceding section 4.4.3, this section will mainly focus on the most major striking and common perceptions held by the students across the seven programmes. The most important and common categories of teaching knowledge perceptions

identified from the students in all programmes in each of the four main themes and also in the newly emerged additional fifth theme are summarised below.

Instructional Repertoire

In this theme, the researcher wanted to elicit students' views about the extent to which their lecturers selected and used variety of instructional repertoires relevant to make students understand the engineering content. One of the most striking findings arising from analysis of the responses in all the programmes is the view that courses were perceived difficult because 'lecturers used ineffective teaching methods and presentation skills'. This perception was found to be the most common and prominent amongst all the engineering programmes with the exception of Surveying. In the Chemical, Civil and Mechanical Engineering programmes, students further associated the perception with rote learning and memorisation of content knowledge.

On the contrary, lecturers' use of interactive teaching methods was found to be the influential factor toward positive attitude on courses perceived to be easy to learn. However, students neither described nor mentioned the types of good or ineffective teaching methods used by lecturers in their classes. Therefore, the inferences made here are based on the general view given by the students. The finding that students associated poor teaching methods with promotion of memorisation in the case of courses perceived to be difficult s whilst lecturers teaching in the courses perceived to be easy were reported to be using teaching methods that promoted deep understanding, confirms the assumption that the predominant teaching methods in some of the engineering courses and programmes were still very much traditional teacher centred 'talk and chalk'. These findings are not surprising within the context of teaching and learning in many South African Higher Education institutions. According to Scott et al. (2007), the South African Higher Education sector has not fully transformed its educational processes to take into account the diversity of students' profile and needs. Even though there are pockets of innovation across the sector, by and large the traditional educational structures and teaching approaches remain predominant across the institutional, faculties and programme levels.

The perception that lecturers use ineffective teaching methods and presentation skills, further demonstrates that a significant number of lecturers (based on the

number of courses identified to be difficult) in all the programmes had limited knowledge and skills in their instructional repertoires as a component of this pedagogical knowledge. Magnusson et al. (1999) demonstrated the dual role of knowledge of instructional strategies as a component of pedagogical content knowledge. Knowledge of subject-specific strategies is only applicable to teaching a specific subject as opposed to other subjects. This implies that these lecturers will need professional development support to improve their knowledge, understanding and skills in employing this dual role of instructional strategies in engineering teaching.

Although this research focussed mainly on students' views of academic nature, there were responses of the affective nature which warrants reporting because they were significant in analysing the quality of teaching and learning, particularly in understanding the views about teaching knowledge and consequently its impact on student performance. As an exemplary case, about 25 responses from Chemical Engineering students revealed that courses were perceived to be easy to learn because lecturers were patient and dedicated to teaching their students. Furthermore, some of the lecturers assisted students to solve difficult engineering problems. On the contrary, about responses from the same programme indicated that courses were perceived to be difficult because the lecturers spoke very quickly hence students experienced difficulties in understanding their lessons. Some lecturers were reported to be relentless or felt uneasy and became angry if students interrupted their lecturers by asking questions.

According to Scott et al. (2007), the benefits of well-designed educational interventions can be neutralised by amongst others, affective factors such as lack of motivation, anxiety about personal circumstances or alienation from the institution. These researchers, through their extensive experience in academic development in South Africa, have identified a relationship between affective factors and academic performance. The negative attitudes such as lecturers becoming angry or impatient with students could lead to students feeling alienated by the educational processes and thus learning may be compromised. Scott et al. (2007) further argued that if the educational processes do not take affective factors into consideration, especially for students who enter the higher education underprepared for traditional educational

provisioning, the impact of the negatively perceived affective factors may cause attrition, not only through academic exclusions but as a result of demoralisation and eventual drop-out.

The literature showed that teachers who were portrayed to have negative attitudes and values towards teaching had low pedagogical content knowledge and consequently did not affect positive learning in their students (Gudmundsdottir, 1991; Kember, 2004). The findings in this research have further confirmed the latter view and consequently challenge the Faculty of Engineering to consider establishing the teaching and learning culture to incorporate more innovative educational and teaching development approaches that takes both academic and affective factors which have influence on students' quality of learning into consideration.

Representational Repertoire

In this theme, the main focus was based on the views held by students regarding the extent to which their lecturers selected and used a variety of representational repertoires to challenge students' previous conceptions in order to ensure meaningful learning. The variety of repertoires included, among others, the use of metaphors, examples and explanations, models and demonstrations.

There were very few responses identified for this theme amongst all the programmes. However, the few that were identified indicated that courses were perceived to be difficult because the lecturers did not select and use representational repertoires at all in their classes. Some students had reported that their lecturers did use demonstrations, graphs, models and other forms of representational repertoires; however students felt that the lecturers could not use the repertoires effectively to facilitate meaningful learning. For example, students in Chemical Engineering thought that some of their lecturers could not use models and demonstrations effectively because lecturers had limited knowledge on the subject matter. This paper did not attempt to examine comprehensively the use models and other representational repertoires by engineering lecturers. Future research could examine how varieties of representational repertoires are used in the engineering classrooms at this university.

On the contrary, students indicated that courses were perceived to be easy because lecturers used practical examples and demonstrations to teach difficult concepts. This finding indicates that there were lecturers who used representational repertoires in their classes effectively to enhance learning. The implication of this perception is that teaching in most of the classes in these programmes is still didactical, where chalk and talk is still the predominant methods of teaching hence majority of the lecturers did not use variety of representational repertoires in their classes.

Amongst the responses analysed in this theme, in almost all the programmes, the researcher observed that only a few students could describe the nature, variety and type of representational repertoires used by their lecturers. The researcher had assumed that students would describe their views using variety of repertoires such as metaphors, diagrams, graphs and demonstrations. However, taking into account that most lectures are presented through talk and chalk, it is understandable that students may have not related their perceptions about use of variety of representational repertoire due to either lack of experience and exposure to the variety of representational repertoires.

Subject Matter Knowledge

There were few responses related to this theme amongst all programmes. One striking finding revealed that students perceived some courses to be difficult because their lecturers did not know the subject matter. Their perceptions were based on the observation that some lecturers failed to explain concepts, formulae, drawings and graphs effectively, which consequently led to the students' dissatisfaction with the way concepts were taught. The lecturers probably did not know that presenting lectures, no matter how good they may look, learners would experience them differently to the lecturers' intentions because different students prefer different learning styles. This view was also shared by Mills (2002) in her observations of the engineering education environments in South Australia.

Knowledge of presentation of subject matter for teaching is an integral element of teaching knowledge. Scholars such as Magnusson, et al. (1999), De Jong (2003), Cochran, et al. (1993) and Jang (2011) seems to agree that the conceptualisation of pedagogical content knowledge in guided by intertwined elements such as, among

others, knowledge of presentations of subject matter for teaching, knowledge of instructional strategies incorporating the presentations and knowledge of the specific student conceptions and learning difficulties associated with the concepts or topics to be taught. These scholars argue that these elements function as a unit. If a teacher become skilled in only one component of PCK, there is no guaranteeing that his/her teaching will improve. The latter conception has major implications for teacher professional development programmes because the professional development models need to be approached from a holistic view, incorporating all aspects of PCK.

Due to the lack of substantial number of relevant responses in this theme, one can conclude that not many students considered the lecturers' knowledge of the subject matter to be a factor influencing how they perceived difficult and easy courses and consequently their perceptions about teaching knowledge. This was found to be an acceptable finding because students considered their lecturers to be experts in their disciplines and therefore their subject matter knowledge could not be questioned. Using her institutional knowledge and experience, the researcher could argue that the teacher-centred approach currently used at the university by the majority of the lecturers further reinforced this observation.

The use of the lecture method, though it may be relevant for teaching certain topics, has been found not to always yield good learning because in most traditional lectures, teaching is teacher centred, while students remain passive during the rest of the lecture. Previous studies (Aguire, et al., 1990; Allie, et al., 2009; Felder & Brent, 2004; Gallagher, 1989; Waghid, 2000) and revealed that the traditional teaching practice paradigm is equated with transmitting of information to the empty minds of students. The predominant use of teacher centred lectures with the purpose of disseminating information conflicts with the role of a lecturer as a facilitator of learning and student support provider (Murray & Macdonald, 1997). Under the paradigm shift of constructivism, science and technology teachers must teach in ways that actively engage their students (Shepstone, 2009; Treagust, et al. 1996; Yager, 2000).

Most of the teachers in the Faculty of Engineering at the university are recruited from industry and thus lack teaching qualifications and teaching experience. Their recruitment is usually based on their expertise in subject knowledge and industrial

experience. Because of this kind of recruitment culture in the vocational or career-focussed tertiary institutions such as the technical universities and colleges, the lecturers see themselves as technical trainers in their subject fields, and are sometimes less concerned about using best practices in teaching. Brent and Felder (2003) also reported similar findings in their studies in engineering education in the USA. Shepstone (2009) argue that it is the nature of the vocational training in engineering, which makes lecturers to perceive themselves as trainers of engineers. It is assumed that since they are experts in their fields, they will automatically become experts in teaching. However, extensive scholarly work has shown that subject knowledge only, without relevant teaching knowledge associated with the subject content cannot always lead to meaningful facilitation of learning. De Jong (2003) argue that an educator, who is only knowledgeable about the subject content, may not necessarily be knowledgeable about pedagogical content. If such a teacher is not made aware about this dichotomy, he or she may be frustrated by the poor performance of students.

Knowledge of Student Understanding

This theme related to how students perceived the lecturers' teaching knowledge regarding knowledge of various ways and approaches of assessing and evaluating student understanding of the engineering content taught in class. There were no responses from students in the Architecture and Building Science Programmes. The most common perceptions identified among the Chemical, Civil, Mechanical and Electrical programmes for courses perceived to be difficult were;

1. Lecturers used simple examples in the lectures but set unfair difficult tests and examination questions

2. Teaching approaches and examples used in classes differed with assessment practices.

3. Lecturers could not explain clearly the various approaches and strategies taken to solve problems

4. Lecturers marked only the final answer in a mathematical problem and did not give credit to the steps taken in solving the problems

These four perceptions indicate an existence of a conflict between students' expectations about assessment and the lecturers' assessment practices. The first three perceptions relates to a conflict about how lecturers teach and how they constructed questions in tests and examinations. Students felt that the assessment approaches differed with the teaching approaches that were used in class, hence assessments were labelled unfair and difficult. For example, some students in the Civil, Chemical and Electrical Engineering programmes reported that their lecturers used simple examples in class but presented difficult questions in the tests. These three perceptions demonstrate that the teaching methods and approaches used by lecturers in the classes were not compatible with the assessment practices. If assessment and teaching strategies and methods are in conflict with one another, students would perceive assessment processes negatively. For example, the responses; 'I understand lectures and tutorials but experienced difficulties in understanding tests and exams' and 'lecturers asked vague and complicated questions not related to the work taught in class' confirms the existence of the assessment and teaching conflict.

The first three perceptions are also indicative of concerns about issues of transparency or lack of shared understanding of assessment criteria and learning outcomes by staff and students in the various programmes. The third and the fourth categories of perceptions related to problem solving skills. It would seem that the students in these programmes had conceptual difficulties regarding their competencies in problem solving. They expected their lecturers to guide them step by step on how the mathematical calculations are done. This finding supports the students' revelations about their learning problems as a consequence of their weaknesses in prior knowledge in science and mathematics which was reported in the previous sections.

On the other hand, these negative perceptions on problem solving, further revealed that some lecturers, though they are expects in the subjects or content could have a limited knowledge of a variety of instructional and representational repertoires which could be used to teach problem- solving to undergraduate students, especially in the engineering content that are perceived to be difficult and complex. Maloney (1994) found that experts and novices used different approaches to problem solving. Experts utilised global approaches and strategies whereas novice students used formulae and

equations memorised in problem solving processes by simply plugging in the known variables while trying to solve the unknown. Hence it is understandable why students in this study were dissatisfied with their lecturers' problem-solving teaching strategies as well as the type of numerical tasks constructed for tests and examinations. These findings raise serious implications for teaching for conceptual and meaningful understanding of problem solving in engineering programmes.

The second argument regarding these conflicts is that students' learning styles were incompatible with the lecturers' methods of teaching and assessment. This assertion implies that the resulting consequences would be that lecturers did not have an understanding of how their students learn and consequently affecting how they assess students' understanding of the content taught in class.

The findings confirmed that lecturers whose pedagogical content knowledge is deficient in the domains of teaching approaches and strategies and assessment may not easily recognise that their students' learning problems could be a result of the conflicting relationship between teaching methods and assessment practices and students' learning styles. Furthermore, due to their limitations in pedagogical knowledge domains, these lecturers may not be aware of their students' learning difficulties. This view is shared by scholars in pedagogical content knowledge such as Jang (2011) who reported that following professional development in PCK, the Physics lecturer at a university was able to understand students' prior conceptions of the subject matter and learning difficulties. This further helped the lecturer to change the instructional strategies accordingly.

Other Curricular Issues

While this theme did not constitute the focus of this study, its inclusion was found to provide some insight into teaching and learning issues identified in the study. Hence the thesis has not attempted to examine the issues reported here in further detail. The most common and significant perceptions and learning difficulties identified in this theme were:

1.   Lack of prior knowledge and skills in science, mathematics and engineering affected achievement and success

2. Nature of the curriculum: The content of the engineering topics were full of abstract theory and mathematical applications which were too complex to understand

3. Nature of the curriculum: Students preferred to learn factual content rather than content with many formulae and mathematical calculations

4. Conceptual difficulties in understanding graphs and formulae

5. Lack of generic skills such as critical analysis, and problem-solving

Prior knowledge is important in teaching and learning. Lack of prior knowledge in fundamental concepts in science and mathematics was raised by students as another reason why they perceived some courses in engineering to be difficult. The students' ability and preparedness to engage with conceptual knowledge in engineering courses were also identified as reasons for perceiving courses as either difficult or easy. Some of these descriptions are therefore important key factors in providing insights into students' understanding of their teachers' knowledge.

The existence of the perception 1 above indicates that these students were not properly prepared cognitively to cope with new complex content in higher education classes. Fundamental prior knowledge and skills are important aspect of successful learning. The constructivist approach to teaching and learning regards diagnosis of students' level of prior knowledge as a starting point in every lesson (Treagust, et al. 1996). Diagnosing students' level of prior knowledge is a skill that that is part of the lecturers' pedagogical content knowledge. The students' perception about their own lack of prior knowledge suggests that their lecturers did not consider their weaknesses in prior knowledge during teaching in their classes. According to Shulman (1986), a teacher with sufficient pedagogical content knowledge will understand what makes learning of specific concepts easy or difficult. The pedagogical content knowing model by Cochran (1997) describes and acknowledges the positive relationship between knowledge of student understanding with that of teacher knowledge. Cochran (1997) argues that knowledge of students' abilities, and learning strategies and prior knowledge of concepts to be taught differentiates teachers from subject matter experts. This implies that lecturers should consider prior conceptions and learning difficulties that students bring into the classroom and

therefore plans and selects pedagogical strategies that will challenge the students' prior knowledge.

Perceptions 2, 3, 4 and 5 are closely interrelated and therefore are discussed together in this section. Many students perceived courses to be difficult due to the theoretical and abstract nature of the curriculum content. They became overwhelmed with the abstract nature of the content and the teaching approaches that were used to teach it. The fact that the engineering content has many mathematical applications became an additional barrier to learning. For example, the responses courses contained abstract theory involving complex numerical calculations and courses were taught in an uninteresting way were found to be prominent. These comments indicate that the teaching strategies used by the lecturers to teach the engineering content were not compatible with the approaches and styles the students use to learn. The lecturers who taught courses perceived to be difficult may have insufficient knowledge and understanding about how their students learn the engineering content, especially if the engineering content is embedded in abstract theoretical and mathematical calculations format.

In order for students to learn problem solving, teaching would require that the learning environment should be interactive. Teaching approaches which embed problem-solving as a learning strategy can provide students with opportunities to enhance their thinking and numerical skills and clarify the content they are having conceptual difficulties with.

Positive perceptions about courses considered easy to learn further revealed that the some students were more comfortable with the content which had less abstract content, was practically- oriented and had close association with life experiences became a positive factor in determining students' success and in the programme. According to students, the abstract and theoretical nature of the content did not often relate well with their practical view of the profession in their everyday life experiences.

These perceptions are an indication that students preferred to learn content that had less mathematical applications. This assertion is supported by some students' preferences to learn content that had less mathematical applications and more factual

content. However, there were students who preferred courses with more mathematical calculations than heavy textual content. These opposing perceptions about students' learning preferences show that a relationship exists between the nature of the engineering content and students' learning styles.

The perceptions and learning preferences identified in the study challenge lecturers to use a greater variety of pedagogical strategies and have enhanced instructional and representational repertoires that could reach out to all students with different learning style preferences. Consequently, more students would find the mathematical applications in engineering content more interesting to learn.

Another argument is that students related their learning style preferences to the content due to their own weaknesses and strengths in generic skills such as analytical and problem-solving skills. Those students with well-developed skills would find the mathematical applications more interesting while the lower achieving students would prefer content which promoted memorisation of factual content.

The emergence of the fourth perception about lack of understanding of graphs and formulae further indicates the conceptual difficulties that students encountered when learning engineering content inherent with graphs and applied mathematical formulae. This perception clearly demonstrates that a lack of prior knowledge and poor academic training in mathematical skills and interpretation of graphs leads to poor understanding of more complex content in engineering. The occurrence of this perception implies that the lecturers might have limited pedagogical content knowledge to identify and understand students learning problems associated graphs.

A lecturer who uses representational repertoires such as graphs and models without taking into consideration the prior knowledge and competence of students in comprehending the use of representations in engineering education is likely to have his/her students experiencing this type of conceptual difficulties. The implication about the negative perceptions about the use of representational repertoires such as graphs and models goes beyond students' conceptual difficulties to include problems in the curriculum design of programmes and how engineering content is being taught. Therefore these findings have implications on how the curriculum is structured to enhance students learning experiences.

This section has presented a myriad of concerns and learning difficulties students experienced in engineering classrooms. In addition it raised implications of the students learning difficulties on the lecturers teaching knowledge. A logical start would require that lecturers should improve their pedagogical content knowledge to be able to explore and use a variety of subject specific pedagogical strategies to assist the students in overcoming their learning problems. Magnusson et al. (1999) argue that knowledge of students' areas of learning difficulties is an important aspect of pedagogical content knowledge. Students find some of the topics to be difficult because the concepts are very abstract or lack any connection with the students' common experiences. Some topics may be difficult because teaching is focused on problem-solving and students struggle to think effectively about the problems and to plan strategies to find solutions. Teachers should be knowledgeable about the kinds of errors that students commonly make and the types of real world experiential knowledge that they need to comprehend novel problems (Magnusson, et al., 1999). However, if lecturers did not have competencies in pedagogical content knowledge issues of this nature will persist to affect teaching and learning in the engineering classrooms.

Some of the 'other' curriculum related issues that have arisen out of the qualitative data were related to factors of affective nature. For example, 'the lecturer gets angry when we ask questions', 'I work hard because my lecturer has time for me' These findings indicates that students need a friendly environments and support for them to be motivated to learn and understanding the complex and abstract engineering content. Teacher support and friendliness are important factors in the learning environments. A friendly environment motivates students to enjoy learning.

4.6   Summary of the Chapter

This chapter presented the results and findings in response to Research Question 1. Quantitative and qualitative data were analysed to identify the perceptions that students had about their lecturers' teaching knowledge.

In response to Research Question 1.1 the results confirmed the reliability and validity of the questionnaire, SPOTK, in the engineering classrooms in this study.

The Cronbach's alpha coefficient values attained for the four scales were all above 0.70.

In response to Research Question 1.2, first the descriptive statistics were used to analyse quantitative data on students' perceptions in the four scales of the SPOTK. The average mean scores for each of the four scales were found to be above mid-point 3, on the 5-point Likert type scale. The results suggested that students perceived their lecturers to be having good teacher knowledge on the aspects that were covered by the four teacher knowledge scales in SPOTK.

This was followed by the analysis to differentiate students' perceptions in the four scales of SPOTK according to various engineering programmes. ANOVA tests revealed a statistical significant difference in the instructional repertoire and knowledge of student understanding scales. The statistical significance differences in instructional repertoire scale were found to be contributed by Electrical, Chemical and Civil engineering scores. For the Knowledge of Students Understanding scale the statistical significance difference was contributed by Chemical and Electrical Engineering scores. This means that the students in these programmes perceived their lecturers teaching knowledge on the two scales more positive than in the other groups.

Secondly, the qualitative data on students' responses about courses perceived difficult and easy to learn revealed positive and negative views about lecturers' teaching knowledge. Students viewed lecturers teaching courses perceived to be easy as having good teaching knowledge whilst those lecturers teaching courses perceived to be difficult were viewed as lacking appropriate teaching knowledge to facilitate meaningful learning. The implications of these findings require lecturers to improve their teaching knowledge. Most of the findings associated with teaching and learning of difficult courses warrant a special teaching professional development programme which could integrate engineering content with pedagogical knowledge. In the next chapter, results and findings on the lecturers' perceptions of their own teaching knowledge, in response to Research Question 2 are presented.

CHAPTER 5

Lecturers' Perceptions of Their Teaching Knowledge

5.1   Introduction

This chapter provides an analysis of data and findings of the R*esearch Questions 2* regarding lecturers' perceptions of their own teaching knowledge. In order to explore the data and results to answer the Research Question 2 comprehensively, the research sub-questions were used to guide the analyses of results and interpretation of findings.

Research Question 2: What are lecturers' perceptions of their own teaching knowledge in engineering classrooms?

    2.5   *Are the personal teaching efficacy and teaching outcomes expectancy efficacy scales reliable for use in a higher education institution to explore perceptions of engineering lecturers on their own teaching knowledge*

    2.6   *Is there a relationship between lecturers' personal teaching efficacy beliefs and the qualifications they taught, highest qualification held by lecturers and the period when they last participated in teaching professional development activities?*

    2.7   *Is there a relationship between the lecturers' teaching outcome expectancy efficacy and the qualifications they taught, highest qualification they held and the period when they last participated in teaching professional development activities?*

    2.8   *What were the most predominant perceptions of the lecturers about their teaching knowledge?*

The results and findings presented in this chapter were computed from quantitative data captured from part A and B of the Teachers Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire (Appendix 4). The questionnaire was composed of three parts. Part A was used to collect data about the participants' background profile. Part B was composed of two teaching efficacy scales which

were extracted from the original Science Teaching Efficacy Beliefs Inventory (STEBI) questionnaire developed by Riggs and Enochs (1990). The two teaching efficacy scales, personal teaching efficacy belief (TE) and teaching outcome expectancy efficacy (OE), provided data about the lecturers' responses on their beliefs about teaching and learning knowledge. The results and findings for Part C of the questionnaire are discussed in chapter 6 of the thesis.

The lecturers responded to 14 statements on personal teaching efficacy beliefs and 11 statements on teaching outcome expectancy efficacy scales respectively. Data were analysed using the statistical package for social sciences (SPSS, 2010) software. The descriptive statistics about means, standard deviations and frequencies percentages were computed. In addition, Cronbach's alpha coefficient values were computed for the two teaching efficacy scales to measure the reliability (internal consistency) of the scales. Furthermore, the effects of interaction between the perceptions on teaching efficacy scales and the groupings of lecturers' defined by the independent demographics variables - qualifications taught by lecturers, highest qualifications held by lecturers and period of participation in professional development were explored using ANOVA tests of differences between the means of different groups.

In the next sections, the results and findings in this chapter are presented according to the relevant research sub-questions.

5.2   Response Rate and Participants Background Information

As described in chapter 3, the final questionnaire was distributed to 59 lecturers teaching in the Faculty of Engineering on the Soshanguve learning site of the university. However, only 24 questionnaires were completed and returned to the researcher. This small sample of participants posed a limitation to the statistical analysis of data. For example, there was only one lecturer from the Surveying Department who completed and returned the questionnaire. Therefore, whenever ANOVA statistics tests were computed, the data from Surveying was excluded. ANOVA statistics tests could not be run on a group composed of one person.

As indicated in Chapters 1 and 3, the university had more than 100 lecturers teaching in the Faculty of Engineering across the three learning sites. However, access to staff

on other two learning sites was difficult due to the social tension which prevailed amongst staff created by the merger of the erstwhile three institutions. Though approval for the research study was granted, there were other staff members who were not keen on participating due to the challenges described in the chapter 3. The challenges of access to some of the staff members initially earmarked for the sample of the study has been noted as a limitation to the study, especially with respect to the effects of the low response rate and small sample on the statistical data analyses. Small samples are known to create statistical analysis errors.

Table 5.1 Lecturers' response rate in terms of positions in the departments

Position	N	%
Head of department	4	16.7
Senior lecturer	2	8.3
Lecturer	15	62.5
Junior lecturer	3	12.5
Total	24	100.0

Table 5.1 shows that the response rate and profile of the participants in terms of their academic positions within the various departments in the Faculty of Engineering. The majority of the participants (62.5%) were appointed at the lectureship level whilst only a small number of respondents (8.3%) were appointed as senior lecturers.

Table 5.2 shows the descriptive statistics in terms of the profile of participants defined by gender, age and teaching experience. It is clearly evident that majority of the participants were male lecturers (95.8%) with few females (4.2%). This finding was not surprising since overall the Faculty of Engineering had largely a higher number of male lecturers than females. In some departments there were no female lecturers employed at the time of data collection for this study. The issue of gender equity would still continue to be a human resource challenge at the University for some time until a larger pool of female engineering academics had been established.

The results in Table 5.2 further show that the majority (70.8%) of the respondents were older than 30 years, with the age range of between 30 and 45 being the highest. The results further show that more than 60% of the lecturers had taught engineering for more than 5 years whilst 45% had teaching experience of more than 10 years. These findings together with other variables such as possession of teaching qualifications and the highest qualification held by lecturers (in Table 5.3) creates an assumption that lecturers with more than 5 years of teaching experience would have

stronger perceptions of their personal teaching efficacy belief than junior lecturers with much lesser years of teaching experience.

In addition, it was assumed that more senior lecturers would have stronger positive perceptions about outcomes expectancy efficacy because their strong teaching efficacy would make them more confident and enthusiastic that their teaching knowledge and efforts would yield quality student outcomes. However, this study did not attempt to investigate the association of teaching experience with perceptions about teaching knowledge.

Table 5.2 Lecturers' response rate defined by gender, age and teaching experience (N = 24)

		N	%
Gender	Male	23	95.8
	Female	1	4.2
Age (years)	Under 30	1	4.2
	30 - 45	17	70.8
	Over 45	6	25.0
Teaching experience in years	Under 2	3	12.5
	2 - 5	5	20.8
	5 - 10	5	20.8
	Over 10	11	45.8
	Total	24	100

Table 5.3 Lecturers' response rate defined by qualifications and professional development activities (N=24)

		N	%
Highest qualification	National Diploma	3	12.5
	National Higher Diploma	4	16.7
	BTech	6	25.0
	BSc	2	8.3
	BSc (Hons)	1	4.2
	Masters	8	33.3
Have formal teaching qualification	Yes	6	25.0
	No	18	75.0
Have been involved in professional development course (PD)	Yes	14	58.3
	No	10	41.7
When last participated in professional development	None	5	20.8
	12 months	7	29.2
	< 12 months	9	37.5
	monthly	3	12.5
	Total	24	100

Table 5.3 present the results about the highest qualifications held by lecturers and their period of participation in teaching professional development activities. Thirteen (53.2%) lecturers held three and four year National Diploma, and National Higher Diploma, and Bachelor of Technology, respectively, as highest qualifications. These qualifications are currently offered only by the universities of technology in South Africa. The results further show that only 12.5% of lecturers held BSc and BSc (Hons) level whilst only 33.3 % had Master degrees in engineering. BSc and BSc degrees are offered only by the traditional universities in South Africa. However, both universities of technology and traditional universities offered Master of Technology and Master of Science in Engineering degrees, respectively. For the purpose of the study, there was no differentiation in terms of the institution type where the lecturers had obtained their master degrees.

Teaching knowledge can be acquired through many avenues such as attaining a formal teaching qualification and or attending teaching professional development short courses or participating in collegial activities with peers in the department, across the faculty and external to the university. In table 5.3, the results show that only six lecturers had a qualification in teaching. Furthermore, only 14 lecturers indicated that they had participated in teaching professional development activities whilst ten lecturers indicated that they never participated in any activity. These results indicate that more than 50% of the lecturers had participated in teaching professional development activities.

Knowledge about participation in teaching knowledge professional development is very important in this study in the sense that it is one of the variables that is assumed to have a profound positive effect on the lecturers' beliefs about their own teaching knowledge and its effect on student achievement.

5.3   Response to Research Question 2.1

Research Question 2.1: Are the personal teaching efficacy and teaching outcomes expectancy efficacy scales reliable for use in a higher education institution to explore perceptions of engineering lecturers on their own teaching knowledge

Previous researchers who used this version of STEBI teaching efficacy scales (Bleicher, 2004; Kiviet, 1996; Riggs & Enochs, 1990; Thair, 1999) in science

teaching efficacy beliefs studies had advised that each time the STEBI scales were used to measure constructs related to teaching knowledge and beliefs from a different population and context, there should be tests of reliability conducted. Reliability of a scale indicates how free it is from random error (Pallant, 2011). In this study, Cronbach's alpha coefficient values for the personal teaching efficacy belief and teaching outcomes expectancy efficacy scales were computed separately. The computation of reliability coefficients values for the two teaching efficacy scales was separated in order to allow individual analysis of each scale. In the previous studies by Riggs and Enochs (1990), advised future users of the STEBI scales to analyse the reliability results of the two scales separately so that the effects of any potential influence of the other factors closely related with each of the teaching efficacy scales could be monitored.

Table 5.4 Cronbach's alpha coefficients values for the personal teaching efficacy belief and teaching outcomes expectancy efficacy scales (N=24)

Variable	Number of items	Cronbach's alpha coefficient	
		(α)	standardised item alpha (α)
Personal teaching efficacy belief (TE)	14	.82	.84
Teaching outcome expectancy efficacy (OE)	11	.73	.72

p<0.05

Cronbach's alpha coefficient values of .7 and above are generally accepted as high values to indicate the reliability level of a scale (Pallant, 2011). The Cronbach's alpha coefficients results in Table 5.4 show that two teaching efficacy scales had very high alpha coefficient values. The Cronbach's alpha coefficient value for the 14 items on the personal teaching efficacy belief scale was .82. The Cronbach's alpha coefficient value for the 11 items on the teaching outcomes expectancy efficacy scale was .73. The high magnitude of these Cronbach's alpha coefficient values indicates that the internal consistency was high for all the scales on teaching efficacy. The high reliability coefficient values confirmed that the scales were reliable for use with the sample of engineering lecturers who participated in the study. The attainment of the high reliability Cronbach's alpha coefficient values reduced the risk created by the small size of the lecturers' sample on statistical data analysis tests.

The Cronbach's alpha coefficient values of the two teaching efficacy scales in this study compared satisfactorily with the values reported in the previous studies by the initial developers and subsequent users of STEBI questionnaire respectively. Riggs and Enochs (1990) found the Cronbach's alpha coefficient values for personal science teaching efficacy belief (TE) and science outcomes expectancy efficacy (OE) scales to be .92 and .76, respectively. Kiviet (1996) reported the reliability values for TE and OE to be .87 and .82, respectively. Bleicher (2004) reported Cronbach's alpha coefficient values of .87 for TE and .72 for OE. Thair (1999) found the reliability coefficient values to be [.34 for Indonesian teachers and .82 Australian teachers] for TE scale and [.19 Indonesian Teachers and .79 for Australian Teachers] for the OE scale.

Though Thair (1999) found the Cronbach's alpha coefficient values for the Australian participants to be acceptable, caution was suggested regarding use of the below standard coefficients found for the Indonesian participants. Pallant (2011) advise that requirements for different levels of reliability are dependent on the nature and purpose of the scales. Attitude related scales were reported to produce lower reliability values (Pallant, 2011). The Cronbach's alpha coefficient values are dependent on the number of items in a scale. Items of fewer than 10, were reported to yield in some cases, small Cronbach's alpha coefficient values (Pallant, 2011) and it is for this reason that the author suggested use of mean inter-item correlations to resolve the problem of small alpha values.

5.4 Response to Research Question 2.2

Research Question 2.2: Is there a relationship between lecturers' perceptions of personal teaching efficacy beliefs and the qualifications they taught, the highest qualification they held and the period when they last participated in teaching professional development activities?

One-way analysis of variance (ANOVA) statistics test was used to determine if there was a statistically significant difference in perceptions between the different groups of lecturers. The eta^2 statistic value from ANOVA analysis indicates the amount of variance in mean scores by lecturer group memberships. ANOVA tests were calculated on the data from 23 lecturers on teaching efficacy scales. One set of data

for Surveying lecturer was deleted for the sake of running the ANOVA test because the test could not be run on a group of one person.

The independent variables used in this analysis were qualifications taught by the lecturers, the highest qualification lecturers' held and the period of participation in the professional development activities. In the following sections the results and findings of the ANOVA tests for personal teaching efficacy beliefs (TE) perceptions defined by each of the three independent variables are presented.

1. *Personal teaching efficacy belief (TE) defined by the qualifications the lecturers taught*

Table 5.5 Results for personal teaching efficacy belief scale defined by qualifications taught by lecturers (N=24)

Department	N	Average mean scores	SD	F	Eta^2
Architecture	5	4.02	0.42	0.35	0.89
Building	2	4.39	0.25		
Civil	2	4.25	0.25		
Chemical	2	4.18	1.06		
Electrical	8	4.36	0.38		
Mechanical	4	4.09	0.53		
*Surveying	1	-	-		
Total	24	4.21	0.43		

$p < 0.05$

Table 5.5 shows that when personal teaching efficacy belief scale interacted with the groups defined by the qualifications the lecturers taught the average mean scores across all the groups were above 4.0. This finding indicated that the all the groups of the lecturers had strong positive beliefs about their engineering teaching knowledge.

The ANOVA results revealed that there was no statistically significant difference (F=.35, eta^2 = 0.89) between the average mean scores of groups of lecturers in terms qualifications they taught regarding their perceptions about their personal teaching efficacy belief. Therefore, these results confirmed that the lecturers teaching in the various engineering qualifications did not vary in terms of the strengths of their perceptions about personal teaching efficacy beliefs. They all viewed their perceptions about teaching knowledge in engineering to be similar.

2. *Personal teaching efficacy belief defined by highest qualification held by lecturers*

The results in Table 5.6 show that for all the groups of lecturers defined by the highest qualification obtained, the average mean scores were above 3.5. Scores of above 3.5 indicated that the lecturers in all qualifications viewed their personal science teaching efficacy belief positively. The BTech, NHD, BSc and Masters groups all produced average mean scores of above 4, which further indicated that their perceptions on outcomes expectations were stronger than that of their colleagues. On closer inspection of the average mean scores, the lecturers with BTech qualification scored higher (mean value of 4.43) than all other qualifications. This may have suggested that lecturers with the BTech qualification viewed themselves as having stronger beliefs about their personal teaching efficacy better than their counterparts with ND, BSc, BSc (Hons) and Master qualifications

Table 5.6 Results for personal teaching efficacy belief scale defined by highest qualification held by lecturers (N=24)

Qualification	N	Average mean score	SD	F	Eta^2
National Diploma (ND)	3	3.90	0.34	.70	.63
National Higher Diploma (NHD)	4	4.30	0.15		
BTech	6	4.43	0.15		
BSc	2	4.21	0.21		
BSc (Hons)	1	3.93	-		
Masters	8	4.16	0.50		
Total	24	4.21	0.43		

p<0.05

The results for ANOVA tests, however, showed that there was no statistically significant difference [F=0.70; eta^2 = 0.63; at p< 0.05] between the various categories of qualifications. Therefore, the results confirmed that all lecturers, irrespective of their highest qualification, equally viewed their personal science teaching efficacy beliefs to be strong.

On the contrary, one would have expected that lecturers with higher qualifications such as BTech, BSc. (Hons) and Master degrees would score better than the three year qualifications, ND, NHD and BSc in terms of the assumptions of the effect of their deeper understanding of the discipline content on personal teaching efficacy beliefs. The results suggest that the highest qualifications held by the lecturers did

not make them think that their perceptions on teaching knowledge were better than their colleagues.

3. *Personal teaching efficacy belief defined by periods of participation in professional development activities*

Lecturers were asked to respond to questions about the extent to which they participated in professional development opportunities. The periods were categorised into strata of 'no participation at all', 'within twelve months', 'less than twelve months' and 'monthly'. Table 5.9 show the descriptive results of the interaction of the personal science teaching efficacy belief scale with the various strata of periods of participation in professional development.

Table 5.7 Results on personal teaching efficacy belief defined by periods of participation in professional development activities (N=24)

Period of participation	N	Average mean scores	SD	F	Eta^2
none	5	4.17	.54	1.05	.34
12 months	7	3.99	.50		
< 12 months	9	4.35	.34		
monthly	3	4.38	.18		
Total	24	4.21	.43		

$p < 0.05$

The results in Table 5.7 show that the mean score for participation on a monthly basis was higher than other strata of periods of participation in professional development activities whilst the stratum of 12 months participation received the lowest scores. Though in all the categories, lecturers responded positively to participation in professional development, there was a high score of 4.17 for 'no participation' in professional development activities. This observation was interesting and raised questions about why would lecturers who never participated in professional development activities seem to feel more positive about their teaching abilities than those who have participated in professional development activities more frequently? Furthermore, this finding raises questions as to how the five lecturers enhanced their teaching knowledge if they did not participate in any professional development activities at all. It was also interesting to observe, from the mean scores, that lecturers who last participated in professional development for

every twelve months scored higher than those who participated more frequently in less than twelve months.

The ANOVA test revealed that there was no statistically significant difference in perceptions about personal teaching efficacy beliefs between the groups of lecturers defined by strata of periods of when they last participated in professional development activities [F=1.05;eta^2 = .34]. This finding suggests that lecturers, irrespective of their period of participation in professional development viewed their personal teaching efficacy belief to be similarly positive.

These findings raise further questions on the nature of professional development activities which the lecturers participate in and also on the impact of such activities on their teaching knowledge. The researcher had not assumed that lecturers who participated regularly in professional development would score higher than those who did not participate at all nor had minimal participation in the last twelve months. Questions requiring further inquiry in future studies would be; what is the nature of the professional development programmes the lecturers get involved in? Do the professional development activities have impact on improving teaching knowledge amongst the lecturers in engineering? What value do such activities add to their teaching practice?

5.5   Response to Research Question 2.3

Research Question 2.3: Is there a relationship between the lecturers' teaching outcomes expectancy efficacy and the qualifications they taught, highest qualification they held and the periods when they last participated in teaching professional development activities?

This section presents results and findings on the analysis of the lecturers' perceptions of teaching outcomes expectancy efficacy defined by groups of qualifications taught by lecturers, the highest qualification they held and the period when they last participated in professional development activities to enhance their teaching knowledge.

1. *Teaching outcome expectancy efficacy defined by the qualifications the lecturers taught*

Table 5.8: Results on teaching outcome expectancy efficacy defined by the qualifications taught by lecturers (N=24)

Department	N	Average mean	SD	F	Eta^2
Architecture	5	3.18	0.22	.56	.75
Building	2	3.16	1.13		
Civil	2	2.95	0.19		
Chemical	2	3.36	0.00		
Electrical	8	2.87	0.67		
Mechanical	4	3.32	0.17		
Surveying	1	2.73	-		
Total	24	3.08	0.49		

$p<0.05$

Table 5.8 presents the results of the perceptions about teaching outcomes efficacy defined by the qualifications the lecturers taught. The average item mean scores for the groups ranged between 2.73 and 3.18 across qualification groups. In addition, the total average mean was 3.08 for the all the groups further indicated that the lecturers might have slight levels of uncertainty about their beliefs in outcomes expectancy efficacy. This finding suggests that the lecturers were uncertain about the effect of their teaching effort on teaching outcomes expectancy. Uncertainty may also suggest that the lecturers were not so confident that their teaching knowledge and effort could lead to high student achievement rate.

The ANOVA results revealed that there was no statistically significant difference (F= 0.56, *eta^2*0.75) between and within the groups of qualifications taught. The results suggest that all lecturers irrespective of the qualifications they taught were equally uncertain about their perceptions on teaching outcome expectancy efficacy.

2. *Teaching outcome expectancy efficacy defined by highest qualifications held by lecturers*

The results in Table 5.9 show that the average mean scores of groups of lecturers per qualification they held ranged between 2.50 and 3.63. These low mean score values indicate some level of uncertainty and may suggest that lecturers, irrespective of their highest qualification were not positive about their perceptions on outcomes efficacy scale. These findings further suggest that the lecturers were not certain regarding the success of their students in the engineering classrooms.

Table 5.9 Results for teaching outcome expectancy efficacy scale defined by highest qualifications held by lecturers (N=24)

Qualification	N	Average mean scores	SD	F	Eta^2
National Diploma	3	3.63	0.33	2.72	0.05
National Higher Diploma	4	2.50	0.25		
BTech	6	3.09	0.14		
BSc	2	2.90	0.27		
BSc (Hons)	1	3.00	-		
Masters	8	3.20	0.17		
Total	24	3.08	0.10		

$p < 0.05$

On closer inspection on the individual categories of highest qualifications held by the lecturers, it was observed that the lectures that held the National Diploma as the highest qualification (average mean score = 3.6) had slightly positive perceptions about teaching outcomes expectations since the average mean score attained was above the midpoint of 3.0 and more closer to 4.0. The average mean scores for the National Higher Diploma and BSc were the lowest at below the midpoint – 3.0. These results suggest that lecturers who held the National Higher Diploma and BSc degree qualifications perceived teaching outcomes expectations to be more negative than the rest of their colleagues who held different qualifications.

The ANOVA results revealed that there was no statistically significant difference [F=2.72, eta^2 = 0.05] on the perceptions of lecturers' groups defined by their highest qualifications held.   From these results, one could conclude that the highest qualifications held by lecturers did not have much effect on the difference between their perceptions about the teaching outcome expectancy efficacy. All groups of lecturers irrespective of their highest qualifications shared similar uncertainty views about teaching outcome expectations within their engineering courses. The finding suggest that these lecturers had little confidence that their teaching efforts would yield high student achievement results.

3. *Teaching outcome expectancy efficacy defined by the period of participation in professional development activities*

The results in Table 5.10 show that the mean scores for teaching outcome expectancy efficacy for the all the strata of periods of participation in professional development activities were dispersed mostly around the midpoint- 3.0 which suggests that lecturers were not sure whether their teaching efforts would lead to

success in student achievement in their courses. The results further showed that the group of lecturers who never participated in professional development activities attained responded a little better than (average mean score = 3.16) those who participated on a twelve month period and monthly basis.

Table 5.10 Results for outcomes expectancy efficacy scores defined by period of participation in professional development activities (N=24)

Period of participation	N	Average mean scores	SD	F	Eta^2
none	5	3.16	.26	.11	.95
12 months	7	3.04	.46		
< 12 months	9	3.03	.48		
monthly	3	3.17	1.03		
Total	24	3.07	.49		

p<0.05

ANOVA tests revealed that there was no statistically significant difference [F=.11; eta^2 =.95] in the perceptions of the groups about teaching outcomes expectancy efficacy scores. This finding suggest that the participation in the professional development activities did not make any group of lecturers to perceive teaching outcomes expectations differently from other groups. The question arising from this finding is what kind of professional development activities did the lecturers participate in? What was the effect of such professional development activities on teaching knowledge of the lecturers with regard to their influence on motivation about expecting more positive student outcomes? These questions may require further investigation into this phenomenon.

5.6   Response to Research Question 2.4

Research Question 2.4: What were the most predominant perceptions of the lecturers about their teaching knowledge?

The lecturers' perceptions on their own teaching knowledge identified by the study have implications for improving teaching and learning in the engineering classrooms. In addition, the results may be used for future planning and design of contextualised teaching professional development programmes for engineering educators. The personal teaching efficacy scale (TE) consisted of statements which elicited perceptions about teaching knowledge. The statements measured the lecturers' level of confidence about their teaching capabilities in engineering. The

outcomes expectancy scale (OE) elicited perceptions about teacher expectations that their teaching efforts would produce good students learning outcomes. The statements in the two teaching efficacy scales were all designed to conform to the study theoretical framework on constructivist teaching and pedagogical content knowledge described in detail in chapter 2 of the thesis.

The items representing statements on the personal teaching efficacy and teaching outcomes expectancy scales were scored from 1 to 5 using the 5-point Likert scale. The lower end, 'strongly disagree' was allocated point 1 while 3 and 5 represented the midpoint and the most desirable response 'strongly agree' respectively. Therefore, the average mean scores of equal to or greater than 4 would be classified as a positive whilst any score equal to or below 2 would be classified as negative.

Table 5.11 Descriptive statistics for the personal teaching efficacy and teaching outcomes expectancy efficacy scales (N=24)

Scale	Number of items	Sum-total mean	SD	item mean	SD	min	max
Personal teaching efficacy belief (TE)	14	58.99	6.05	4.10	0.38	47	69
Teaching outcome expectancy (OE)	11	33.87	5.48	3.14	0.48	22	44

The results in Table 5.11 show that the average item mean score for personal teaching efficacy belief (TE) scale was 4.10. The mean score of 4.10 indicates that the lecturers were very positive about their teaching efficacy. This finding suggests that the lecturers perceived their teaching knowledge in their engineering classrooms to be good and strong. The finding further implies that lecturers believed that they have the competence to teach engineering courses effectively.

The results for the teaching outcome expectancy (OE) scale in Table 5.11 show that the average mean score of 3.14 was slightly above midpoint. The results suggest that the lecturers were uncertain about the effect of their teaching knowledge and effort on student outcomes. The finding suggests that the lecturers had a lower expectation that their students would succeed well in the courses or subjects they were teaching. Previous studies by Riggs and Enochs (1990), Kiviet (1996), Thair (1999) and Bleicher (2004) had reported similar findings where the average mean scores of TE scale was higher than the OE scale.

The individual item analysis results in Table 5.12 show that lecturers' perceptions about their teaching knowledge were very strong. This is depicted by the high average mean scores of above 4 for all TE items with the exception of B6, which attracted lower responses. The high average mean scores of TE suggest that the engineering lecturers were very confident about their teaching abilities in the engineering classrooms.

However, the average mean score of 3.6 for item B6 was not consistent with other related items in TE scale. The statement required lecturers to agree or disagree about teaching competences such as knowledge of strategies to teach engineering concepts more effectively. The results revealed that the lecturers were slightly positive about their teaching knowledge to teach engineering concepts effectively. This finding suggests that lecturers were not as confident when so confident that their teaching approaches were effective.

Another interesting finding which seems to contradict the overall positive findings on the lecturers' perceptions about their teaching knowledge is the results for item B18 and B24. In both these items, the average mean scores were 4.29 and 4.04 respectively. The results suggest that the lecturers were in agreement that they did not know how to help students who experienced learning difficulties with engineering concepts. In addition, they did not know how to motivate their students to learn better in engineering. Perhaps these lecturers did not understand the statements or they may not have considered motivating students and assisting them to understand engineering concepts as an important key aspect in their role as educators.

Table 5.12 Results on individual item responses about perceptions of personal teaching efficacy belief scale (N=24)

Scale	Item	Statements	Mean	SD
TE	B2	I am continually finding better ways to teach engineering	4.29	.46
TE	B3	Even if I try hard I do not teach engineering well	4.33	.87
TE	B6	I know the steps to teach engineering concepts effectively	3.62	.65
TE	B7	I generally teach engineering ineffectively	4.00	1.22
TE	B11	I understand engineering concepts well enough to be effective in teaching	4.17	1.01
TE	B14	I find it difficult to explain to students why experiments work	4.46	.66
TE	B15	I am typically able to answer students engineering questions	4.25	.89
TE	B16	I wonder if I have the necessary skills to teach engineering	4.29	.99
TE	B18	When a student has difficulty understanding an engineering concept, I am usually at loss as to how to help the student understand it better	4.29	.55
TE	B19	I would not invite colleagues to evaluate my teaching	4.08	.92
TE	B20	I usually help the students who have difficulty in understanding engineering better	4.25	.44
TE	B21	When teaching engineering I usually welcome students' questions	4.60	.48
TE	B22	I do not know what to do to motivate students to learn engineering	4.29	.69
TE	B24	I do not know what to do to turn students on to engineering	4.04	.80
		Scale average	4.10	.38

This finding has implications in terms of the lecturers' understanding of what teaching knowledge is and its role in facilitating effective teaching and learning for the benefit of students. Being able to motivate students and to assist them to understand content is a critical feature of pedagogical content knowledge domain.

In contrast, Table 5.13 show that all the items in Teaching Outcomes Expectancy Efficacy scale had average mean scores below 4. This finding suggests that lecturers were not positive about their expectations of student achievements. Even though the results in Table 5.13 show that there were items which received slightly positive responses, there was a striking observation where six items out of eleven had very low scores of between 2.0 and 3.0. Items B5 and B10 received average mean scores of below 3.0. The responses on Item B5, showed that lecturers disagreed that students underachievement had any association with ineffective teaching methods. This finding further confirmed that lecturers believed that their teaching knowledge was good and therefore when a student was not doing well, it had nothing to do with teaching methods used in the classroom.

Table 5.13 Results on individual item responses about perceptions of teaching outcomes expectancy efficacy (N=24)

Scale	Item	Statements	Mean	SD
OE	B1	When a student does better than usual in engineering it is often because the lecturer has exerted a little extra effort	3.60	.70
OE	B4	When the engineering marks of students improve it is often due to a more effective teaching approach	3.63	.87
OE	B5	If students are underachieving in engineering it is most likely due to ineffective teaching	2.50	1.02
OE	B8	The inadequacy of student's engineering background can be overcome by good teaching	3.5	1.18
OE	B9	When the low achieving student progress in engineering it is usually due to extra attention given by the lecturer	3.79	.88
OE	B10	The low engineering achievement of some students cannot be blamed on their lecturers	2.04	.75
OE	B12	Increased effort in engineering teaching produces little change in some students' achievement	2.65	1.00
OE	B13	If a student is showing more interest in engineering it is probably due to the performance of the lecturer	3.38	.77
OE	B17	Effectiveness in engineering teaching has little influence on the achievement of students with low motivation	2.52	1.17
OE	B23	Even lecturers with good engineering teaching abilities cannot help some students to learn engineering	2.62	1.17
OE	B25	Students' achievement in science is directly related to their teacher's effectiveness in science teaching	3.63	.82
		Scale average	3.14	.48

This finding is further supported by the results of item B10. The lecturers disagreed (average mean scores = 2.04) that the low students' achievement was associated with the lecturers' teaching competence. These two findings suggest that the lecturers in this study did not believe that their teaching approaches could lead to student underachievement and lack of motivation to learn. These findings further suggest that the lecturers might have limited teaching knowledge in terms of knowledge of student understanding. Therefore, they were unable to realise that teaching approaches used in class may contribute towards emergence of students learning difficulties and demotivation to learn.

The low average mean scores for the Outcomes Expectancy efficacy scale further suggests that lecturers were slightly negative about the effect of their teaching effort on student outcomes because they believed that they had no control on student learning. This finding suggest that lecturers who believe that they had no control on student learning displayed low levels of teaching outcomes efficacy with regard their own expectations and student motivation.

5.7 Summary of Findings on Perceptions about Teaching Knowledge

The results revealed that the Personal Teaching Efficacy Belief (TE) and Teaching Outcomes Expectancy Efficacy (OE) scales used in the sample of this study produced Cronbach's alpha coefficient values of between .80 and .70 for TE and OE respectively. This finding upheld the previous reliability results of the two teaching efficacy scales reported in science teaching efficacy studies. It further confirmed that the two teaching efficacy scales were reliable for use in engineering classrooms at a higher education institution.

The results of the ANOVA test of differences between the mean scores of engineering lecturers groups produced the eta^2 values which were above 0.05 when the statistical significance level was set at $p < 0.005$. ANOVA tests results revealed that there was no statistically significant difference between the means of the various groups of lecturers when their perceptions on TE and OE were defined by the qualifications they taught, highest qualification they held and the period of participation in professional development activities.

The ANOVA findings eliminated the assumption that lecturers with the highest teaching qualifications such as BSc (Hons) and Master degrees would have stronger personal teaching efficacy beliefs and outcomes expectancy efficacy perceptions than their counter parts with National Diploma and National Higher Diploma. The assumption was based on the belief that senior degrees would provide the lecturers with deeper and wider scope of content knowledge in engineering than their counter parts. Consequently, deeper knowledge of the discipline would assist the lecturers to know better how to teach the engineering concepts. However, the results had proved that acquiring a higher qualification in a discipline does not always make one a good teacher. A combination of the discipline expertise and pedagogical knowledge makes a good teacher.

A question which arose at the conception of the study (described in Chapter 1) was whether acquiring the highest qualification in engineering would increase the level of positive perceptions about teaching knowledge and skills amongst lecturers? The results had revealed that in this sample of engineering lecturers, the highest qualifications did not have any different effect on their perceptions about personal

teaching efficacy belief and teaching outcome expectancy efficacy. This finding is not surprising since Burn (2007) also reported that even some professors and other senior academics in universities in the UK were found to be having low teaching knowledge, an observation she regarded as crucial for stimulating participation in teaching professional development activities.

Secondly, one would have assumed that participation in professional development activities would enhance the lecturers' teaching knowledge and skills, which will in turn would make would the lecturers have strong and positive opinions about the impact of their teaching on student achievement. However, the findings revealed that participation in professional development activities did not make any difference in terms of the perceptions of lecturers about personal teaching efficacy beliefs and teaching outcomes expectancy efficacy. The question arising is that why should lecturers participate in professional development if it is not going to make any difference in their teaching and outcomes expectation efficacy? What is the nature of the professional development programmes in terms of addressing the teaching knowledge needs of the lecturers?

The descriptive results revealed that personal teaching efficacy belief (TE) scale received average mean score values of higher than 4.0. The results suggest that the lecturers, irrespective of qualifications they taught, or highest qualifications they held, and periods of participation in professional development perceived their personal teaching efficacy beliefs positively. This finding further suggests that the high TE scores demonstrated that all lecturers held strong positive views about their teaching knowledge experiences in engineering.

In contrast, the average mean scores for the teaching outcomes expectancy efficacy (OE) scale were found to be mostly distributed around 2.0 and 3.5. This finding suggests that there was a level of negativity and uncertainty amongst the lecturers regarding their perceptions about their teaching expectations and their relationship to student achievement. This finding implied that the lecturers did not have confidence that their teaching knowledge and efforts, no matter how strong and positive they were, would not yield very positive student achievement results.

These findings may suggest that the lecturers, even though they were positive about their teaching efforts, they did not have high self-assurance that their teaching effort would yield successful student outcomes. These findings confirm what has been reported in literature regarding the results of the two teaching efficacy scales. Riggs and Enochs (1990) reported that the lower mean scores and reliability coefficients on teaching outcomes expectancy efficacy scale might be due to the contribution of multiple factors beyond teachers control such as inadequacy of students' science background and low motivation of students towards learning. Therefore, such variables may have affected the lecturers in various ways not to have a high confidence that their teaching efforts may culminate in high student success rate.

5.8   Summary of Chapter

In this chapter, lecturers' data from the quantitative analysis of the two teaching efficacy scales adapted from the original STEBI questionnaire developed by Riggs and Enochs (1990) were described and followed by the interpretation of the findings.

Cronbach's alpha coefficient values indicated that the teaching efficacy scales were reliable. The ANOVA test showed that the lecturers' biographical profiles with respect to the engineering qualifications they taught, the highest qualification they held and participation in professional development did not have any effect on the differences in perceptions about personal teaching efficacy and teaching outcomes expectation efficacy. This result confirmed that for the sample of lecturers used in this study, the three independent variables about biographical information did not have any statistically significant differences in how they perceived their teaching knowledge.

The descriptive results revealed that lecturers' views on teaching knowledge varied in terms of their beliefs between personal teaching efficacy and teaching outcomes expectation efficacy. There results revealed that lecturers demonstrated higher personal teaching efficacy beliefs scores. This suggested that the lecturers had positive experiences about their teaching in the engineering classrooms. In addition, the results indicated that the lecturers perceived their knowledge to be strong and positive classroom teaching practice.

On the contrary, the average mean scores for the teaching outcomes expectancy efficacy scale were found to be lower than the TE scores. Most of the lecturers' responses were clustered around the midpoint and of the response scale. The finding suggests that some lecturers were not certain whilst others were slightly negative about the effects of their teaching efforts on producing positive student outcomes.

In chapter 8, I will focus on the discussion of the major study findings from this chapter with respect to how the participants responded to the research questions and compare this with the literature reviewed. Furthermore, the discussion will explore the possibility of a link between the findings on perceptions of teaching knowledge from this chapter with the other chapters, especially 4 and 7. The findings will also be used to recommend a possible contextualised professional development framework which could be used by the engineering lecturers to enhance their teaching knowledge.

CHAPTER 6

Lecturers' Perceptions of Professional Development

6.1   Introduction

This chapter provides an analysis of data and findings in response to Research Question 3 regarding lecturers' perceptions of professional development. The results and findings presented in this chapter were computed from data obtained from part C of the *Teachers' Beliefs about Teaching and Learning in Engineering* (TBTLE) questionnaire (Appendix 4).The original professional development scale was developed by Thair (1999) in his study with Australian and Indonesian teachers. In this study, the scale was modified to ensure that the content was relevant for engineering education environment.

Research Question 3: What are the lecturers' perceptions of their professional development?

3.5   *Is the professional development scale reliable for use in a higher education institution to explore the perceptions of engineering lecturers on their professional development?*

3.6   *Is there a relationship between the professional development scale and the qualifications the lecturers taught, the highest qualifications held by lecturers and the period of participation in professional development activities?*

3.7   *What were the most predominant opinions about sources of professional development the lecturers preferred to participate in?*

Part C of the TBTLE questionnaire was composed of the professional development scale. The scale comprised of statements associated with various sources of professional development.

The main focus of Research Question 3 was to elicit the lecturers' views about sources of their teaching professional development. In order to answer the Research Question 3, the lecturers were asked to indicate their level of agreement or

disagreement with the 20 statements about professional development sources on a 5-point Likert scale. In the results, the mean scores of above 3 indicated positive level of agreement or perceptions whilst mean scores of between 2.5 and 3 indicated uncertainty whilst scores below 2 indicated strong negative perceptions.

The quantitative data from completed questionnaire were analysed using the Statistical Package for Social Sciences (SPSS, 2010) software. The descriptive statistics about means, standard deviations and frequencies percentages were computed. Cronbach's alpha coefficient values were computed to measure the internal reliability consistency for the 20 items in the scale. Furthermore, the analysis on relationship between the means scores of groups of lecturers defined by the independent biographical variables - the qualifications the lecturers taught, the highest qualification held by lecturers and period of participation in professional development activities were also explored. In order to test for the differences of perceptions between the groups of lecturers, ANOVA statistics test were conducted.

The descriptive results for the three biographical variables - qualifications being taught by lecturers, highest qualifications held by lecturers and the period of participation in professional development activities were presented in Table 5.2 in chapter 5.

Research sub-questions were used as a guide for developing and presenting in a systematic and comprehensive manner answers to the main research question. Therefore, the results and findings in this chapter are presented according to the related research sub-questions.

6.2   Response to Research Question 3.1

Research Question 3.1: Is the professional development scale reliable for use in a higher education institution to explore the perceptions of engineering lecturers on their professional development?

Table 6.1 displays the statistical analysis results for the professional development scale where it produced a high Cronbach's alpha coefficient value of .95. Therefore,

the scale was found reliable for use in terms of the constructs it was investigating amongst the engineering lecturers sample used for this study. Furthermore, the Cronbach's alpha coefficient value was found to be consistent with values reported in the previous study by Thair (1999) with a sample of Australian and Indonesian secondary school science teachers. Thair (1999) reported Cronbach's alpha coefficients of above .88 and .90 for the Indonesian and Australian, participants, respectively in the teacher professional development scale. According to Pallant (2011) Cronbach's alpha coefficient values of above 0.70 reveal a high level of internal consistency of items in a scale. This consequently makes the instrument reliable for use with the sample or population being studied.

Table 6.1 Descriptive statistics for professional development scale (N=24)

Scale	No of items	Sum-total mean	SD	Average item mean	SD	min	max	Cronbach's alpha coefficient α
Professional development	20	76.03	13.07	3.80	.65	1.60	4.80	0.95

$p<0.05$

6.3 Response to Research Question 3.2

Research Question 3.2: Is there a relationship between the professional development scale and the qualifications taught by lecturers, the highest qualifications held by lecturers and the period of participation in professional development activities?

This section presents the results and findings of the professional development scale defined by the qualifications taught by lecturers, the highest qualifications held by lecturers and the period when the lecturers last participated in professional development activities.

1. *Professional development scale defined by the qualifications taught by lecturers*

The results in Table 6.2 show that the average mean scores for all groups of lecturers per qualification they taught were higher than the midpoint-3. This finding indicates

that the lecturers perceived the professional development sources and activities represented by the statements in the questionnaire positively.

Table 6.2 Results for professional development responses defined by qualifications taught by lecturers (N=24)

Qualification	N	Average mean scores	SD	min	max	F	eta^2
Architecture	5	4.17	.25	4.00	4.59	1.37	.28
Building	2	3.50	.35	3.25	3.75		
Civil	2	3.90	.07	3.85	3.95		
Chemical	2	4.33	.17	4.20	4.45		
Electrical	8	3.39	.88	1.60	4.60		
Mechanical	4	4.09	.49	3.65	4.80		
Surveying	1	3.45	-	3.45	3.45		
Total	24	3.80	.65	1.60	4.80		

p<0.05

On closer inspection at the average mean scores for each grouping per qualification taught, it was observed that Architecture and Mechanical Engineering lecturers had stronger views on professional development than their colleagues teaching in other qualifications. However, the ANOVA statistics test revealed that there was no statistically significance difference [F= 1.37; eta^2= .28] when significance level was set at p<0.05. This suggested that the qualifications taught by lecturers did not have any differentiating effect on their responses. Therefore, all the lecturers had similar positive levels of agreement about the professional development sources they used for the enhancement of their teaching knowledge.

2. *Professional development scale defined by highest qualification held by lecturers*

The mean scores presented in Table 6.3, show that in four programme groups, the average mean scores were above 3.5. This finding indicates that, the responses above 3.5, taking into account the range between 1.60 and 4.80 suggested that the lecturers had viewed their professional development to be positive.

Table 6.3 Results for professional development defined by highest qualification held by lecturers (N=24)

Qualification	N	Average mean scores	SD	min	max	F	eta^2
National Diploma	3	4.25	.33	3.95	4.60	1.90	.15
National Higher Diploma	4	3.11	1.06	1.60	3.85		
BSc	2	3.60	.49	3.25	3.95		
BTech/BSc Hons	7	3.89	.56	3.05	4.80		
Masters	8	3.95	.42	3.25	4.59		
Total	24	3.80	.65	1.60	4.80		

$p<0.05$

However, the ANOVA test results revealed that there was no statistically significant difference between the average mean scores for the lecturers' perceptions about professional development when defined by the highest qualifications the lecturers held [F=1.90; eta^2=.15] at the statistical level set at, $p<0.05$. Therefore, all the lecturers, irrespective of their highest qualification, viewed their professional development sources similarly.

3. *Professional development scale defined by period of participation in professional development activities*

The results on perception on professional development sources defined by period of participation on professional development activities in Table 6.4 showed the overall mean score to be 3.8. This finding indicates that the lecturers viewed their professional development to be positive.

Table 6.4 Results for professional development responses defined by period of participation in professional development activities (N=24)

Period of participation in professional development	N	Average mean scores	SD	F	eta^2
none	5	4.05	.38	.50	.69
12 months	7	3.60	.99		
< 12 months	9	3.87	.40		
monthly	3	3.66	.80		
Total	24	3.80	.65		

$p<0.05$

The results further showed that the group of lecturers which never participated in professional development viewed their professional development more positively than those who participated in a period of twelve months or less than 12 months. This was an interesting observation to note. One would have assumed that those

lecturers who have participated regularly in professional development activities would score higher than the colleagues who never participated at all. This observation has implications on the effectiveness and value of professional development programmes and activities on teaching professional development of engineering lecturers.

The ANOVA test revealed that there was no statistically significant difference with regard to participation in professional development activities between the various strata of periods of participation. [F=.50; eta^2= .69]. This finding suggests that lecturers' views on professional development were similar irrespective of their period of participation in professional development activities.

6.4   Response to Research Question 3.3

Research Question 3.3: What were the most predominant opinions about sources of professional development the lecturers preferred to participate in?

This section present the results and findings of the individual analysis of all 20 items in the professional development scale. The objective was to identify the most prevalent opinions about sources and activities for professional development in response to Research Question 3.3.

The average item-mean scores results for the scale and subscales in Table 6.1 were found to be above 3.5. This finding suggests that there was a fairly positive level of agreement by all lecturers on the issues depicted by statements represented by groupings of items in the main scale and its subscales.

Table 6.5 Results for the individual item responses on professional development sources (N=24)

Professional development statements		Item average mean score	SD	min	max
C1	Talking with other lecturers	3.75	1.11	1.00	5.00
C2	Reading education material	3.54	1.25	1.00	5.00
C3	Reading scientific and engineering material	4.00	.83	1.00	5.00
C4	Listening to a lecture	3.75	.89	1.00	5.00
C5	Trying out new teaching activities	3.87	.79	1.00	5.00
C6	Acquiring new ideas for teaching	3.95	1.08	1.00	5.00
C7	Sharing teaching resources with others	4.16	.87	1.00	5.00
C8	Having support of other lecturers	4.00	.88	1.00	5.00
C9	Attending a course	3.95	.80	2.00	5.00
C10	Thinking about what I will do in class	3.82	.87	2.00	5.00
C11	Visiting other lecturers' classes	3.50	.83	2.00	5.00
C12	Having support of my head of department or dean	3.71	.99	1.00	5.00
C13	Talking with students	3.88	.85	1.00	5.00
C14	Evaluating the success of my lessons	4.17	.87	1.00	5.00
C15	Getting feedback from other teachers	3.75	.60	2.00	5.00
C16	Writing a new teaching and learning resource or unit of work	3.33	1.12	1.00	5.00
C17	Watching another lecturer teach?	3.25	.79	2.00	5.00
C18.	Sharing problems with other lecturers	4.04	.69	2.00	5.00
C19	Analysing tests and examination results	3.70	.99	1.00	5.00
C20	Getting feedback on changes I have made to my teaching	3.87	.94	1.00	5.00
	Scale average	3.80	.65		

However, the individual item means scores in Table 6.5 showed that some statements were rated below 3.5, which indicated some level of uncertainty by the lecturers in terms of perceptions about whether topics depicted by the item statements were agreeable as good sources of professional development. For example items C16 and C17 received average mean scores of 3.33 and 3.25, respectively. Item C16 probed the lecturers' views about reviewing and writing of teaching and learning materials as an activity for improving teaching knowledge. The results show that the lecturers were uncertain about using the review and writing materials as sources for teaching knowledge development. The finding suggests that lecturers probably did not regard reflection about and the writing of teaching and learning resources as an activity that could enhance their teaching knowledge. Item C17 probed the opinions about observing other lecturers teach in their classrooms as

a source of teaching knowledge. The low responses on this item suggest that it was not common practice in the teaching and learning environment of the participants in this study that colleagues observed each other when teaching so that they could learn from each other.

The individual item means in Table6.6show that topics related reading scientific and engineering materials, sharing resources and problems with other lecturers and having support of other lecturers and evaluating the success of my lessons as sources for teaching professional development were rated highly positive (item average mean scores of 4.0 and above). At the lowermost point of the responses (item average mean scores of 3.54 and below) were writing a new teaching and learning resource or unit of work, watching another lecturer teach, visiting other lecturers' classes and reading education material respectively.

Interestingly, for items C7, C11, C17 and C18 the focus was about activities associated with culture of practicing collegiality in terms of learning and gathering teaching support from other colleagues. However, the results showed that the two sets of collegial statements were rated differently to each other. The lower scores on items that had statements about class visits; peer evaluation and observing other lecturers teach suggest that the lecturers had negative feelings about exposing their teaching practice to other colleagues. The implication of this finding is that these lecturers would not feel comfortable doing collaborative teaching. Collaborative teaching was reported in the literature (Allie, et al., 2009; Burn, 2007; SPSS, 2010) to be one of the professional development opportunities for teaching development, especially in crafting subject specific teaching knowledge, pedagogical content knowledge.

Table 6.6 provides lecturers' opinions according to frequency in percentages in terms of the most highly rated items. The most preferred sources and activities for professional development are represented by the items selected by more than 80% of the lecturers as positively agreeable. The less rated source or activity would be those that are represented by items which received less than 50% of responses as agreeable. In determining the most highly rated activity, the researcher added the percentage responses of the 'agree' and 'strongly agree' categories together per item.

Table 6.6 Results on percentage frequencies responses for individual items on perceptions of lecturers about professional development sources (N=24)

Professional development statements		Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
C1	Talking with other lecturers	8.3	4.2	12.5	54.2	20.8
C2	Reading education material	12.5	8.3	8.3	54.2	16.7
C3	Reading scientific and engineering material	4.2	-	8.3	66.7	20.8
C4	Listening to a lecture	4.2	4.2	16.7	62.5	12.5
C5	Trying out new teaching activities	4.2	-	12.5	70.8	12.5
C6	Acquiring new ideas for teaching	4.2	8.3	8.3	45.8	33.3
C7	Sharing teaching resources with others	4.2	-	4.2	58.3	33.3
C8	Having support of other lecturers	4.2	-	12.5	58.3	25.0
C9	Attending a course	-	4.2	20.8	50.0	25.0
C10	Thinking about what I will do in class	-	12.5	8.3	58.3	16.7
C11	Visiting other lecturers' classes	-	8.3	45.8	33.3	12.5
C12	Having support of my head of department or dean	4.2	4.2	29.2	41.7	20.8
C13	Talking with students	4.2	-	16.7	62.5	16.7
C14	Evaluating the success of my lessons	12.5	4.2	29.2	45.8	8.3
C15	Getting feedback from other teachers	-	4.2	20.8	70.8	4.2
C16	Writing a new teaching and learning resource or unit of work	2.5	4.2	29.2	45.8	8.3
C17	Watching another lecturer teach?	-	16.7	45.8	33.3	4.2
C18	Sharing problems with other lecturers	-	4.2	8.3	66.7	20.8
C19	Analysing tests and examination results	4.2	4.2	29.2	41.7	20.8
C20	Getting feedback on changes I have made to my teaching	4.2	4.2	12.5	54.2	20.8

The results in Table 6.6 showed that reading scientific engineering materials, trying out new activities, having support of other lecturers, were found to be the most highly rated sources and activities for professional development by majority of the lecturers (selected as agreeable and highly agreeable by more than 80% of the lecturers). The topics which were found to be moderately rated as activities for

professional development (those that were selected by 60% to 70% of participants) were 'talking with lecturers, reading education materials, listening to a lecture, acquiring new ideas for teaching, attending a course, thinking about what I will do in class, talking to students, getting feedback from other teachers, and getting feedback on changes I have made to my teaching'. The bottommost activities selected for teaching knowledge development by the participants were 'watching another lecturer teach, visiting other lecturers in classes, watching other lecturers teach, having support of my head of department, analysing tests and examinations, writing a new teaching and learning resource and evaluating success of my lectures'.

The results in Table 6.5 and Table 6.6 suggest that activities which had something to do with collegial practice such as visiting colleagues in their classrooms for observing teaching and evaluation were not highly favoured by the lecturers. The finding further indicates that lecturers in this sample may have preferred to work alone rather than participate in collegial activities such as team teaching and cooperative teaching clusters. However, the results indicate that the only teacher-teacher interaction activity rated higher by more than 50% of participants was when the lecturers preferred to work with colleagues for sharing of resources and discussing other kinds of problems.

Modern teaching development practices encourage lecturers to participate in collegial activities such as team and collaborative teaching, observing colleagues teach, peer evaluation and cooperative learning groups as best activities for teachers to learn from each other. It would have been interesting to know why these lecturers had rated such important collegial activities on teaching knowledge development so low. On the contrary, an interesting finding from the analysis of individual items response is that sharing of resources and gathering support of other lecturers were rated highly. The question which arises from this finding is what type of support did the lecturers get from colleagues, if they were not keen to visit, observe or evaluate each other's teaching in their classes? However, the investigation of these questions was outside the scope of this study.

Reading scientific and engineering materials were rated as the most predominant professional development activities by many lecturers. In the context of this

research, scientific materials would be those publications which would focus on discipline specific research other than educational materials related to teaching and learning in engineering. The finding suggests that this group of lecturers may have viewed reading educational materials as of less value to their profession than the engineering scientific materials. This finding is confirmed by literature (Burn, 2007; Coetzee-Van Rooy, 2002; Felder & Brent, 1999; Waghid, 2000; Weimer, 2007) which indicates that some engineering educators and professors in universities did not care much about improving their teaching knowledge as opposed to their interests in engineering disciplines.

6.8   Summary of Chapter

In this chapter, the results and findings from the quantitative data analysis of professional development scale in part C of the TBTLE questionnaire (Appendix 4) were presented. The Cronbach's alpha coefficient value of .95 revealed that the professional development scale was reliable. The reliability results conformed to those reported by Thair (1990). This finding confirmed that the scale was reliable to use with the sample of engineering lecturers from a higher education institution used in this study.

The high average mean score rating in the scale suggest that the lecturers were positive regarding their perceptions about using various sources and activities of professional development to enhance their teaching knowledge. Furthermore, the positive perceptions suggest that participation in professional development was regarded by lecturers as an important aspect in their quest for improving their teaching knowledge.

The highly rated sources of professional development included activities which involved support from colleagues with respect to sharing of resources, reading scientific materials, talking to students and getting feedback about teaching from students. The items which were rated low were mostly the activities associated with collegiality as a source of professional development such as peer involvement in terms of classroom visits, peer evaluation and observing other lecturers teaching. The results suggest that the engineering lecturers, though their responses show that

they agreed to using collegiality as a source of teaching professional development, in practice it would seem that they were not comfortable with involvement of their peers in classroom teaching and preferred to work in silos.

In chapter 7, the construct of professional development sources was further pursued through interviews with eight lecturers. The findings in this chapter and chapter 7 will be synthesised and compared for the purpose of establishing similarities and differences regarding the views of lecturers about their teaching knowledge professional development.

In chapter 8, the discussion of the major findings, with respect to how the lecturers responded to the research question 3 and literature reviewed is discussed. Furthermore, the discussion explored the possibility of a relationship between the findings from chapters 6 and 7 regarding the lecturers' perception about professional development. The findings will also be used to recommend possible strategies for professional development conceptual framework which could be used for enhancement of the lecturers' teaching knowledge and skills.

CHAPTER 7

Interviews with Lecturers

7.1 Introduction

This chapter report on the results and findings of interviews conducted with nine lecturers teaching in various programmes in the Faculty of Engineering. Creswell (2009) argues that problems addressed by social sciences are complex and therefore the use of one research approach or technique may not be adequate to address the complexity. Creswell (2009) suggested a combination of research techniques provide an expanded understanding of the research problems. In this study, the purpose of the interviews was to gather deeper understanding, which could have been overlooked by the quantitative questionnaire, of the perceptions of lecturers about teaching knowledge and professional development. Therefore the results on the interviews were meant to triangulate, augment and support the quantitative findings reported in Chapters 5 and 6.

Research questions answered by data from interviews:

Research question 2: What are lecturer's perceptions of their own teaching in engineering classrooms?

Research question 3: What are lecturers' perceptions of their professional development?

7.2 Approach to Interviews

The in-depth interviews were conducted a few days after the lecturers had completed the teaching knowledge questionnaire. Each of the interviews lasted for approximately one hour. The interview questions followed a semi- structured approach mainly due to the purpose of the interview session being in relation to the research questions. In addition, as suggested by Fontana and Frey (1994), the semi-structured approach offered the individual lecturers an opportunity to respond to questions regarding their perceptions of teaching knowledge and professional development in a relaxed way whilst at the same time allowed the researcher to focus on the purpose of the interview. In addition, the semi-structured approach was

selected because of its other benefits such as allowing the nature of the topics of inquiry to flow with the participants' personalities. Though the themes and questions of the interviews were defined, the interview process allows flexibility for the researcher and interviewees to probe some topics and responses in a more detailed form. In addition, the semi-structured interview approach allowed for the interview communication mode to be conversational between the researcher and the interviewee (Hancock, 1998).

Interview questions, though open-ended in nature, were structured around the teaching knowledge and professional development issues, they were however generated to be aligned with the major themes and categories of teaching knowledge and professional development as described by the conceptual theoretical framework of pedagogical content knowledge (PCK) and professional development constructs described in chapters 1 and 2. The interview question schedule is attached as appendix 5. It should be noted that the interview schedule comprised of 37 questions. However not all the 37 questions were asked to all interviewees? Common and critical questions to support research questions and teacher knowledge and professional development perceptions are marked with an asterisk in the interview schedule. The other questions were used for probing further to seek understanding and clarity on some of the responses provided by interviewees. Therefore, the analysis and format of presentation of results and findings followed the topics or issues directed by the questions marked with asterisk in the schedule. The results and findings are presented according to the same themes and categories used in the students' and lecturers' questionnaires and analysis of results in Chapters 4, 5 and 6.

The profile of the interviewees

All the lecturers had more than ten years teaching experience. Five of the interviewees had dual roles in the departments. They were lecturers as well as heads of departments. The names of the lecturers were replaced with codes which start with 'P' for the purpose of protecting their anonymity. In addition, the names of the academic departments associated with the interviewees were replaced with codes which start from letter 'A to F' in order to comply with conditions of anonymity. Table 7.1 provides a summary of the profile of the interviewees.

Table 7.1 Demographics profile of the interviewees (N=9)

Lecturer/ Data Source Code	Academic Position	Gender	Department/ Programme	Teaching experience (years)	Highest Qualification
P1	HoD	male	D	>10	MTech
P2	HoD	male	C	>10	MSc
P3	HoD	male	A	>10	MSc
P4	Senior lecturer	female	B	>10	MSc
P5	Lecturer	male	E	>10	MSc & MBA
P6	Lecturer	male	F	<10	BTech
P7	HoD	male	B	>10	MSc
P8	Lecturer	male	A	<10	BTech
P9	HoD	male	E	>10	MTech

HoD = head of department

7.3 Approach to the Interview Analysis

The data generated from the nine interviews was transcribed and quality assured. The procedure for quality assurance involved, first, the researcher listening to each tape twice, followed by the transcription of all audiotapes by the researcher. This was followed by listening and reading of the transcripts at the same time to verify correctness of the transcription process. Transcripts were sent to the interviewees for verification of content and correctness of responses. Each transcript was allocated a code representing a data source as described by Table 7.1. In addition themes were coded for easier analysis and presentation of findings. Analysis of the interview was conducted manually using the interview questions schedule as a guide for categorising data into predetermined teaching knowledge themes.

In order to analyse, interpret and understand the meaning of the qualitative data, in response to the research questions, the researcher used the inductive qualitative analysis approaches and guidance suggested by Huberman and Miles (1994) and Denzin and Lincoln (1994), and supported by (Kvale, 2007). The analysis approach suggested by Huberman and Miles (1994) has 13 steps. The steps at the beginning entails noting patterns and themes, seeing plausibility, clustering of responses by conceptual grouping, making metaphors, counting, making contrasts and comparisons, shuttling between first data level and more general categories and ending at more abstract level building of logical chain of evidence to have coherent understanding of the data set in order to make conceptual coherence with literature and findings from quantitative results. Kvale (2007) referred to this approach as ad

hoc technique on interview analysis which followed a *bricolage* analysis approach. According to Kvale (2007) a bricolage is a mixture of analytic techniques which are brought together to generate meaning of qualitative texts. A bricolage approach does not subscribe to a particular conceptual approach or discourse but uses multiplicity of approaches and theories, thus allowing the researcher to move freely between different analytic techniques in a quest to make meaning out of the data.

Though some of the themes were already predetermined, due to the open ended nature of some of the interview questions and the reflective nature of the lecturers' responses, the bricolage analytical technique allowed the researcher to generate patterns and categories emerging from the data. Within the context of using this approach, thematic and content analysis techniques were found to be relevant for providing thought-out procedures to ensure that meaningful descriptions of participants were revealed. Ezzy (2002) argues that a combination of deductive (content analysis) and inductive (thematic analysis) techniques provide the researcher with an opportunity to analyse data using predetermined themes as well as allowing 'other' emerging themes to be interpreted alongside the predetermined.

The study's conceptual framework provided by the teaching knowledge models of Shulman (1987) and Grossman (1990), discussed in detail in chapter 2, on pedagogical content knowledge (PCK) provided guidance in terms of analysing and interpreting the interview responses. Based on the PCK model, the constructs pursued by the interviews were classified into broad categories or areas of teaching, learning and professional development. These broad categories were further divided into themes, categories and sub-categories in order to analyse and cluster systematically the lecturers' responses. The various teaching knowledge scales of the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire and the lecturer's questionnaire on Teacher Beliefs about Teaching and Learning in Engineering (TBTLE) served as themes within the three broad categories. Other teaching, learning and professional development related themes and categories which emerged during data analysis and could not fit into the predetermined themes were classified as either 'curriculum knowledge' or 'general pedagogical knowledge'.

The approach taken in the presentation of results in the next sections, took all the complexity of categorising the data into predetermined and emerging themes into

consideration and thus further organised the presentation into three main broad categories, namely, teaching, learning and professional development. This approach allowed the researcher to fit in all other findings which were related to teaching, student learning and professional development which were not covered by the scope of the four categories of teaching knowledge from the SPOTK and professional development scale from the lecturers' questionnaire. In addition, the approach was used as a measure not to restrict or enforce the lecturers' responses to fit only in the predetermined SPOTK and teacher questionnaire scales and categories. The results in this chapter are presented according to the research questions and predetermined teaching knowledge and professional development broad categories at the macro-level. At the micro-level, the presentation followed the topics or issues which formed the essence of the interview questions. At the end of the analysis of responses for each question or cluster of questions, a summary of findings and interpretation was generated. Learning from Grossman's (1990) approach, summaries of findings for each question were used as analytic tools in order to tie pieces of data and findings together. These summaries were compared to generate a much broader summary of each of the three broad teaching knowledge categories.

7.4 Results in Response to Research Question 2

Research question 2: What are the lecturer's perceptions of their own teaching?

This section presents the results and findings in response to research question 2 on the lecturers' perceptions about teaching knowledge. For the purpose of analysing and interpreting the responses systematically, teaching knowledge as a construct of inquiry was divided into two broad categories, viz, teaching and learning. The pedagogical content knowledge (PCK) domains which were related to the teaching and learning broad categories were instructional repertoire, representational repertoire, knowledge of student understanding and assessment and knowledge of the learner. Each of these PCK domain were used a 'basket of themes 'to cluster all related responses. Other themes and categories which emerged and fell outside the scope of the PCK domain and professional development were categorised into the new themes, - curriculum knowledge and general pedagogic knowledge.

The instructional repertoire as a domain of PCK has its focus on instructional approaches, methodologies and strategies which lecturers used to teach content in order to promote meaningful student learning. The representational repertoire focus is on how the lecturers selected and used various representational repertoires such as models, metaphors analogies and examples to make students understand concepts. The subject matter knowledge focus was based on views related to how lecturers comprehend the disciplinary knowledge to be able to use it to choose the relevant strategies and methods to teach students content in a meaningful way. The knowledge of student understanding as a PCK domain refers to perceptions about the extent to which the lecturers viewed their practice in terms of evaluating student understanding in class, selection of relevant assessment protocols, knowledge of student learning difficulties, misconceptions, how easy or difficult topics of content are, knowledge of student learning styles, prior knowledge and knowledge of student intuitive ideas.

7.4.1 Results and Findings about Perceptions of Teaching

This section presents the results and findings regarding lecturers' opinions about teaching. The PCK domains which were used as overarching themes in the analysis of responses were instructional repertoire (IR) and representational repertoire (RR). However, there were teaching related responses non-related to these themes which were identified during analyses. Such responses were matched with the relevant themes such as student learning and professional development. This approach was used for the purpose of easier interpretation and synthesis of findings.

General feelings about teaching

Lecturers were asked to talk about their general feelings about engineering teaching. This was a general question used to allow the interviewees to relax and also prepare their minds to focus on responding only to issues related to engineering teaching and learning. Therefore the responses were mostly about their general opinion on their teaching experiences in the engineering teaching and learning environment.

Analysis of the responses led to the emergence of seven themes related to teaching knowledge and professional development. The seven themes identified were professional development (PD), Instructional repertoires (IR), representational repertoires (RR), knowledge of student understanding (KSU), resources, curriculum knowledge and general pedagogy. Each of the themes was further divided into categories and subcategories. In addition, there were positive and negative responses identified in some of the categories. Positive responses are mainly those responses which revealed that participants were satisfied and enthusiastic about their teaching experiences. Negative responses are those comments which revealed dissatisfaction, demotivation or feelings of despondency about teaching in engineering.

The results and findings are presented according to the themes and their related categories and subcategories where applicable. In addition, for easier linkage of the results, findings and interpretation, the narration flows continuously from results to interpretation of findings in a form of a story.

Theme 1: Professional Development (PD)

Five responses were related to professional development domain. Three categories emerged from the five responses. The sources value of professional development in teaching knowledge advancement.

    (i)   Sources of professional development

There was a strong positive feeling from P1 that acquiring a more senior degree in his field of expertise provided him with an opportunity to acquire knowledge and confidence to teach. The following excerpt provides evidence to this finding.

> [P1, L1]…"Acquiring a higher qualification makes one a better teacher"

Another source of professional development in teaching was cited as participation in workshops and short courses. There was a feeling from P1 that the workshop sessions contributed positively towards improving teaching skills in the classroom. The following excerpt attest to this finding.

[P1, L1]... "Attending professional development courses.... shaped my teaching"

The third source of professional development which was reported to have led to improved teaching practice was identified as 'evaluation and reflection on teaching practice'. Two types of responses formed this subcategory. First, it is the evaluation and reflection conducted by the lecturer on day to day teaching activities and functions, which contributed positively toward teaching knowledge development.

[P4, L1]..."Teaching engineering is a process"

In addition, the P4 felt strongly about 'passion and talent in teaching as an occupation, as her strongest motivator and source of inspiration to enjoy teaching. She reiterated the comment about talent and passion several times during the interview. Furthermore, the same lecturer indicated that it was due to these personal intrinsic motivators that she was able to manage many of the teaching challenges she came across as an engineering educator.

[P4, L1]... "Teaching is a calling and a talent ..... not a career"

On the contrary, the third category generated from two negative responses revealed that some lecturers did not see the importance or role of PD in teaching knowledge. Professional development activities were not taken seriously. This finding confirmed what previous studies revealed about university lecturers not taking teaching development seriously, (Coetzee-Van Rooy, 2002). The following excerpt provides evidence to this finding:

[P1, L1]... "My guys (lecturers) do not think we should take teaching and learning development seriously."

The same head of department [P1] felt very strongly that the only way for engineering lecturers to improve their skills in teaching and classroom practice was to participate in PD activities. However, this comment was raised as a sentiment that all the lecturers in his department could attend courses to improve their teaching knowledge. P1 in addition felt that lack of teaching knowledge and skills was associated with teaching problems in the classroom. However, he did not elaborate on the nature of the problems. The following excerpts confirm to the findings above:

[P1, L1]... "All lecturers should attend professional development if they want to improve their teaching skills and curriculum review knowledge"

[P1, L2]..."Lack of teaching skills is a disadvantage in the classrooms"

The findings suggest that PD in teaching knowledge was viewed both positively and negatively amongst engineering lecturers who participated in the interviews. In addition, the lecturers had variance in terms of the things they regarded as their sources of professional development. Others preferred to use self-reflection and informal activities whilst others preferred more formal programmes such as workshops. In both cases, findings suggest that participation in professional development on teaching knowledge was intrinsically driven and/or stimulated by the teaching challenges lecturers met in the classroom. The perception held by one lecturer that teaching was a calling or talent and not a career, indicates a belief that teaching was an inborn trait. This notion should be challenged since the lecturer who holds this view may miss out on valuable learning opportunities from participating in PD activities such as collaboration with other colleagues and attending formal teaching development courses. Grossman (1990) argued that inherent traits such as talent in teaching as a source of teacher knowledge was a misconception. Reliance on talent was reported as a problem, particularly in gathering knowledge about student understanding and their learning styles.

Theme 2: Instructional repertoire (IR)

Two categories emerged in this theme, the 'inadequacy of teaching skills' and 'selection of teaching strategies'.

Category 1: Inadequacy of teaching strategies and skills

Two responses were associated with this category. The responses revealed that the lecturers were concerned that they did not have adequate knowledge of teaching strategies and skills, which in turn they believed had negative consequences on effective implementation of the curriculum content in the classroom. For example the following excerpt attest to this finding:

[P1, L1]... "I do not know how to teach theory and practice. Lack of teaching skills is a disadvantage in the classroom"

Category 2: Selection of teaching strategies

Lecturer P6 felt strongly that his rationale for the selection of teaching methods was determined by the nature of the qualification and the topic he was to teach. Therefore, he preferred to use the textbook in certain instances and practical sessions in others. In addition, his rationale for selection of teaching methods was based on the equipment or device they had to train the students on. The following excerpt attest to this finding:

> [P6, L1-L2]..."...the career forces you to employ certain methods of teaching. This means that the teaching methods I employ, I chop and change every day so it means that I have to use a bit of the textbook to learn (teach) theory and I have to do without textbook for a more practical........ I move from one method to another depending on what particular topic I am dealing with and whether the topic is explanations or calculations or practicals. When I switch to practical task I physically show them what they should understand...Look out methods is restricted by the type of equipment that you have your teaching..."

The use of the textbook as a teaching method was cited by P6, as his main predominant method. Though the excerpt above may suggest that P6 could have been aware of the PCK principles in selecting relevant instructional repertoire of teaching approaches in line with the content to be taught, it is evident from the selection of the textbook as his dominant teaching method that his classrooms were still very much teacher centred.

The findings in this theme, though the data generated was not representational of all participants' views, indicate that the lecturers had a limited knowledge of a variety of instructional strategies available within their subject areas to help students learn the content in a meaningful way. According to Shulman (1987) a teacher who demonstrates understanding of PCK should be able to demonstrate knowledge in planning, organising and presenting the subject matter in such a way that it is

adapted through use of appropriate instructional strategies, to meet the needs of the diverse interests of students.

Use of a textbook as a teaching method suggests that teaching in the classes of such a lecturer was still teacher centred. The finding further suggests that the lecturer would believe that teaching was about imparting knowledge. A teacher who believes in imparting knowledge is likely to use teacher –centred teaching approaches such as the textbook method. On the contrary, a teacher who believes in stimulating students to construct their own meanings about content taught would use learner-cantered teaching methods and strategies. Such a teacher would be functioning at the heart of principles of constructivism and PCK.

Theme 3: Representational Repertoire (RR)

Five responses were identified in this theme. Three responses revealed that lecturers preferred to use practical sessions and models to make students understand the subject matter. The fourth response revealed that the lecturer used 'technology' (technology meant the use of Power Point presentations and e-learning) to teach so that student could understand. The fifth response revealed that the lecturer preferred to use case studies to promote conceptual understanding in his classes. Exemplary excerpts:

> [P7, L1]...."In my classes I use technology to make students understand"

> [P5, L2 & P7, L1]..."I use practical and models to bring subject to life for students"

> [P7, L1]..."I use examples and models from industry to make students understand better

> [P8, L4]... "I use case studies in class to promote conceptual understanding and the link with industry functioning"

The findings in this theme indicate that the three lecturers who used a variety of representational repertoires in their classes were aware of the importance of choosing

the relevant and appropriate representational repertoires such as models or case studies for making students understand the subject matter. In addition, the selection of industry related case studies suggest that the approach to teaching and learning in the classrooms of these lecturers was contextualised to the professional competences that students were to demonstrate when they graduated.

Theme 4: Knowledge of student understanding (KSU)

Two categories of response were identified in this theme. There were both positive and negative responses associated with this theme. The first category, composed of two responses was related to 'knowledge about background of students and their expectations'. One lecturer thought that his teaching was informed by his knowledge of the type of learners enrolled in his programme. P7 indicated that he viewed knowledge of students' background as important in terms of the approaches and methods he selected for teaching. On the contrary, P8 felt that lack of knowledge of students' expectations of teaching and learning was a concern in terms of the quality of student learning. However, both lecturers agreed that knowledge about background of students was important in teaching.

> [P7, L1] ....."My teaching is focused on the type of student enrolled in
> the programme."

> [P8, L1]..."Teaching does not address what the learners need"

The second category in KSU was assessment approaches. Lecturer P8 felt strongly that assessment approaches and protocols they used were disjointed from teaching and learning purposes. He reported that the assessment approaches used by many lecturers in his department were not appropriate for assessing knowledge and skills in terms of the nature of the subject matter taught and the appropriate cognitive levels. The following are exemplary excerpts about the lecturers who felt that they lacked knowledge about selecting the appropriate teaching approaches and assessment methods.

> [P8, L3]..... "Teachers use poor assessment protocols which do not
> promote critical thinking and problem solving and conceptual
> understanding"

> [P8, L2]…"the type of questions we sometimes ask students such as list, give names etc, do not help students to learn critical thinking and problem- solving. I would expect teachers to use case studies instead of listing questions"

One lecturer believed that teaching in his programme was not effective in terms of providing students with their needs and expectations of teaching knowledge of student understanding and the value of engineering education in the students' career lives.

> [P8, L1] "The way teaching is taking place now is not exactly addressing what the learners need. It's a question of failing to interrelate the learning that takes place in class with industry"

Theme 5: Resources

Two responses revealed a concern regarding the inadequacy of relevant teaching resources [P5 and P2] as a factor contributing to teaching difficulties in achieving high quality student achievement outcomes. Amongst resources mentioned as inadequate were laboratories and models. Exemplary excerpt for this finding are:

> [P5, (L2)] "Lack of laboratories, models, makes teaching difficult"

> [P2, (L1)] "The problem is facilities. The state of facilities is poor"

Theme 6: Curriculum knowledge

A collection of five responses revealed that curriculum design for various learning programmes was flawed. The lecturers raised concerns about the disconnection between practical work and theory components of the curriculum. The disconnection was viewed as an obstacle towards giving students an integrated learning opportunity.

> [P3, L1; P9, L1, P8, P1] "Teaching is a challenge because theory and practice have been separated. They are taught by different people."

> [P8, L1] "Teaching does not interrelate (not integrated) learning taking place in class with industry"

In terms of the curriculum implementation structure in the faculty, lecturers only teach the theory component whilst the practical component was taught by technicians. Lecturers viewed this approach as an anomaly since technicians were not classified as academic staff. In addition, the theory taught in class at a specific period was not aligned to the practical topics or themes taught by technicians at the same period. This separation of roles and responsibilities on curriculum implementation was viewed as an obstacle towards holistic teaching and learning experience for both lecturers and students. Jang (2011) viewed curriculum implementation flaws such as the as lack of general pedagogic planning knowledge in PCK.

In addition P8 and P1 expressed strong views about lack of curriculum review skills and interest among the lecturers as a reason for the poor curriculum design in some of the learning programmes. Break down of the curriculum into semesters was viewed as a problem affecting the quality of teaching and learning. According to P9, lecturers were forced to rush and complete the syllabus before the end of semester. Accordingly, the fast-tracking of the syllabus led to some students to experience learning problems. Exemplary excerpt:

> [P9]… "Semesterisation of the curriculum forces lecturers to rush through the curriculum leaving behind certain students without having grasped the content in a meaningful way".

Integration flaws in the theory and practical components of the curriculum and its implementation plan were viewed by some lecturers as a source of problems in teaching and learning. Lecturers also associated weaknesses in the curriculum design with lack of curriculum review knowledge amongst many of the engineering lecturers. This was a reason why generally some programme curricula were never reviewed to resolve the observed flaws. Many lecturers were not able to resolve teaching problems associated with a flawed curriculum design. According to Shulman (1987), curriculum knowledge is a 'tool for trade' for teachers. Curriculum knowledge provides teachers with the skills to understand the design and development of program of study and associated teaching and learning materials. In addition, the knowledge gives the teachers the edge to be able to evaluate the effectiveness of the curriculum amongst other curricular matters.

Theme 7: General pedagogy

Two responses revealed that some lecturers viewed the purpose of teaching as imparting knowledge [P4 and P9]. This view of purpose of teaching, as opposed to facilitation of learning, differed from views held by proponents of meaningful learning, such as social constructivist who viewed teaching as an active process shared between the teacher and students as they engage in meaning formation from concepts taught. The finding suggests that lecturers' opinions about purpose of teaching differed from purpose and objectives of teaching as described by the principles of PCK. An exemplary excerpt

> [P4,L1: P9,L1]..."Role of engineering educator is to impart
> knowledge"

This view of the purpose of teaching may influence the lecturers to select teaching strategies which may be aligned with teacher centred approaches to 'training". Waghid (2000) referred to imparting of knowledge as a behaviourist approach to teaching, which consider the student as empty minded and thus requiring the teacher to fill his mind with knowledge. The finding confirms what was reported in literature that some engineering educators viewed purpose of teaching as 'training of engineers' rather than facilitation of learning (Coetzee-Van Rooy, 2002; Jang, 2011; Waghid, 2000).

P9 felt that some lecturers were overloaded with teaching responsibilities, whilst others barely completed minimum load on teaching responsibilities. According to P9, workload distribution and level of commitment by lecturers on teaching responsibilities had effect on the quality of teaching and learning. This lecturer was despondent about his experience of teaching in engineering. Coetzee-Van Rooy (2002) referred to this feeling of despondency as 'disengagement' from core academic business and the institution. Exemplary excerpt:

> [P9] … "Teaching involves more work and takes time out of the
> teacher. It requires dedication. Other colleagues just do bare minimum
> of teaching responsibilities"

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Seven themes were found to be underlying views about teaching in engineering. There were both positive and negative opinions on issues related to some of the identified themes and related categories. This finding indicates that the lecturers perceived their teaching experiences in engineering both positively and negatively. For instance there were positive responses about the value of attending professional development and subsequent positive effect it had on their teaching experience in the classroom. In addition, the findings suggest that the lecturers were aware of their limitations in terms of teaching knowledge, especially with respect to in instructional repertoire, representational repertoire and knowledge of students understanding and the impact the shortcomings had on the overall quality of teaching and learning.

From the responses, and findings reported here it is apparent that the lecturers' feelings about teaching experiences varied. There were revelations which indicated that they had limitations in terms of effective skills in teaching such as knowledge and selection of appropriate teaching approaches and strategies. These limitations led to some of the lecturers believing that their teaching was not effective. Lack of curriculum review knowledge was cited as a shortcoming. Hence though they were aware of the flaws in the curricula, they felt despondent that there was nothing they could do to resolve the problem due to lack of curriculum review knowledge. Lecturers had general feelings of despondency towards teaching due to heavy teaching loads and the rush to complete the curriculum syllabus before end of the semester. This was viewed as a possible factor which could have negative effect the quality of teaching in engineering learning environments.

Introducing a new teaching activity

Lecturers were asked if they would be concerned about what their colleagues would say if they introduced a new activity. The main focus of this question was two-fold. First, the question probed views about working collaboratively on selecting teaching activities which promoted interest of their students. Secondly, it probed the type of activities lecturers selected to promote student learning. Therefore, the overarching theme for analysing the responses was the representational repertoire (RR).
The results revealed that three lecturers indicated that there was no collaboration between the lecturers. Therefore they would not be concerned that their colleagues

were using the same activity or not. This finding may suggest that there are no collegial activities to share ideas and knowledge on teaching knowledge. The following excerpts provide support to this finding.

> [P6, L;   P8, L8]..."No. There is no collaboration between lecturers
> who teach in the same Diploma (programme)"

> [P4].... "Engineering lecturers do not work as a team"

On the contrary, three other lecturers indicated that there was collaboration amongst lecturers. However, their approach and practice on collaborative activities varied. One lecturer indicated that collaboration with colleagues on teaching activities and approaches was dependent on the topics to be taught. In some cases he would chose activities according to the needs of the students without checking with colleagues. The other two lecturers agreed that they would be concerned if their colleagues were not involved in the selection of teaching activities. Their most common reason was that collaboration was so important to ensure consistency and equity of delivery of curriculum objectives amongst all the lecturers to avoid students' complaints.

Another reason sighted as important in collaboration was that colleagues shared similar teaching aids. This finding confirmed those in chapter 6 where the mean score of the professional development source items on collegiality regarding sharing of resources with colleagues was rated very high.

> [P3, L3; P1, L7]... "Yes. We use a lot of models in our teaching
> which must be shared amongst all lectures. Students must be exposed
> to similar approaches to teaching. Otherwise students will complain
> that teacher X is better than teacher Y"

The findings suggest that there is an element of collaboration amongst some lecturers used for sharing the use of teaching aids and also for ensuring consistency/uniformity of teaching in terms of the teaching activities, content and approach to teaching. The main purpose of the collaboration efforts was reported to be provision of equitable experiences and learning opportunities for students. Hence, lecturers felt that they needed to have common agreement about the type of teaching

activities used in class. In addition, collaboration activities were seen as a vehicle to encouraging lecturers to work together as a team.

On the contrary, the finding regarding lecturers who were not keen on collaborative efforts in designing teaching activities is not surprising. This finding supported the quantitative results in chapter 6. The results in chapter 6 revealed that lecturers were not positive about collegial activities such as collaborative teaching. There were more lecturers who preferred to work in silos and not as a team.

Importance of covering the teaching curriculum

The lecturers were asked if it was important to cover the teaching curriculum. This question was used to probe whether teaching purpose was content/syllabus driven or determined by knowledge of student understanding and learning outcomes. The overarching theme therefore was knowledge of student understanding with particular reference to the purpose of teaching.

All lecturers agreed that it was important to complete the syllabus. However the reasons for completion of the syllabus were three-fold. The first reason, shared by seven lecturers [P1, P2, P3, P4, P5, P8, and P9] was that for students to function effectively as engineers in the industry, they needed to know all the body of knowledge in the discipline prescribed for the qualification. These suggest that lecturers considered students' minds to be empty and thus needed to be filled with lots of information. This perception could lead to students suffering from information overload or even cause learning problems. A view shared by P6. This view in addition may encourage lecturers to adopt behaviourist's approach to teaching.

Another reason provided for supporting why completion of the content in the curriculum was important related to the large body of knowledge being a prerequisite for students to engage with the practical work in the laboratory. This view was shared by three lecturers, [P1, P3 and P7]. Accordingly, students required to know a large body of theoretical knowledge prior to conducting practicals in the laboratories. These lecturers believed that students could only engage constructively with practical work in them had substantive content knowledge in engineering. This finding may be in contradiction with the study conducted by Swart (2010). Swart

reported that it did not matter in engineering whether theory was presented first prior to practice or practice before theory. According to Swart both approaches had merits in engineering education. Their success was more dependent on a number of factors such as prior knowledge of the students and the cost of the laboratory equipment students where to use in the practical session.

Though P7 agreed that completion of the prescribed content was essential, his view about the purpose and approach for completing the syllabus was different from other lecturers. He used project oriented learning as the main teaching approach in his subject. P7 believed that students should be taught engineering content only at the time when such body of knowledge is required to solve a problem within various stages of the project. He believed that teaching too much content at a time was not meaningful to students learning since they could not apply it to solve problems at the same time.

Three lecturers [P4, P6 and P8] believed that if all the content prescribed for the undergraduate qualifications were not taught, students would graduate with insufficient theoretical knowledge. This in turn, would affect their performance and success at postgraduate level. However, P6 was concerned that the content load for one study level in his discipline was too much to complete in one year. In addition, he indicated that students experienced information overload.

Though all lecturers agreed that they believed that teaching should be about completing the syllabus or curriculum content for a specific year of study, there were however three main different views shared by lecturers regarding the importance of completing the entire syllabus or curriculum content.- accumulation of relevant theoretical knowledge to tackle the practical component, large body of knowledge required to operate effectively in industry and preparation for postgraduate education.

These opinions may suggest that lecturers viewed learning as a consequence of completing the syllabus or curriculum content. This finding suggests that knowledge about purpose of teaching, as a means to facilitate meaningful learning, was limited among all the lecturers. The finding also suggests that the teaching approaches used by many of the lecturers interviewed could be teacher centred to allow the lecturers

to complete the syllabus within reasonable time prior to end of semester examinations. This in turn may produce poor student achievement outcomes. On the contrary, constructivists would argue that effective teaching was not about completing the syllabus but was about facilitating meaningful learning to equip students with learning skills to become self-directed and lifelong learners who will not depend on the lecturers to supply them with all the content knowledge.

Influence of examinations on teaching

Lecturers were asked if examinations had any influence on their teaching approach. The focus of the question was to ascertain whether teaching in the classroom was driven by assessment protocols such as tests and examination. At the essence of this question was ascertaining views about purpose of teaching and knowledge of students understanding and learning.

The results revealed that most lecturers [P1, P2, P3, P5, P6, P7, and P9], with the exception of P4 and P8, agreed that teaching and learning in their programmes was driven by examinations. P4 and P8 felt strongly against assessment being used as a driver of teaching, especially that assessment protocols used in their programmes focussed more on testing acquisition of theory content. P4 maintained that the assessment approach used promoted rote learning rather than development of competence through practice. According to P4, achieving high marks in formal examinations did not mean that one could function as an engineer.

The following are exemplary excerpts of the two different views on the influence of examinations on their teaching**:**

> [P3]..."Exams are used to prove student readiness for the industry ...a pass is proof that a student is ready and companies can employ such students"
>
> [P7]..."Students are driven by examinations only that is why we teach".
>
> [P4]... "If I had my way, engineering should not have formal examinations. I would rather do practical examinations or oral

examinations. Students cram equations and a lot of equations come in the exams… he gets 100% in equations but knows nothing about concepts. Actually, in engineering the people with the 90% marks are not as good engineers as those who get the 60%. … the people who get 60% in class are not confined to what is happening in class. They think deeply about a problem and concepts than those who just want to pass. They are not interested in what is coming out in the exams."

[P8]. "We are doing it just to comply with policy so that if someone comes to check our work, they will find that students are being assessed... But I think the way it should be done, is to ensure that knowledge acquired would be individually perfected through practice. Good lecturers like us hate theory section because you find that the lecturer will be doing good and beautiful calculations but the learners would not understand or have clue what those beautiful calculations meant in terms of practice."

Seven lecturers believed that their teaching approach was driven by assessment because it was the only way they could measure student competence. On the contrary, P4 and P8 disagreed with the use of formal examinations in engineering. According to the two lecturers, the examination (paper and pencil versions) as currently used in the faculty did not assess students' meaningful learning but rather promoted rote learning. The two lecturers preferred other forms of assessment such as oral exams or practical exams.

The findings further suggest that there were varied views about the purpose and nature of examinations in engineering. There were those lecturers of which their teaching was driven by assessment and those who believe that teaching was about assisting the students to understand concepts and assessments were merely used as tools to assess progress and success in learning and to take appropriate action necessary to support the learners.

Furthermore, the findings suggest that some lecturers used examinations as their main purpose of teaching while others disagreed completely. In addition the findings indicate that the views shared by P1, P4 and P8 could be an indication that their outcomes expectancy efficacy was low because the current approach to assessment

through examinations did not fit well with their personal teaching efficacy on assessment and expected teaching outcomes in engineering. For them, the current approach to examinations did not assess students understanding of concepts holistically and acquisition of critical engineering skills such as problem-solving, but rather promoted rote learning.

Predominant teaching strategies used by lecturers

This question was used to elicit the lecturer's views on their most predominant teaching strategies they used in their classrooms. The focus of the question was to ascertain whether the teaching strategies were teacher centred or provided students with an opportunity to engage actively in class to encourage meaningful learning. Therefore the overarching theme for analysis of data was instructional repertoire (IR). The results revealed that four categories of teaching strategies were used by the lecturers. In addition, some lecturers indicated that they used more than one teaching strategies. This was been considered in the categorisation of responses.

Category 1: seven lecturers used traditional lectures ('chalk and talk', text book, and Power Point presentations) [P2, P3, P4, P5, P6, P7, P9].
Category 2: two lecturers used case studies from industry [P8, P9]
Category 3: Three lecturers used project oriented learning [P1, P8, and P7]
Category 4: only one lecturer used e-learning [P4]

The findings suggest that use of traditional lectures (chalk and talk, power point presentations) were the most prevalent teaching strategies used by most lecturers. This finding suggests that teaching in most of these lecturers classrooms could be teacher- centred.

On the contrary, there were other lecturers who indicated that they used learner centred teaching methodologies such as project and problem based learning and case studies related to the engineering industry. This finding suggests that such lecturers realised the importance of selecting appropriate instructional repertoires to make students understand engineering concepts better and to engage them actively in their learning process. These lecturers, I would argue, conformed to the constructivist principles of teaching and learning in their classrooms. In addition, the finding

indicates that they had reasonably good pedagogical content knowledge. For example, P1 selected teaching approaches and strategies according to the personalities of his students. This finding indicates that P1 knew the importance of aligning teaching strategies to the learning styles students used to make sense of the subject matter.

In addition, P4 also indicated that she selected her teaching strategies according to the personalities and learning styles used by her students. She categorised her students into two groups, the enthusiasts and non-enthusiasts. For enthusiasts she used more learner centred strategies such as inquiry learning. For non-enthusiasts she used traditional lectures. In addition, P4 used variety of electronic resources categorised as e-learning such as Web CT. Amongst the e-learning tools used were social media networks such as twitter and Facebook, mostly used by the youth. She felt that using the same technology as the students to communicate teaching and learning issues with students made the learning process fun. Consequently, students enjoyed learning. Exemplary excerpts:

> [P2, L8]..."Chalk and talk"

> [P7, L33]..."Most of what our lecturers are doing in mechanical engineering is still using board and chalk and also some guys are using Power Point at the end of the day"
> "I use a textbook" [P6, L1]

> [P8, L19]..." I worked in industry for 14 years. I took examples from the projects I was doing in the industry and brought it to my students"

> [P4, L32]... "Depends on the group of students I teach enthusiasts and non-enthusiasts. I try to accommodate all the students. Traditional lectures (chalkboard), PowerPoint presentations are used for non-enthusiasts while research work, investigation through mini review papers, internet searches etc. are used for enthusiastic students"

The findings indicate that in the engineering classrooms of the lecturers interviewed, two types of teaching strategies were used. There are classes where the lecturers preferred to use teacher centred teaching approaches and strategies, whilst in other

classrooms, more learner centred approaches were used. This finding suggests that students taught by these groups of lecturers experienced teaching and learning differently. Prevalence of teacher centred teaching strategies indicates that lecturers could be having a limited teaching knowledge of the possible instructional repertoire and representational repertoire available to make their teaching interesting and more meaningful to their students.

Approaches used by lecturers to help students reflect on their own learning.

Lecturers were asked to give views regarding the kind of teaching approaches they used to encourage their students to reflect on their own learning intentions, behaviour and practice, and to develop effective skills for life- long learning. The overarching theme for responses on this question was the instructional repertoire. The analysis of the responses revealed two categories of approaches used by lecturers, namely, assessment feedback and storytelling.

Five lecturers [P3, P4, P5, P8, and P9] indicated that they used post assessment feedback sessions to discuss with students how they should have responded to the test questions. [P4] indicated that in addition to post-assessment feedback, she used various learner centred teaching strategies such as investigations, storytelling and lots of homework to encourage students to reflect upon their own learning. She marked the homework tasks in class so that she could provide students with immediate feedback to help them learn and understand concepts better.

There were no responses which indicated that lecturers used variety of instructional or representational repertoires to stimulate students to think hard and reflect on their learning. This finding may suggest that teaching was still teacher centred in the classrooms of these lecturers. However, P3 was concerned that students in his class remained inactive most of the time even though he wanted them to engage him by asking more questions during feedback sessions. He felt that lack of participation by the students in his class was very frustrating.

The findings suggest that lecturers did not know any other best instructional methods available to challenge student to develop reflective practice towards their learning. Exemplary excerpts:

> [P8, L24]..."If they wrote a test, I design tests to check a number of qualities. They are given an opportunity to check how I have marked scripts. We discuss the post assessment findings in class. I explain why each problem was marked in a particular way"

> [P9, L19]..."After assessments I give feedback on how they should have approached the questions. In my teaching portfolio I make short notes as I mark students' scripts which I use to reflect on post-test discussions."

> [P3, L18]...."I take a back seat in class to allow them to ask questions. When I complete marking assignments and tests, I allow them to discuss their marks and their work. I give them feedback on what was expected of them. However, the problem is that students just keep quite. Not proactive."

> [P4, L42 – 43] ..."I give little bit of extra lessons in my subjects.....Yes I do (give homework). I expect them to do their part. They know that I mark everything and I keep record of it. ......Yes, they do (students engaging with homework). It is a lot of extra work for me but it helps the students to learn and understand concepts. When I mark it in class, I can see that this student has worked hard"

Summary of findings on perceptions about teaching approaches and strategies

The results revealed that teacher-centred teaching methods such as traditional lectures (chalk and talk) were used as the predominant teaching approaches. Learner centred instructional and representational repertoires such as cooperative learning, problem solving were not used by many lecturers in the classrooms of the participant lecturers. Traditional lectures, when combined with other teaching strategies are still acceptable. However, predominant use of the traditional lectures would mean that the lecturer would be unable to reach out and serve the diverse needs of learners in his / her classes or subject. According to Shulman (1987), a teacher functioning

within the principles of PCK would draw from a variety of repertoires on instructional and representational strategies to provide meaningful learning opportunities for students. As such, teaching was viewed as not satisfying by many of the participants. Lecturers were aware of the limitations the traditional and teacher- centred teaching approaches had on teaching outcomes; however it would seem that they did not know what to do to improve teaching in their classrooms. Hence some of the lecturers felt frustrated by the quality of student learning.

The findings suggest that lecturers had limited teaching knowledge and skills regarding selection and use of relevant and appropriate instructional and representational repertoires to reach out to all diverse groups of students in their classes. One of the features of PCK is that educators should be able to design, plan and identify relevant teaching approaches and strategies which could be used to teach students for meaningful understanding. According to Tobin and Fraser (1987) effective teachers used, amongst others, strategies such as problem-solving activities, provided concrete for abstract concepts, helped students to engage in large and small group activities to increase students understanding. However, only few lecturers in this study were found to be using a variety of teaching strategies to make teaching and learning more meaningful. This suggest that lecturers had inadequate knowledge of instructional and representational repertoires

In addition, these findings may suggest that lecturers who believed that they had limitations of knowledge in a variety of instructional strategies within their disciplines had low personal teaching efficacy and low teaching outcomes expectancy efficacy.

7.4.2 Results and Findings about Perceptions on Student Learning

This section present the results related to the lecturers' perceptions about knowledge of student understanding, prior knowledge, learning, misconceptions, student learning difficulties and assessment.

Feelings about student learning

Lecturers were asked to reflect on their views about learning in the engineering classrooms. Four themes emerged from the responses of the lecturers regarding their perceptions on learning in their respective programmes, viz; knowledge of student understanding, instructional repertoires, and curriculum design and student attitudes towards learning.

Theme 1: Knowledge of student understanding (KSU)

Seven responses were matched to KSU. On further analysis, the responses were further clustered into two categories.

Category 1: Lack of exposure and prior knowledge in engineering

Four lecturers (4 responses) raised concerns regarding students' lack of exposure and prior knowledge in engineering as an industry and also the purpose of individual engineering learning programmes they had enrolled in. Lack of exposure in engineering and prior knowledge was viewed as factors which contributed to frustrations in teaching, learning problems and high failure rate in most programmes. Exemplary excerpts:

> [P1, L5]...“Most of the students take Architecture as a second choice programme. So, they are just confused. They do not know what the course is all about. Only a few know what the course is all about. So, they can't cope with the workload and thus fail along the way. During class, when you give them the requirements of a project, they do not grasp it. It is frustrating”.

> [P9, L2]...“Many of our students are not exposed to Building Science as a professional career. They think it is about brick and mortar. They do not do well in Quantity surveying because they do the subject for the first time in their lives. “

> [P3, L2] ....“Students find it difficult to learn because they are mostly not exposed to engineering courses”

Category 2: Role of assessment in learning

Analysis of the three responses (from three lecturers) revealed that the perceptions regarding the role of assessment amongst students and lecturers differed. According to the lecturers, students viewed assessment as just an opportunity to collect grades towards graduation as opposed to learning. Therefore, this perception, led to students focus on teaching and learning being exam-oriented. Consequently, the exam–oriented attitude was found to be affecting the quality of teaching and learning negatively since it forced the lecturers to use assessment as a 'driver' of teaching and learning. Exemplary excerpts:

> [P2, L2; P8, L5,]..."Students are exam oriented"

> [P8, L6]....."Students' attitude is that they are here to come and pass.
> It is wrong…they are here to learn. Students learn to pass and not to
> develop knowledge and skills. They just study to pass the exams and
> tests"

Theme 2: Instructional repertoire (IR)

Only one response matched this theme. Lecturer P8 felt very strongly about the selection of poor teaching strategies by lecturers as a concern since it encouraged rote learning and the dependency on examinations as evidence of learning. P8 felt that lecturers should use other instructional strategies to encourage students view learning as a skill and competence development opportunity rather than an examinations oriented activity. Because she viewed examinations as promoting rote learning, P4 felt that the formal paper and pencil examinations should be ended and be replaced with more rigorous assessment techniques in engineering. P4 maintained this view throughout the interview. The following excerpt attest to this finding:

> [P8, L6]..."The way we are teaching them encourages those to rote
> learn…. The best methods to teach the students, is to use the
> outcomes based education. When we teach through outcomes, we
> shall be able to teach the students the basics. ..But I do not see this
> happening here in TUT"

This excerpt suggests that this particular lecturer was aware of the flaws in the approaches adopted by his department on teaching and learning and was feeling frustrated about the problem.

Theme 3: Curriculum Knowledge

Lecturer P3 thought that the quality of learning in his programme was not satisfactory because the materials used for teaching and learning by students were foreign. According to P3, the examples and case studies used were unfamiliar and decontextualized from the environments with which the students were familiar. P3 felt that if lecturers could use local and familiar examples and case studies in their teaching, student would learn better. Exemplary excerpt:

> [P3, L2]..."Another thing is that we use more European books. The language and examples used in these books is inaccessible to most students. ..It is the responsibility of the lecturers to teach students about what they know from home"

Theme 4: Attitudes towards learning

Another factor which the lecturers found to be a cause for poor success rate was the attitude of students towards learning. Three responses revealed that lecturers thought that students were unsuccessful in engineering because of laziness. There was a perception that students did not take responsibility towards their own learning seriously. Exemplary excerpts follows:

> [P7, L4] "Students are lazy and playful"

> [P2, L2] "Students sometimes are not serious. They play too much. They also lie too much. they do not attend classes. They just want the scope of the exams"

These finding suggests that the lecturers who held this view could possibly have low teaching outcomes expectancy efficacy about their students' achievement. This finding is consistent with the results in chapter 5 regarding the low rating of outcomes expectancy efficacy by lecturers.

The results revealed lecturers were not satisfied about the quality of learning in their programmes. The high number of responses associated poor learning outcomes with lack of prior knowledge and exposure to engineering preceding registration and enrolment as the cause for high failure rate attest this view. Another factor thought to contribute to poor student outcomes was associated with students' attitudes towards own learning. A number of lecturers thought that students were generally not making an effort towards their own learning.

On the contrary, other lecturers thought that the quality of learning was below the expected standards mainly due to poor teaching approaches selected by lecturers, flaws in the selection of appropriate learning materials and assessment techniques used to assess learning. In addition, views about the purpose of assessment differed. There were views that current teaching approaches were not challenging and motivating for students to take charge of their own learning. In addition, assessment was found to be the main driver for teaching and learning. This suggests that probably lecturers focussed on teaching only those aspects of the curriculum which were assessable through paper and pencil tests and examinations. Knowledge of student understanding and how learning took place was found to be low amongst the lecturers interviewed, except for two lecturers. These findings suggest that lecturers could be having limited PCK to guide them in resolving the various teaching and learning challenges they encountered in their classrooms.

Purpose of student assessment in engineering

Lecturers were asked to give their opinion about the purpose of assessment in engineering. The essence of this question ascertained whether the lecturers knew that purpose of assessment in engineering education was to evaluate understanding of concepts and to improve student learning.

A lecturer with a good PCK is expected to use various assessment approaches and techniques to evaluate student understanding of concepts. Assessment approaches could include diagnostic evaluation of the students' prior knowledge and learning difficulties they experience in class. Therefore the overarching theme for clustering responses for this question was assessment and knowledge of student understanding

(KSU). Two categories of responses about the purpose of assessment emerged from data analysis.

Category 1:   Check mastery of the subject matter.

Six responses conforming to this view were identified. P2, P3, P4, P5, P7 and P9 thought that the purpose of assessment in engineering was to check whether students had mastered the subject matter. These lectures viewed mastery of subject matter as the evidence for learning. This finding is congruent with the previous finding where majority of the lecturers indicated that teaching in their classrooms was driven by assessment. For these lecturers, the main purpose of teaching was to ensure that students passed examinations. Some of the exemplary excerpts were:

> [P3, L4] ..."The role of student assessment is to check competence."

> [P5, L8]..."we assess them based on what we impart to them also on
> what we expect them to know outside the classroom"

This view of assessment by the six lecturers suggests that they have limited knowledge of the purpose of assessment as an important feature and tool of knowing about student understanding. The finding confirms the view held by some lecturers reported earlier in this chapter that teaching was about imparting knowledge and consequently assessment was thought as a way of testing whether students could regurgitate the content knowledge taught in class. In addition, the finding is in support of the teacher centred and content driven teaching approaches reported to be used by the lecturers reported elsewhere in this chapter. This also confirms why some lecturers felt strongly about completion of the entire curriculum prescribed for a year of study.

Category 2: Purpose of assessment is to assess student understanding

P1, P6 and P8 were the only lecturers whose opinion on assessment was based on testing for student understanding and meaningful learning. In addition these lecturers viewed assessment opportunities as a tool to evaluate the effectiveness of their teaching methods. This finding indicates that the three lecturers were well-informed about the role of assessment in improving learning and student outcomes.

Furthermore, the finding suggests that these lecturers' knowledge on student understanding was satisfactory when in comparison to the PCK principles. Knowledge of student understanding is a good feature of PCK.

Some exemplary excerpts:

> [P6, L11]… "I think if you are doing an assessment… I would say for us lecturers we would be able to pick up from these assessments as to see whether the large failures rates we have in certain subjects has got no connection in the way we present these subjects or does it have no connection with the attitudes of students are towards these subjects. I myself believe that maybe the manner of presenting these subjects might be causing complications or students might not be comfortable with them …."
>
> [P8, L11]… "it is to ensure that knowledge acquired will be individually perfected through practice…you mark the knowledge looking at whether the learner understand the process"

Majority of the lecturers had limited knowledge about the purpose of assessment in student learning. This finding suggest that if assessment in their view, was about mastery of subject matter, their teaching approaches and assessment techniques would also not conform to characteristics of a teacher well-informed about PCK and constructivist's educational principles. Only three lecturers showed a good understanding of the purpose of assessment in learning.

Knowledge of barriers to student learning

The essence of this theme was about knowledge of learners, their characteristics and how they impact on learning. Amongst students' characteristics the question tried to probe were knowledge about learning difficulties and what appropriate teaching approaches and support mechanisms lecturers used to help students understand concepts. The overarching knowledge theme therefore was 'Knowledge of student understanding'. Lecturers were asked to give opinions about major barriers to their students' learning.

One important feature of PCK is the lecturers' knowledge of students' misconceptions and learning difficulties with the concepts the subject. The principle put a great expectation on the lecturers to consider students' learning difficulties and to teach accordingly to facilitate understanding of the concepts and meaningful learning. Five categories emerged from the data. These categories brought to surface opinions about the types of barriers lecturers viewed as the reasons for students learning problems.

Category 1: Lack of prior knowledge.

In this category, responses from (P7, P6, P5 and P4) revealed that lecturers thought that learning barriers were caused by students' lack of mathematical knowledge and skills to cope with the engineering curriculum. In addition P1 felt that students' lack of prior exposure to engineering profession also contributed to difficulties in understanding what engineering profession was all about and the implications on learning. His comments signalled that lecturers were required to improve their teaching knowledge to confront students' learning problems. Exemplary excerpts:

> [P6, L5]..."I think that the basic mathematics is lacking. The subject that has lots of mathematics gives them problems. And this is not complicated mathematics. Sometimes it may not be lacking but because they have done it a few years before, they might not remember it. "

Category 2: Lack of cognitive ability

P5 was the only lecturer who believed that the greatest barrier to learning amongst his students were students' inability to visualise things in a 3-Dimensional way. Exemplary excerpts:

> [P5, L15]…" The basic thing that has been there which has manifested itself year after year is their inability to visualise things in three-dimensions."
> [Interviewer]…" how do you deal with this problem?

[P5, L16 - 18]…." We encourage them to try to bring in those site visits. …look at books and pictures in the library….in a number of cases you find that basic mathematical concepts are lacking…another factor is that there is unwillingness on the part of the students to make up for this deficiencies."

[P7, L11]…." the barriers I can tell you, I don't know why our students have a big problem with mathematics. That is one of the big problems….and I don't know why. A guy may be already in S4 but still have a problem with mathematics. The other thing is the pace of learning. I do not know if it is because of life skills problems. I can tell you there students who don't even know how to use a calculator and they sit in S4 class"

Category 3: Student attitude towards learning

P1 thought that his students did not have interest in learning. P7, on the contrary, believed that his students experienced learning problems because they did not buy textbooks.

[P1, l11]..." many students register Architecture as a 3rd choice. So, they do not have interest to learn"

[P7, L24]…." the thing is S1, S2, S3 and s4 use the same textbook. Exams and tests are written on the same day. The guy may be borrowing every time a S4's textbook. And what happens now is that the S4 guy wants to study and would say sorry I want to use my book tonight to study and he has no textbook to study with that is why they fail"

Category 4: Flawed curriculum design

P9 felt that the curriculum structure of the programme he taught was flawed, which consequently deprived the students with the opportunity to attain expected outcomes.

Category 5:   Lack of collaborative teaching among lecturers

P3 thought that barriers to learning were caused by lack of teamwork and collaboration among lecturers who taught the same courses within a programme and across the Faculty of Engineering. In addition, he thought that different teaching approaches used by the lecturers within the same programme created confusion among the students; consequently it led to learning difficulties. Exemplary excerpt:

> [P3, L7]…"The greatest barrier is that we (lecturers) do not work as a team. This has an implication on student learning. It's a problem in all engineering departments. For instance, we had a POL (project oriented learning teaching approach) as a teaching model. We were supposed to have developed a project together so that when students come to present orally, the entire person offering various subjects could be there to assess various concepts from different subjects used in the project….. The project oriented learning approach collapsed because we (lecturers) could not work as a team. Though we agree that engineers should always work as teams, here in the institution we do not model what is happening in the industry. We cannot work as teams"

Various opinions emerged about the sources for student barriers to learning. The most prevalent view was that students lacked necessary foundations in mathematics to understand the engineering content which was dependent on the mathematics background. The problems raised by P5 and P7 regarding lack of mathematical skills raises further questions about the type of teaching approaches and strategies used by mathematics lecturers. Do they promote meaningful learning? Are the mathematics lecturers using relevant PCK to teach mathematics for conceptual understanding? These questions signal the need for deeper investigations on lecturers' PCK through case studies.

On the contrary, P9 felt very strongly about the flaws in the curriculum, which was contributing to students not being exposed to adequate knowledge about the profession. He believed that students were being cheated. P4 felt strongly about the fact that students were not interested in learning, a view also shared by P5 in response to Question 2. P3, a head of department, believed that innovative teaching

approaches such as project oriented learning failed in the department because lecturers did not want to work as a team. As a consequence it affected the quality of learning. He believed that if lecturers use same teaching approaches which engage learners actively, learning in his department would improve.

The categories of perceptions identified in this theme suggest that lecturers had limited knowledge of appropriate teaching knowledge domains to assist them address the barriers to learning described here. The findings further suggest that such barriers to learning were not addressed through use of appropriate teaching approaches and strategies, lecturers might feel desponded about their effort of teaching, which could lead to low teaching outcomes expectancy efficacy. None of the reasons given by lecturers had pointed out to a lack of relevant teaching strategies and skills as a possible cause of student learning problems. Most of the lecturers, with the exception of P3 and P9, blamed the student for doing nothing about addressing the barriers they had about learning.

The question arising from this findings is did the lecturers have relevant teaching knowledge to can identify this learning problems and teach students accordingly to improve their understanding? According to most of these lecturers, students' lack of mathematical knowledge is a problem and they do not know how to solve it.

Use of student life experiences in teaching

The essence of this topic was on identification of prior knowledge student brought to class from their life experiences and how it was utilised in teaching process to make students understand concept meaningfully. This feature of teaching knowledge forms the essence of knowledge of student understanding as a theme.

The responses revealed that five lecturers never considered identifying and using students' life experiences and prior knowledge in their teaching. [P1, P4, P6, P7, P8]. Exemplary excerpts:

> [P1, L16]...."Not really doing anything about identifying students'
> prior knowledge and life experiences, may be next time".

[P4, L35]..."Hmmm, I do not have much, other than technology. The guy who teaches mathematics is very good at that."

On the contrary, four lecturers indicated that they did take their students prior knowledge into account. However, their approaches of how they used students' prior knowledge in teaching differed. Two lecturers [P3 & P9] incorporated it directly into their teaching lessons, i.e., tapping on societal problems and issues on how technology is being used. On the contrary, P2 and P5 took their students to real project sites so that they could gain experience on how the knowledge in the discipline was used in society. Exemplary excerpts:

[P3, L13]..."Uses students' life experiences, societal issues, as a way of creating awareness about the use of technology in our lives. .. *I u*se relevant life experiences to explain high technology of brewing such as traditional Marula beer brewing"

[P2, L10; P5, L25]... "Take students to project sites"

The findings suggest that lecturers have different perceptions about the value of student prior knowledge and personal life experiences in teaching. The findings suggest that P2, P3, P5 and P9 seem to be taking knowledge of their students understanding very seriously in their teaching. On the contrary, the majority of the lecturers may have not yet tapped on this important category of teaching knowledge. This finding suggests that some lecturers had limited knowledge of the importance of student life experiences in shaping their learning path to successful student outcomes signals that they had limited knowledge of PCK. Use of prior knowledge and student life experiences is an important domain of PCK and the constructivist approach to quality teaching and learning.

Knowledge about characteristics and diversity of students

The focus of topic was on knowledge of student understanding and how the lecturers recognised and dealt with diversity of students in terms of gender, ethnicity and other characteristics in teaching**.** The lecturers' responses were categorised into those who took cognisance of diversity and those who do not take cognisance of diversity in terms of gender and ethnic cultural issues when selecting teaching approaches. Five lecturers indicated that they took cognisance of the gender and other background

characteristics of students in their teaching. They indicated that in their classes students were treated equally. However, three of these respondents indicated that they sometimes found themselves being more sensitive towards women students than male when they teach because females were a minority in the classrooms. Exemplary excerpts:

> [P8, L22]… "I noticed that the females were able to accept that they cannot do certain things and thus called for assistance. I try all the time to assist female students. Students sometimes come back from workstations not understanding how to solve a problem. They would approach me to clarify the problem even if the practical session is not facilitated by me. I always help them."

> [P4, L39]… "Yes, I actually do. I am more inclined outside the classroom to give more attention to the ladies than guys. They are a small group and they do not express their questions in class in front of the guys. They do not like the attitude of guys in class, who might look down at them. So, while in class, I do not show any favouritism. Everybody is treated the same."

> [P9, L15]…"Yes, I take all students background seriously; I make no assumptions that students are homogenous".

Only one lecturer indicated that he did not take note of the student characteristics and differences in his teaching. The findings suggest that approach towards embracing diversity of students in teaching varied from lecturer to lecturer. It was more done on a personal level than as part of knowledge and understanding that learners personal characteristics, gender and cultural believes have impact on the quality of learning. Hence, teaching approaches selected by lecturers had to take such knowledge into account in planning and implementation of lessons.

Question 15: Knowledge of students learning difficulties

This question focused on eliciting responses about knowledge of student understanding with special reference to providing support to students with learning difficulties so that students' learning experiences could be better.

Three lecturers [P7, P8, and P3] indicated that they were aware that their students experienced learning difficulties and thus required additional academic support to address their learning problems. However, they decided not to do anything about it. The nature of the conversation during the interview influenced P7, a head of department, to do introspection on their practice in the department and decided to think about ways of addressing the problem. See the exemplary excerpts below:

> [P7, L15] "…. Mathematics is a problem, how to use a calculator is for me personally a problem. And then we also have a problem with writing of reports and I can tell you for me, have been with a communications lecturer a hundred times but still there is a problem. Now I pick it up with the industry. They also say the guys have problems with writing of reports"
> I…Have you taken it up with This?

> [P7, L16]…."Not yet, that is why I make a list and at the end of the semester …that is why I will also address it in our department meeting. We will do that next semester"

> [P8, L10]…"if the drivers of teaching and learning at the department have a vision, then it would be easier to develop structured processes which could help students learn better. This could be done in collaboration between ourselves as engineering lecturers and your department. I think I said a mouthful here"

> [P3, L16]…"I do not provide personal assistance. When we work on projects we sometimes refer them to websites to go and look for information. Other than that we are not doing anything more."

On the contrary, four lecturers [P9, P6, P1, and P4] indicated that they assisted their students in order to solve the learning problems as much as possible. Exemplary excerpts which attest to this finding are:

> [P9, L16]… I assist all my students during contact time in class or during consultations in my office. It is my duty to assist the students at all times so that they become good quantity surveyors. If my budget allows me, I would like to employ senior students at third year as

tutors to assist me in helping my first years understand and succeed. I want to improve my graduation rate".

[P9, L20] …." We do team coaching in projects with other colleagues. Other lecturers, when they realise that a student has a problem, they come in and assist the student. In that way, students gain a lot. That is why, if after such an exercise I still have a student who struggle, it means there is something wrong with the students."

The finding suggests that knowledge of student understanding and the need to take appropriate action to assist students varied amongst lecturers. Furthermore, the results suggest that additional student support from the lecturer was done on a personal level. It depends on the passion and level of commitment and trust between the lecturer and students. Waghid (2000) referred to such a relationship of trust, commitment and personal interest between the educator and the students as dialogical agape pedagogy. Waghid (2000) argued that if implemented in engineering classrooms, dialogical agape pedagogy would improve teaching and learning and consequently student outcomes. The findings further suggest that some of the lecturers' had limited knowledge of students learning difficulties and how to address it. Knowledge of student learning difficulties and ways of addressing it is an important attribute of PCK.

Knowledge of students' preferred learning styles

The topic was used to ascertain lecturers' perceptions about knowledge of students' learning styles and how such knowledge was used in teaching. Responses were clustered into two categories. The first category, composed of four lecturers [P3, P4,, P8 and P9] who admitted knowing about the diverse learning styles their students brought to class and had subsequently used the knowledge to select appropriate teaching approaches and strategies. Some exemplary excerpts:

[P9, L18]…."I teach using critical cross field outcomes, through role playing, scenario, problem solving, simulations, and interactive classes on actual professional industry case studies. Students enjoy this approach because they think they are already working in the

industry in real time. The method also encourages them to realise that in industry they will have to work with many other role players other than the quantity surveyors".

[P3, L17]…" I allow it in my class because I believe that students can learn from other students. Participation in class allows both students and the lecturer to learn a lot from each other.

The second category consisted of responses from five lecturers who admitted to lacking awareness and knowledge about the kinds of learning styles their students used or preferred. Various reasons were provided by lecturers for not tapping on this important feature of knowledge about student understanding. The following excerpts provide an array of reasons provided by both categories of lecturers:

[P5, L35]..." There is no one who has spoken about it"

[P6, L43-L44]…"It is not possible…because I have a problem with assessment. I prefer to use practical exercises I am comfortable with. . I cannot give a practical or something that I do not feel comfortable with students who were given classes do not specialise. We are giving a general survey course there is no specialities."

The findings suggest that some lectures were aware of the different learning needs of students and thus choose their teaching approaches accordingly. The approach used by P9 is a good example which demonstrated that a mixture of learner-centred approaches could stimulate diverse group of students to learn and understand how engineers work in reality. Allie, et al. (2009) referred to such teaching approach as discursive communities and participative teaching approaches. Only lecturers with a good understanding of PCK would be able to use this method of teaching.

On the contrary, there were some lecturers who were aware of the importance of knowledge of student learning styles in teaching practice, but due to other obstacles such as class sizes, they were unable to accommodate students learning needs in their classes. The three lecturers who indicated that they did not know that they could be having students who preferred other teaching approaches other than those they used in class, indicates that their knowledge of students learning needs and understanding

was limited. These are an example the type of lecturers who may benefit from awareness about pedagogical content knowledge and how such knowledge could assist them to reflect on their teaching approaches to accommodate the needs of all students.

Alignment of teaching approaches with students learning styles

Through this topic perceptions about knowledge of student learning styles and how lecturers aligned their teaching approaches to accommodate the students learning styles were elicited. Knowledge of student learning styles is a key feature of PCK. Two categories of responses emerged from the data. The first category was composed of four lecturers [P1, P8, P3 and P6] who did not know anything about the type or patterns of learning styles their students used. In addition they were not even aware of the importance of knowledge of students' learning styles in teaching and learning. Although, most of them acknowledged that it was their responsibility to teach the students in a manner that would yield meaningful learning and positive outcomes. However, a lack of teaching knowledge in terms of selecting the relevant teaching methodologies was cited as the main reason why they did not know of its importance and how they could identify it. The following excerpts give evidence to this finding.

> [P8,L12]..."It is upon lecturers to teach students in a manner that will give them good learning outcomes… if the learners does not get what they expect in class their behaviour and attitude become vulnerable and they start focussing on other things"

> [P6, L71]... 'We have good people here who have higher qualifications in engineering but never taught well in class not because they do not know the subject but because they do not understand that they cannot teach."

Three lecturers [P4, P5 and P9] indicated that they considered their students learning styles and hence they conducted diagnostic assessment to find out more about their students learning needs and then adjust their teaching strategies accordingly to ensure that students understood the subject matter. In addition, lecturer P1 indicated that in order to find out more about her students, she used social communication

media frequently used by students to communicate teaching and learning issues with students. Her view on using social communication media in teaching is that students liked it because the approach assisted in creating relationship and trust with their lecturer. An idea supported by Waghid (2000). To show how important this approach was to her, the lecturer emphasised this view on more than two occasions during the interview. Students were reported to like the approach since it was less intimidating. In addition the method was reported to have motivated students to enjoy learning. According to P4, the approach contributed to improving the learning environment and student success rate in her subjects. Some exemplary excerpt

> [P4, L30]... "The professor must know his students by using various presentation and social communication styles frequently used by students such as face book and twitter to accommodate variety of learning styles "

> [P9, L27]..."I consider their learning styles because it is important on how one approach teaching certain topics and concepts"

The findings suggest that most lecturers are not knowledgeable about the importance of knowing the learning styles that students use to comprehend the subject matter. Only a few lecturers did. These findings confirmed and supported findings reported in question 29. The lecturers blamed their lack of awareness about students learning styles on their limited awareness and understanding of teaching knowledge and skills.

Approaches used by lecturers to help students assess own work

This topic was used to elicit lecturers views about teaching approaches used to encourage students to develop a habit of assessing their own work.

Three (3) [P4, P3 and P6] indicated that they did not allow their students to assess own work because of the culture that exist where a teacher is expected to carry out all assessments. Exemplary excerpts:

> [P3, L21]…"May be the problem lays with us lecturers. We do not tell them to assess themselves. Yet we give them study guides with questions they could use for self- assessment. Perhaps this also comes

from the culture that a teacher is expected to do everything. Teach and give tests. So, students and teachers do not promote students self–assessment".

[P4, L50]…"No, I assess their work. I assess everything. Most of the assessments do not look for straightforward answers. Somebody can use different approaches but arrive at the same solution."

On the contrary, 4 lecturers [P1, P2, P9 and P5] indicated that in their classes, students engaged in peer and self- assessment through projects and work in the laboratory, design studios, and homework tasks. Exemplary excerpts:

[P5, L40]…"I give them a lot of homework"

[P2, L20}..." We do group work. The questions they ask me in class could be answered by their own peers"

[P1, L23]..."they spent a lot of time working on projects with their fellow colleagues in the studio. They can ask other students."

[P9, L22}…"I advise my students to use the self-assessment questions at the back of the module learning materials"

The responses suggest that some lecturers took student reflection on their own work as an important learning opportunity for students whilst others did not. The culture of teacher centeredness in teaching and assessment could probably be the reason why some lecturers believed that students could not assess themselves but only the lecturer can. This finding further supports an earlier discovery where lecturers' views of the purpose of assessment as regurgitation of content through tests and examination rather than learning. An effective teacher will always encourage and stimulate students through relevant strategies to evaluate themselves in order to assess the extent to which they have understood the concepts. Self- assessment is a powerful tool to promote meaningful learning. It forms an important feature of the PCK and constructivist's learning environments. However, the findings suggest that the lecturers who participated in this study had limited knowledge on the value of this important aspect of PCK.

Mechanisms used to offer feedback to students for learning improvement

This question was used to ascertain opinions concerning lecturers' use of assessment as a tool to provide feedback to students about the strength and weaknesses of their learning progress. The overarching theme was knowledge of student understanding. Three lecturers [P9, P6 and P5] indicated that it was part of their teaching practice to provide students with feedback as a review of assessments completed. *Exemplary excerpts:*

> [P6, L61]…"Yes, I certainly do. When the scripts come back I encourage them to do the corrections and make them copy answers from the board. And I try to go through the questions again in class and tell them that next time I want them to do just as what I just did today"

> [P5, L36]..." After every test I ask them if it is necessary for us as a group to go through it and if they feel so, we went through the whole test and they see their deficiency but sometimes they see their obvious errors and they say it. And I respect that"

> [P9, L24]..."After every assessment I make it a habit to discuss feedback with students. Unfortunately, we cannot do feedback on the end of semester exams because of the semesterisation of the curriculum. This is a problem. It does not allow for articulation of work very well."

On the contrary, three lecturers indicated that they did not provide their students with feedback. Their reasons varied from not knowing how to mentor and coach students to assessment purpose being solely the responsibility of the lecturer to provide students with an opportunity to get semester and exam marks for promotional purposes. One lecturer indicated that he would provide students with feedback if they requested it. This latter statement supports an earlier finding that some lecturers viewed the purpose of assessment as a grading system rather than a mechanism to assess learning. Exemplary excerpts:

[P2, L21]..."No feedback. I always tell students that the purpose of assessment through tests is to make sure that they get the semester mark for entrance into examinations."

[P3, L22]..."don't know how to do it. A workshop could help us lecturers to develop the tools on how to coach students"

The findings suggest that only a few lecturers understood the importance of providing feedback to students so that they could improve their understanding of the subject matter and thus improve their learning experiences. The common feedback mechanism used by some lecturers was post-mortems of tests and assignments. The majority of the lecturers did not provide students with formal feedback sessions on their learning progress. In addition, lecturers' knowledge of student understanding was found to be limited. This finding, was not surprising taking into account that some lecturers thought that assessment was used for promotional purposes (pass or fail) rather than for checking student learning and for improving students experiences and academic outcomes.

7.5   Results in response to Research Question 3

Research Question 3: What are the lecturers' perceptions of their professional development?

This section presents the results and findings in relation to the lecturers' perceptions about professional development. The main critical issues pursued during the interviews were sources and activities used by lecturers for improving their teaching knowledge. In addition, views about their most preferred teaching knowledge professional development programme were solicited. Results and findings are presented according to issues pursued during interviews.

Information collected by lecturers on their teaching practice

Lecturers were asked to share the type of information they collected on a regular basis to evaluate and reflect on their teaching practice. Reflection and evaluation of practice, if well utilised could serve as a good source of teaching knowledge

development. Three categories emerged from the lecturers' responses regarding the kind of information they collected and the mechanisms used to collect it.

In first category related to use of student feedback system, four lecturers [P9, P2, P7 and P4] had indicated that they used the official teaching evaluation surveys to collect views of their students about their learning experiences. However, the information collected and how it was used to improve teaching varied between lecturers. Other lecturers took the survey results seriously whilst others indicated that they conducted the surveys to comply with the institutional policy. For instance, P9 used the results of the surveys to improve on some aspects of teaching practice whilst P7 used the probability statistics to determine if action to address issues raised by students was necessary. Exemplary excerpts:

> [P7, L32]…"we have a questionnaire, an evaluation questionnaire for the students to evaluate all lecturers. Once a semester we let the students complete the questionnaire for us…I rank everyone all lecturers. And what I have done in my case I let the senior lecturer ask someone to evaluate myself and then we go through it. And then we pick up quickly for example, let's say the lecturer is not always in class that type of thing. I read through the comments and of one student say the lecturers are bad they don't want the lecturer they do not like them and things and the rest say no he is a good lecturer then it's okay. ..I go by 50%. If 50% is happy then it is alright. We also cover what kinds of teaching methods are used in class."

> [P9, L28]… "I always reflect on what my students say. The problem is the gap between semesters due to curriculum design. It impacts on how you go back to address the shortcomings in the previous semester.

The second category involved two lecturers who collected feedback for reviewing their teaching and learning materials [P1 and P3]. P3 had reiterated throughout the interview concerns about the poor quality of practical work manuals in his course. It therefore makes sense why his focus was only on reviewing the practical modules. .The third category was related to those lecturers who did not collect any information

about their teaching nor conducted any reflections on their practice, [P5, P6 and P8]. Exemplary excerpts:

> [P5, L45]…" I still visit the textbook from time to time. But not very regularly. Much of what I collect regularly is from journals, professional journals, and trade brochures keeping up to date with industry and for my own practice (consulting company)."

> [P4; L51]... "The students would say she is too slow or too, she cannot control the class fast or she is too much of an engineer than a lecturer. I am not a teacher. …the intention that I am supposed to produce an engineer in you"

On the contrary, P4 though she acknowledged that she sometimes administered the official teaching evaluation survey, the results really meant nothing to her since she viewed students' comments as unusable. For instance, the excerpt above suggests that her view of the role of teaching was to train an engineer. Therefore she does not regard herself as a teacher but a trainer to produce engineers. This view was found to contradict her earlier conviction that teaching for her was an inborn trait (talent).

Views that the role of engineering educators is to train future engineers rather than teaching conform to the teacher–centred and behaviourist approach to teaching. This confirms similar perceptions reported in previous studies that engineering lecturers views themselves as trainers rather than teachers (Allie, et al., 2009; Coetzee-Van Rooy, 2002; Felder, Woods, & Stice, 2000; Weimer, 2007).

Only a few lecturers used student feedback system as a source of teaching development. Other lecturers either just collected the information or did nothing about or they do not conduct teaching evaluations at all. This finding suggest that majority of the lecturers probably did not see any value in doing reflection and evaluation of their practice and its potential to assist them in enhancing their teaching knowledge.

Views such as those held by P4, regarding the value of generic institutional teaching evaluation surveys, leads one to begin to question the value and purpose of using

teaching evaluation surveys in the university? Does it really bring about reflection on teaching practice? Do such generic teaching evaluation surveys enhance teaching knowledge development? According to P4, generic institutional surveys did not help to improve her teaching knowledge

Professional development through reflection and evaluation of practice

This topic was used to elicit perceptions about how lecturers used the teaching evaluation information they collected from students to change or improve their teaching approaches. Four categories of responses emerged. Two lecturers [P1and P8] reiterated that they used the information to review and revise teaching and assessment practices and learning materials. Two other lecturers [P4 and P9] indicated that they used the information to improve themselves but no specific areas of improvement were mentioned. One lecturer [P7] attended to common and a frequent problem identified by students and resolved it. The last category relates to responses shared by four lecturers that they did nothing with the results of teaching evaluation surveys [P2, P3, P6 and P5]. P4 insisted that such evaluations had no value on improving her teaching knowledge.

The findings reported here further confirmed those reported in the previous section. There is an inconsistency in how the reflection and evaluation of teaching are done and how the outcomes are used to improve teaching and learning. These findings suggest that evaluation and reflection of teaching did not necessarily lead to improvement in teaching knowledge and practice.

Professional development approaches and opportunities used by lecturers

Lecturers were asked to give their views about opportunities, sources and activities available for their teaching knowledge development. Three categories of sources for teaching development emerged from the responses. Seven lecturers [P1, P4, P8, P2, P6, P9 and P7] indicated that they participated in professional boards' development activities external to the university, where they learned mostly about latest trends in the engineering field such as new technologies. P8, P9 and P7 indicated that their source of teaching knowledge was collegial activities such as learning from colleagues and attending teaching development workshops. P5 used reading of

professional materials such as journals as his sources of professional development. Exemplary excerpts:

> [P4, L63-64]...” The boards generally look at the content of the curriculum and delivery. Mostly on quality. That is why we do a lot of paperwork for them. When they come to visit the institution they look for old question papers etc. To me that is not enough. I think they should do random visits to classes. They will see how we can improve teaching”

> [P9, L29-L30] ...” I participate in various professional boards and agencies within the construction industry. I am involved in consultancy work. I am also involved in CPD, continuous professional development. .It includes both teaching development and discipline based information. It improves the subject content”.

> [P7, L33].” I learn from other colleagues....we use self -reflection and ‘learn it by ourselves”

> [P5, L56]...”we pick these things up from professional journals. And then again from the internet...if you tap into subject related matter you will pick a lot of information”.

Findings revealed that the dominant source of professional development used by the majority of lecturers was professional boards’ programmes and activities. These were used to advance engineering discipline knowledge other than teaching. In most cases professional boards’ interest in teaching and learning was concerned with the curriculum content and infrastructure for compliance with accreditation standards. Professional boards usually are not concerned about teaching knowledge of lecturers. The teaching knowledge development was not a priority for many of the lecturers, though some lecturers had acknowledged having shortcomings and weaknesses on certain aspects of teaching knowledge domains. This confirmed the observed poor participation in teaching development activities, which has always been a problem in the faculty of engineering. Only one lecturer indicated that he used colleagues as sources of teaching knowledge development, whilst one read professional materials from journals and websites. Though advancement of discipline knowledge is also

very important in tertiary education, balancing discipline knowledge with pedagogical knowledge would make lecturers achieve good teaching outcomes. The finding suggests that engineering lecturers need to be motivated to engage in activities related teaching knowledge development.

Opportunities to discuss aspects of teaching and learning with colleagues

The focus of the topic was on eliciting responses about collegial activities which existed amongst colleagues regarding teaching development. Two categories of responses emerged. Only two lecturers [P2 and P9] confirmed that collegial activities as a source of professional development were formalised in their department. In most cases, the activities focussed on sensitisation about education reforms which took place at national level within the discipline. However, they did not expand much on the impact of such activities on teaching knowledge development.

Six lecturers [P5, P6, P3, P8, P4 and P1] indicated that no collegiality activities existed in their departments. In the cases where some collegial activities existed, it was more on an informal basis. The following excerpt is an example:

> [P9, L9] " As the head of department , I advised staff about developing personal development improvement plans with regard to teaching and learning, attend curriculum development courses, importance of feedback from students with regard to improving own teaching skills. But staff feels uneasy about teaching evaluations"

These findings suggest that there were no concerted efforts to work on collaborative teaching and learning improvement projects in the departments. The findings suggest that collegiality was not yet adopted by lecturers as an official and mainstream source of teaching knowledge.

Opportunities available to receive feedback from colleagues

This topic was used to elicit responses regrading use of peer evaluation and feedback as a source of professional development. At the heart of this question is the role of collegiality in enhancing teaching knowledge of colleagues.

All nine lecturers confirmed that they did not participate in peer evaluation nor provided their colleagues with any feedback regarding their teaching. This finding confirms why the average mean score for this item in chapter 6's data analysis was below the midpoint score of 3. There were varying reasons provided for this important collegial activity not being active in the departments and faculty of engineering. There was a feeling amongst lecturers that colleagues did not trust each other. One lecturer even viewed peer evaluation as a risk. See excerpt below:

> [P9; L33]... "To be honest, I have not engaged in an exercise to get feedback from colleagues. I think we still do not trust that your colleagues could visit your class and give you good criticism. We regard it as a risk, inspecting others, protection of own environment and space ...Perhaps in future we could lecturer-lecturer evaluation"

> [P4; field notes] ...".No. There is no time. People are also conscious of paperwork"

However, there were voices which indicated dissatisfaction with the current situation in the department where collegial activities were not part of the main stream plan of professional development in teaching. Such lecturers indicated that there was a great need for formal collegial professional development to be established in their departments; however the role of academic leadership in driving this idea forward was questioned. The following excerpts testify to this need:

> [P5, L57]... " I would like to see a situation where we have a formalised programme where we can all sit around the table and discuss what we do with the students and what we are going to do with ourselves to make sure we are giving the students up to date information and how we are presenting as well. But then I know if we do, we will be treading on people toes."

> [P8, L10]..." if the drivers of teaching and learning at the department level have a vision, then it would be easier to develop structured processes which could help students learn better. This could be done in collaboration between lecturers ....but up to now, I do not think my vision will be realised". [P4; field notes]..."No, there is no leadership

to drive professional development. ...on the other hand, it will be good if we could have peer evaluation. It will improve (teaching and learning) a lot. We should be open to other means of assessment".

Peer evaluation and feedback was not used as a source of teaching knowledge development. Findings suggest that this important source of teaching knowledge was not used due to two reasons. First, the lecturers still operated independently and had not formed collegial teams for collaborative approach to improving their teaching knowledge. Secondly, lecturers were not comfortable in opening up their private space for peer evaluations. As such, they felt that they could not trust their colleagues. The findings further suggest that lectures were not comfortable in sharing their expertise with colleagues. Peer evaluation, as part of collegial effort to improving practice, could play a major role in enhancing teaching knowledge of staff, especially if activities such as coaching and mentoring were incorporated into the teaching improvement system.

Preferred professional development model

Lecturers were asked to describe their preferred professional development model which could be used to advance their teaching knowledge. Five categories of responses emerged. Two lecturers [P7 and P2] indicated that there was no need to participate in teaching development activities. Four lecturers [P1, P8, P5 and P3] preferred participation in professional boards' activities. In addition P5 felt that establishing a non-profit company, Section 21, in the faculty would benefit both staff and senior students in engineering. Exemplary excerpts:

> [P1, L30]..."I think the professional board is where we get all the information".
> [P3, L29] …" the best ways is to attend chemical engineering workshops and conferences. I use the information to empower me as a teacher"

On the contrary, P6 believed that every engineering lecturer should do a teaching short course. Accordingly, the teaching course should focus on technical education didactic methods (PCK) and didactical technical equipment (teaching aids in

engineering for demonstrations) so that lecturers could learn meaningful ways of presenting concepts for learning. P6 sentiment suggest that there was a great need for engineering educators to learn about PCK and how they could use it to improve teaching and learning in their classrooms.

> [P6, L72-L73]...” To start with, the teaching qualification has never been compulsory for lecturers in engineering. I would suggest that could have been foolish. However, everybody should know something about teaching. Everybody needs to do a teacher training course ......It should focus on technical didactical methods and didactical technical equipment which most of the lecturers did not know. They might not know what the importance of it since most of them use chalk and talk methods. They might not know why they have to use other methods of teaching. The other thing is that the syllabus might not allow talk and chalk. It can be that you have to do a demonstration...If a guy goes to teacher training his teaching methods might improve”

P4 supported the view that teaching professional development was an individual lecturer's choice. She referred to this choice as '*self-education*'. She identified four features of 'self-education'. According to P4, improvement of teaching knowledge growth starts with intrinsic motivation from the lecturer. The second feature is that the lecturer should think like students in order to reach out to them. Third feature is that the lecturer should learn from their students. The last feature of 'self-education' is about awareness relating to how students learn

> [P4, L66]...”I think the lecturer should be acquainted with technology at hand. If they use something as small as 'MixIt' they should be able to reach out to their students.... People are used to their own models or ways of doing things.. it will never work. So to me the model is that the lecturers themselves should educate themselves on the latest technology and not necessarily the core engineering technology.

> [P4, L68]…” For example a lecturer must not always look at yourself as a professor or lecturer. Think about the time when you were seating on that seat as a student. Once you are aware of your student times,

tell yourself that you can always learn something from the students. Sometimes when I need to use technology to do something in class such as using word processor formatting etc, I always ask the students to help. I tell them that I need to learn because I do not know how to do it. And I learn from the students. So, if you take your class to be your own classroom, I think you learn better and then you can teach better. The fact that I use very hard strategies to teach, it does not mean that my students do not like me. They actually come to me after class or send emails of appreciation. I think the professor must know the student.....".

Summary of perceptions about professional development

Professional board activities were found to be the most dominant source of preference for professional development in teaching. However, the reasons behind choosing this option were mostly related to growth in discipline related issues rather than in teaching knowledge.

The second most preferred source of teaching knowledge was participation in teaching courses relevant to engineering. The third source, though it was only the view of an individual lecturer, related to the establishment of a non-profit company within the Faculty of Engineering to teach students about industry related projects and to allow staff to operate as consultants through the company. According to P5, the activities in the company would provide an opportunity for developing both discipline specific knowledge with PCK. Views shared by P6 indicate that some lecturers were aware of the negative effects of being a teacher who was incapable of influencing learning in a positive way because they lacked teaching knowledge and skills. Hence, P6 felt strongly about making it obligatory that all engineering lecturers should attend teaching knowledge development courses, specifically designed for engineering lecturers. This findings, suggest that teaching knowledge, especially PCK, was limited amongst the lecturers. This is exacerbated by the fact that some lecturers still believed that teaching knowledge development was not important in engineering.

The view that 'self-education' was as a good source teaching knowledge development has got both merits and shortcomings. The merits about it is that it encourages and motivates the lecturer to reflect on a number of issues taking place in his or her teaching and learning environment and then take action to address those issues. P4's views on teaching knowledge growth are consistent with the principles of PCK as viewed by Grossman (1990).

7.6 Summary of Chapter

In this chapter results and findings of nine lecturers' interviews in response to research questions 2 and 3 were presented. Perceptions about teaching knowledge and professional development were explored. Analysis and interpretations of the responses was conducted, guided by the teaching knowledge theoretical framework of the study, pedagogical content knowledge and constructivism. The summary of findings is presented according to the three broad categories, teaching, student learning and professional development perceptions

Perceptions about teaching

Perceptions of lecturers about teaching in the engineering programmes varied. They experienced teaching differently. Some lecturers had both positive and negative experiences of their classroom teaching practice. Lecturers faced a number of challenges in the classrooms. Findings showed that lecturers were aware of some of the problems associated with teaching and learning in their programmes. Amongst reasons cited were acknowledgement of limitations regarding knowledge and selection of appropriate teaching approaches and strategies to motivate their students to learn meaningfully.

The most predominant teaching approaches and strategies used in the classrooms were found to be teacher-centred such as chalk and talk and use of power point presentations. Only a small number of lecturers used learner centred teaching approaches and strategies. Detailed analysis of the PCK domains on instructional and representational repertoires confirmed the lecturers' view that they had limited knowledge regarding selection of relevant teaching methods. Hence, some lecturers felt that their teaching effort was not effective. This finding signalled low personal teaching efficacy and teaching outcomes expectancy. This finding, contradicted the

results reported in chapter 5, where lecturers rated their teaching knowledge highly, with average item score of above 4 on the 5-point Likert scale. The findings about low outcomes expectancy efficacy were consistent with the quantitative results in chapter 5 and 6, respectively. Items related to collaborative teaching were rated lower than the midpoint 3.0. They were not so positive that their teaching efforts would yield good outcomes.

Collaborative teaching approaches and strategies were limited only to sharing of teaching resources. This finding was also consistent with the findings reported in chapter 6. Some lecturers expressed sentiments of using collaborative teaching in order to provide students with equitable learning experiences, but not all lecturers agreed to any collegial effort that was to expose their teaching practice to their colleagues. This included peer evaluation, as a source of teaching knowledge development.

Perceptions about student learning

The essence of this category was about exploring perceptions about lecturers' knowledge of student understanding. In the heart of this category, lecturers' knowledge of student understanding with respect to how lecturers identified and used prior knowledge, misconceptions and diversity of student learning styles were explored. In addition, views about purpose of assessment and its role in teaching and learning were explored**.** Lecturers were not satisfied about the quality of learning in their programmes. Lecturers associated poor learning with students' own problems such as attitude towards learning and lack of prior knowledge. This perception was consistent with the findings from chapter 5, where average mean scores for items on outcomes expectancy efficacy were rated lower than midpoint-3.0. However, there were lecturers who attributed the poor quality of learning to inappropriate and ineffective teaching approaches selected by lecturers, flaws in the selection of appropriate learning materials and curricula design.

Knowledge of student understanding varied from lecturer to lecturer. The findings revealed that almost all lecturers had limited knowledge of student understanding. Lecturers had limited knowledge about the kind of learning styles their students used to comprehend the subject matter. The majority of the interviewees indicated that

they did not know their students learning styles. For effective teaching to take place, lecturers should be aware of the learning styles their students use. Individual students use different learning styles. Establishing knowledge about types of learning styles existent among students is essential in helping the lecturer to adopt relevant and appropriate teaching approaches and materials to accommodate students learning styles. A lecturer with good teaching knowledge would use a variety of instructional and representational repertoires to accommodate a variety of student learning styles. Some students are visual and thus learn better when they see variety of representations while others learn better if subject matter is presented in oral form. Using more than one teaching approach and strategies will promote successful teaching and meaningful learning.

A number of lecturers were able to identify their students' learning problems and some possible roots of such problems. However, the majority did very little to address barriers to learning which were associated with teaching and learning approaches used by both lecturers and students. The findings suggest that lecturers can sometimes be oblivious of the kind of learning barriers which their students experience in trying to comprehend the subject matter. Subsequently, if lecturers do not have knowledge about the kind of learning barriers student have, lecturers may use teaching methodologies that are not aligned to alleviating existing learning problems amongst students. This may lead to poor students' outcomes and high failure rate. Researchers such as Felder and Spurlin (2005) and Allie, et al. (2009) have alluded to lack of knowledge on students learning barriers and learning styles has led to lecturers using incompatible teaching methods to students challenges to learning. In turn, poor student outcomes may lead to lecturers experiencing low teaching outcomes efficacy. Therefore it is crucial that lecturers should become aware of the effect learning difficulties have on their teaching and expected student outcomes.

Assessment was perceived to be the driver of teaching rather than a tool to assess and improve learning. The findings revealed that lecturers generally lacked knowledge and understanding of the main purpose of assessment in teaching and learning. The majority of the lecturers felt that assessment was mainly conducted to check mastery of the subject matter. This perception was found to be consistent with

the lecturers' perception about the purpose of teaching: - to impart knowledge. Their views differed from understandings of the purpose of assessment from the constructivist view of learning and the guidance from guidelines provided the PCK principles.

Perceptions about professional development

The findings in the professional development section are consistent with those reported in Chapter 6, where participation in professional boards, reading scientific materials, use of student feedback on teaching and reviewing own teaching materials were perceived highly positive as sources of teaching development. On the other hand, collegial activities such as peer evaluation, collaborative teachings were perceived negatively.

There were also views from some lecturers that participation in teaching knowledge development projects was a waste of time for engineering educators. This view may have emerged from their previous experiences of attending general teaching development short courses and workshops. However, the findings in this study have revealed the great need for engineering lecturers to take action on improving their teaching knowledge, if they aspire to improve the quality of teaching and learning in their programmes.

Furthermore, these findings suggest that engineering lecturers need capacity building in PCK development. A good approach to improving the lecturers teaching knowledge would be to consider more contextualised formal and informal activities which conform to the principles of PCK in engineering education. Balancing professional development within the discipline and in teaching would also give the engineering lecturers a competitive edge on achieving excellent academic outcomes.

Though the perceptions of the lecturers varied in some cases regarding teaching knowledge and professional development, the findings suggested that lecturers' views on teaching knowledge were in contradiction with principles of PCK and constructivism. These findings suggested that there was a great need for lecturers to be sensitised about the importance of pedagogical content knowledge and how it

could assist them in alleviating some of the teaching and learning challenges reported in this study.

CHAPTER 8

Discussion of Major Findings, Recommendations and Conclusion

8.1   Introduction

In this thesis, I have attempted to investigate the perceptions of lecturers and students about teaching and learning in engineering. Teacher knowledge was used as one of the constructs underpinning the investigation. The study was premised upon the lecturers' teaching knowledge as being one of the important factors in determining student achievement and success in engineering education. This premise was demonstrated by concerns that students' achievement in the Faculty of Engineering at the institutions used in this study was not satisfactory. Several remedial measures were undertaken by academic departments but none of them involved investigation into teaching knowledge of lecturers. I reflected on this observation overtime which led to the concern that engineering lecturers probably had limited knowledge of pedagogical principles and strategies to facilitate meaningful learning and consequently achieve excellent students' success rates. This stimulated the quest to investigate perceptions about teaching knowledge of the engineering lecturers. In addition, the literature review on engineering education studies supported the conception of this study. Therefore, the main focus of this study was on the perceptions of students and lecturer's about teaching knowledge in the engineering classrooms.

Teacher knowledge within the scope of this study was defined through the teaching and learning theory of social constructivism and pedagogical content knowledge principles. Pedagogical content knowledge (PCK) is significant to this study in the sense that it integrates discipline knowledge with pedagogical knowledge useful to teach the subject matter in a meaningful way. The PCK domains investigated in the study were instructional repertoire, representational repertoire, subject matter knowledge and knowledge of student understanding. In order to gather a full understanding of how the engineering lecturers acquired their teaching knowledge, an additional construct was introduced to the study professional development of teaching knowledge.

8.2   Summary of the Thesis

In the introductory chapter 1 of the thesis, the rationale and significance for investigating teaching knowledge views from both the students and their lecturers was described in detail. The objectives and research questions of the study were outlined.

Chapter 2 presented a review of literature regarding the research on conceptual frameworks and the theory on teacher knowledge and teaching professional development as the main construct of investigation within this study. Since the study pursued teacher knowledge perceptions within engineering in a South African university, an overview of the related research in teaching and learning conducted in engineering education in South Africa was also presented. Studies on historical developments of the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire, the two scales of the Science Teaching Efficacy Inventory questionnaire and Professional Development scale used to compile the Teacher's Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire for data collection purposes were reviewed.

In Chapter 3 the investigation on perceptions about teacher knowledge was approached from two different perspectives – the engineering students' and lecturers' views. A mixed methods research design, which utilised qualitative and quantitative approaches and techniques to collect and analyse data was used to investigate the perceptions held by students and lecturers. Data from 450 completed Student Perceptions of Teachers' Knowledge questionnaire (SPOTK) were used for providing answers to Research Question 1. The Teachers' Beliefs about Teaching and Learning in Engineering (TBTLE) questionnaire was used to collect data from 24 engineering lecturers in response to Research Questions 2 and 3. Nine lecturers participated in in-depth semi-structured interviews. The data from students' open ended questions and lecturers' interviews were used to compliment the quantitative results about teaching and learning knowledge and professional development.

Quantitative data from the questionnaires were analysed using the SPSS. Qualitative analysis of students open ended questions on courses perceived to be difficult or easy were conducted to further identify perceptions about other issues regarding teacher

knowledge which could have been omitted by the limitations of the scope of scales and items in the SPOTK questionnaire. The interviews from the lecturers were used to gather more information about the perceptions of the lecturers on their own teaching knowledge and professional development.

Chapters 4, reported results and findings in response to Research Question 1 on students' perceptions of teachers' knowledge. Chapter 5 presented the quantitative results and findings about lecturers' perceptions of own teaching knowledge in response to Research Question 2. In chapter 6, results and findings in response to Research Question 3 about lecturers' professional development sources were presented. Chapter 7 provide the results from interviews with the lecturers on teaching, learning and professional development in response to Research Questions 2 and 3.

This chapter provides a summary of the major findings of the study, the implications for teaching and learning in engineering. Limitations of the study and recommendations for future research and conclusions are considered.

8.3   Major Findings and Implications for Teaching and Learning

The major findings from this study are presented according to the associated research questions. In the discussion narrative of the major findings I have embedded the implications for teaching and learning in engineering. This approach was taken in order to make the integration of the findings, teaching implications and supporting literature cohesive and interesting to read. Therefore, there is no separate section dedicated to the implications on teaching and learning in this chapter.

8.3.1 Findings for Research Question 1

Research Question 1: What are students' perceptions of their lecturers' teaching knowledge within their engineering classrooms?

The focus of this research question was to ascertain the perceptions of students in the seven engineering programmes about their lecturers teaching knowledge using four teacher knowledge scales in the SPOTK questionnaire - Instructional Repertoire,

Representational Repertoire, Subject Matter Knowledge and Knowledge of Students'
Understanding.

*Research sub-question 1.1: Is the student perception of teacher knowledge (SPOTK)
questionnaire reliable for use in a higher education institution to explore
perceptions of students about teaching knowledge of their lecturers?*

Since this study used the SPOTK for the first time in higher education engineering
learning environment, reliability of the questionnaire had to be investigated. The
results in chapter 4 revealed that the internal consistency for the instructional
repertoire, representational repertoire, subject matter knowledge and knowledge of
students' understanding scales was acceptable. Each of the scales produced
Cronbach's alpha coefficient values of above 0.70. Thus the results confirmed that
the teacher knowledge scales in the SPOTK were reliable for use in the engineering
classrooms of this study. The Pearson correlation coefficient value of above 0.40
confirmed acceptable inter-scale relationship between the four scales (see tables 4.2
and 4.3, respectively). These internal consistency results were found to be consistent
with the previous study by Tuan et al., (2000).

*Research Question 1.2: What are the perceptions of students from various
engineering programmes on each teaching knowledge repertoire evaluated by the
SPOTK questionnaire?*

The overall quantitative results revealed that the average mean scores between the
four scales ranged between 3.53 and 4.38, with subject matter knowledge at the
upper end of the range and representational repertoire at the lower end of the range
respectively (see table 4.2, tables 4.4a, table 4.4b and table 4.5.). This finding
suggested that students perceived their lecturers' teaching knowledge issues
represented by the four SPOTK scales positively.

The differences of perceptions about instructional repertoire, representational
repertoire, subject matter knowledge and knowledge of student understanding from
the various groups of students defined by the seven engineering programmes were
explored and the results were presented in section 4.2.3. ANOVA results revealed a
statistically significant difference in the instructional repertoire and knowledge of
student understanding scales (see table 4.5). The statistically significant difference in

two scales was found to be contributed by students' responses in electrical, civil and chemical engineering programmes. However, the Post Hoc Scheffe' tests showed that the effect of the differences was very small. Thus the perceptions of students in instructional repertoire and knowledge of student understanding scales in all engineering programmes were found to be similar.

Though the quantitative results have indicated that students perceived their lecturers' teaching knowledge positively in all the four scales of SPOTK, the findings from the analysis of individual items and responses from the two open-ended questions on courses perceived to be easy or difficult to learn revealed both confirming and contradictory information.

Instructional Repertoire: Analysis of the individual items which were rated above 4.0 on the Likert scale in the questionnaire revealed that the statements which were related to the teacher-centred teaching methodologies were selected by the majority of students. Statements which reflected learner centred teaching strategies were rated lower. This was not surprising as it confirmed students' familiarity with the predominant teacher centred teaching strategies which were used in their classrooms.

The results from open-ended questions revealed that students believed that some courses were perceived difficult to learn because lecturers used ineffective teaching methods and presentation skills. In addition, students believed that the teaching methods used by lecturers promoted memorisation of the subject matter. From this finding one could conclude that lecturers who taught courses perceived to be difficult, were still using teaching methods which were predominantly teacher centred such as talks and chalk. In contrast, courses which were perceived to be easy to learn were characterised by lecturers using a variety of teaching methods and strategies which made the lectures more interactive and interesting for students. Use of teacher-centred instructional methods and ineffective teaching strategies and presentation skills reported by students may demonstrate that lecturers had limited teaching knowledge and skills in selecting the best instructional repertoires for teaching their courses to meet the diverse needs of all their students. Selection of effective instructional repertoires by lecturers forms a key feature of pedagogical content knowledge principles. Effective teachers demonstrate a balance of good knowledge of subject matter knowledge and selection of instructional strategies to

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facilitate meaningful learning of the selected content (Grossman, 1990; Magnusson, et al., 1999).This dual competence for the teacher to integrate content with pedagogical knowledge forms a key principle in pedagogical content knowledge.

Representational Repertoire: The students' perceptions about the extent to which the lecturers used a variety of representational repertoires such as diagrams and graphs, familiar examples, models, demonstrations, analogies and metaphors to challenge students' conceptions and to enhance learning were elicited. Analysis of individual items revealed that a high percentage of students selected items which were related to the use of diagrams and graphs. This was not surprising as students were familiar with use of diagrams and graphs from the lectures and textbooks. Statements which were linked to other representational repertoires such as the use of models were rated lower. These findings imply that lecturers were probably not using the models and demonstrations more often in their classes hence students were not so much familiar with their usage in the classrooms. In addition, the finding confirmed comments made by lecturers during interviews that models were used by technicians in the practical laboratory sessions which were conducted separately from the theoretical content lectures.

On the contrary, students perceived certain courses to be easy to learn because lecturers effectively used demonstrations, graphs and models to teach difficult concepts. Though some students acknowledged that their lecturers used a variety of representational repertoires, there was however views of doubt about the competence of some of their lecturers to use models effectively to facilitate learning. This finding was consistent with comments made by the Surveying lecturer during interviews that most lecturers in engineering required some kind of professional development to learn about how to use engineering teaching aids effectively in order to facilitate meaningful learning.

Two major implications for engineering teaching and learning arise from these findings. First, the engineering profession is a field which uses models and technology to explain abstract knowledge. In addition, students use variety of learning styles to make sense of the engineering subject matter (Felder & Spurlin, 2005). The implication of limited use of variety of representational repertoires in class is that the students who are more visual and would have learned better from

models and demonstrations in class were left out during teaching. Students need to be exposed to use a variety of representational repertoires in the learning environments so that they could develop good understanding of engineering concepts. Secondly, lecturers who are perceived by students as not using representational repertoires well could demotivate students from experiencing learning environment in a positive way. Shepstone (2009) argues that the use of a variety of repertoires such as models, metaphors and demonstrations, could bring more negative teaching and learning outcomes if both the lecturers and students fail to understand the role of the models in the engineering teaching and learning situations.

Subject matter knowledge: Perceptions about lecturers' knowledge of the engineering content were explored. Issues examined included the lecturers' knowledge of the content, how history and theories in the subject have been developed, satisfaction about the lecturers answers to the students' questions on engineering concepts, how the lecturer related science and engineering to societal problems and needs. Analysis of individual item responses showed that majority of the students agreed more positively with the items which represented knowledge of content, theories and principles of engineering disciplines. Items related to how science, engineering and technology were related to society received lower rating. This finding suggests that students' experiences of knowledge of the subject matter was only limited to the theoretical content they were taught in class. However, the relationship between engineering content with societal needs and how it is used to solve real-life problems was not addressed through subject curriculum content. This finding was corroborated by comments made by some lecturers during the interviews that engineering content was full of abstract content and mathematical calculations. In addition, there were concerns that textbooks presented alien examples to students. Students could not relate such content with the societal issues of interest to local engineers. Due to the abstract nature of the content and the teacher-centred teaching strategies, students preferred to memorise content without generating meaningful understanding of how engineering concepts related to day to day functioning of engineers in society. The implication of this finding is that the approach to presentation of the subject matter in the engineering classrooms was not designed to

include issues of societal nature and how engineering knowledge is used to address those issues.

The students believed that some courses were difficult because lecturers failed to explain the concepts, formulae, drawings and graphs which consequently led to the students' perception that some of their lecturers' did not have good knowledge of the subject matter. This finding has always led to a contentious concern about knowledge of the subject matter between some students and lecturers in some courses in the Faculty of Engineering. Students and lecturers' views of how the subject matter is presented in engineering would always differ because different students prefer different teaching approaches and learning styles (Mills, (2002). Therefore lecturers need to broaden the use variety of instructional strategies in order to ensure that all students could generate meaningful learning of the difficult concepts.

Knowledge of student understanding: Knowledge of student understanding is associated with the lecturers' knowledge of students' understanding of concepts, use of most appropriate variety of strategies to evaluate students' understanding, diagnosis of prior knowledge and misconceptions which students bring to class and use of the appropriate assessment techniques to evaluate students' understanding.

The quantitative results showed that students' perceived their lecturers to have a good knowledge of students' understanding. The results implied that students were satisfied that their lecturers knew how to use a variety of strategies and approaches to assess and evaluate their understanding of concepts. However, analysis of responses on individual items revealed that a majority of students selected items in the scale which were associated with tests as forms of assessment. The other items such as for example, 'my lecturer use of different approaches to assess my understanding' and 'my lecturers' questions evaluate my understanding|' received lower scores. This finding was not surprising as students were only familiar with the use of tests and examinations as forms of assessment of learning.

In contrast, the qualitative results about courses perceived to be difficult to learn revealed concerns about the way in which assessments were conducted. Students were concerned that teaching approaches used in the classrooms were not compatible

with the assessment practices. Lecturers were perceived to use simple examples in class during teaching, but tests and examinations questions were composed of difficult and unfamiliar examples. This finding suggests that there could have been a lack of shared understanding of the assessment criteria, learning activities and the learning outcomes of the courses between lecturers and their students. The implication of this finding on teaching and learning is that students might lose interest in learning if they perceived that assessment practices were unfair. This might have negative consequences on success rate and attrition in the programme. Lecturers have to ensure that there is consistency between teaching approaches and strategies used to teach the subject matter with assessment approaches.

The second major finding in this domain was that students acknowledged that they found some courses difficult because of their inadequate knowledge in fundamental concepts and skills in mathematics and engineering. Treagust et. Al (1996) argue that prior knowledge serves as an important foundation for successful teaching and learning. Therefore, it is important that lecturers in this study develop a culture to conduct assessments to diagnose students' level of prior knowledge and misconceptions and use the results to select the most appropriate instructional approaches to address the identified weaknesses.

The constructivist approach to teaching and learning regards diagnosis of students' level of prior knowledge as a starting point in every lesson (Treagust, et al., 1996; Treagust, Jacobowitz, Gallagher, & Parker, 2003). The finding that lecturers, though they knew that their students revealed inadequacies in mathematical fundamental knowledge, yet could not do anything to address such inadequacies in their teaching confirmed their inadequacies in PCK. Knowledge of students' prior knowledge is a critical feature of PCK. Therefore, lecturers need to integrate both subject matter expertise with appropriate pedagogical content knowledge to be able to address issues of students' prior knowledge in their teaching. A teacher with sufficient pedagogical content knowledge will understand what makes learning of specific concepts easy or difficult to learn (Shulman, 1986, 1987). Knowledge of students' abilities, learning styles and strategies and prior knowledge of concepts to be taught differentiates teachers from subject matter experts (Cochran, 1997).

The third major finding was that students raised concerns that they could not understand some engineering concepts because of the perceived misalignment between their learning styles with the teaching strategies used in class by lecturers. Some students indicated that they preferred to learn textual material because they could memorise the texts easily. However, because they could not memorise content embedded in mathematical applications, they viewed such content as difficult to learn. On the contrary, there were students who enjoyed learning content embedded with lots of mathematical applications. This finding indicates that students used variety of learning styles to make sense of engineering content. Some students, because their learning styles were not aligned to the nature of the content, encountered conceptual difficulties when learning engineering content inherent with mathematical applications and required deeper thinking than surface learning. The finding suggest lecturers may be having limited pedagogical content knowledge to understand the impact of their students' learning styles on the learning process and thus select most the appropriate teaching approaches to address the learning needs of their students.

Overall, the findings on knowledge of students' understanding domain have indicated that students perceived some of their lecturers not to have good knowledge of students' understanding and assessment in engineering. This finding has implications on the lecturers to broaden their teaching knowledge about how student create meanings of the subject matter. In addition, assessment approaches used to evaluate student understanding of content need to go beyond the use of traditional tests and examinations. Frequent use of a variety of other diagnostic assessment tools is required so that students' learning experiences and success rates in the programmes could be improved. In addition, the finding that students learning styles contribute to emergence of learning difficulties in content embedded in mathematical concepts and applications indicates that students learning needs are not fully addressed and thus could signal attention by the lecturers. Knowledge of students' learning styles are useful in assisting the lecturers to design alternative teaching strategies to address the learning needs of all their students (Felder & Spurlin, 2005).

Overall, in response to Research Question 1, the findings indicated that students perceived their lecturers' teacher knowledge both positively and negatively. These

findings are not surprising within the context of teaching and learning in many South African Higher education institutions. Within the higher education institutions, teaching practices have not yet been fully transformed to take into account diversity of students profile and learning needs. Even though there are pockets of innovation in teaching across the sector, traditional teaching approaches remain predominant across the institutions, faculties and at programme level (Scott et al. 2007). Not all lecturers have relevant competencies in teaching knowledge to teach effectively to facilitate meaningful learning amongst all their students. Therefore these findings have implications for engineering educators to broaden their teaching knowledge to address the students' concerns identified by the findings to Research Question 1.

8.3.2 Findings for Research Question 2

Research Question 2: What are lecturers' perceptions of their own teaching knowledge in engineering classrooms?

The answers to Research Question 2 were produced from data collected through two teaching efficacy scales in the lecturers' questionnaire and interviews with selected lecturers.

Research Question 2.1: Are the personal teaching efficacy and teaching outcomes expectancy efficacy scales reliable for use in a higher education institution to explore perceptions of engineering lecturers on their own teaching knowledge?

The results indicated that personal teaching efficacy belief (TE) and teaching outcomes expectancy efficacy (OE) scales produced Cronbach's alpha reliability coefficient values of above 0.7 respectively. The high Cronbach's alpha coefficient values confirmed that the personal teaching efficacy beliefs and teaching outcomes expectations efficacy scales were reliable for use in engineering classrooms used in this study. The Cronbach's alpha coefficient values were found to be consistent with the results reported in the previous studies (Bleicher, 2004; Kiviet, 1996; Riggs & Enochs, 1990; Thair, 1999).

Research Question 2.2: Is there a relationship between lecturers' personal teaching efficacy beliefs and the qualifications they taught, the highest qualification held by lecturers and the period when they last participated in teaching professional development activities?

Research Question 2.3: Is there a relationship between the lecturers' teaching outcomes expectancy efficacy and the qualifications they taught, the highest qualification lecturers held and the period when they last participated in teaching professional development activities?

Differentiation in perceptions of the lecturers were investigated using the biographical profiles defined by the qualifications the lecturers taught, the highest qualification lecturers held and the period when they last participated in teaching professional development activities? There was a premise that these biographical profiles would have effect on their perception about teaching knowledge. The answers to Research Questions 2.2 and 2.3 were combined for the purposes of presenting the major finding concisely.

ANOVA statistic results revealed that there was no statistically significant difference between the perceptions of groups of lecturers about personal teaching efficacy beliefs and teaching outcomes expectancy efficacy when defined by the qualifications they taught, highest qualification they held and their period of participation in professional development activities respectively. Biographical profile of lecturers had no effect in differentiating the lecturers' perceptions about teaching knowledge and expectations about students' achievement.

Research Question 2.4: What were the most predominant perceptions of the lecturers about their teaching knowledge?

The overall quantitative results of the lecturers' perceptions for personal teaching efficacy beliefs (TE) revealed high average item mean scores of above 4.0 (see Tables 5.11 and 5.12). The results indicated that the lecturers viewed their teaching knowledge extremely positively. This finding suggests that the lecturers were satisfied that they had adequate teaching knowledge competences to teach effectively in their engineering courses. High personal teaching efficacy beliefs scores were

reported to be positively associated with high teaching competence perceptions (Goddard, et al. 2000; Riggs & Enochs, 1990).

On the contrary, the lower average mean scores of 3.14 (see Tables5.11 and 5.13) obtained for the outcomes expectancy efficacy (OE) scale suggested that the lecturers did not have similar confidence they had with TE, that their students would succeed well following the lecturers' effort to facilitate teaching interactions in the classrooms. According to Riggs and Enochs (1990) lower scores in OE might be contributed by the other factors the lecturers perceived to be outside their control and yet had effect on the quality of student learning such as inadequacy of resources, ill preparedness of students to cope with the demand of the engineering curriculum and low motivation of students to learn. Teachers with high personal teaching efficacy and low outcomes expectations efficacy may try hard to intensify their teaching efforts to improve the students learning experiences and achievement. Consequently, if all their efforts fail to improve the situation, teachers may ultimately be frustrated (Riggs & Enochs, 1990). Frustration may lead to demotivation and lack of interest in improving one's teaching efforts. The findings from interviews revealed behaviour of frustration amongst lecturers regarding their students' quality of learning and overall academic performance. The lecturers believed that though they tried very hard to help their student performed well in their subjects, at the end they lost confidence in their expectations for better student achievement because of factors they perceived to be beyond their control such as students' lack of interest in their own learning reported in detail in Chapter 7.

The findings in terms of how lecturers perceived their own teaching efficacy is important in terms of the implications for planning relevant professional development programmes. Past studies (Bleicher, 2004; Enochs & Riggs, 1990; Enochs, et al. 1993; Kiviet, 1996; Thair, 1999) have reported the benefits which resulted from the use of teaching efficacy measuring tools to collect teachers' perceptions of own teaching knowledge competences. Amongst the benefits reported is the use of teaching efficacy scales as measuring tools to identify the teachers' needs for professional development in science content and pedagogical knowledge. Therefore the findings in this study have the potential for informing conceptions of

professional development of engineering educators to address factors that led to the lecturers' perceiving their teaching outcomes expectations less positively.

Findings from interviews

Teaching approaches and strategies: The interview results revealed that lecturers did not have a shared view of teaching in engineering. Some thought it was about vocational training of engineers whilst others lecturers believed that it was about teaching content knowledge so that graduates could apply it in the industry to solve engineering problems. However, both groups agreed that the current teaching approaches used in engineering classrooms did not yield the preferred student achievement outcomes. This finding confirmed the lower rating on the teaching outcomes expectancy efficacy scale revealed by the quantitative results.

Secondly, the lecturers' perceptions about predominant teaching approaches and strategies used in their classrooms varied. The most predominant teaching approaches and strategies used in many classrooms were found to be teacher-centred methods. This finding confirmed that teaching approaches and strategies used in the engineering classrooms of the lecturers in this study were not consistent with the constructivist teaching and learning principles. In addition, the finding about lack of knowledge in selecting appropriate teaching strategies acknowledged by the lecturers' signals that lecturers' pedagogical content knowledge was limited hence they could not address the teaching challenges they faced in their classrooms successfully.

The results indicated that lecturers were aware of their limitations regarding teaching knowledge, especially with the selection of appropriate teaching approaches and strategies to can motivate their students to learn meaningfully. Hence some lecturers thought that their teaching methods were not effective, which signalled a low personal teaching efficacy. This finding contradicted the quantitative results reported in Chapter 5, where lecturers perceived their personal teaching efficacy extremely positively. Acknowledgement of shortcomings in teaching knowledge is a positive indicator of reflection on one's teaching practices. Questioning one's existing teaching practice and acknowledging the limitations of what one currently knows can therefore be regarded positively as a part of a professional commitment to

continuing professional development rather than a sign of weakness (Burn, 2007; Rodrigues, 2005).

Knowledge of student understanding and learning: Knowledge of student understanding and how learning took place was found to be low amongst the lecturers. Responses about attitudes towards student learning revealed that lecturers were not satisfied about the quality of learning in their courses. The lecturers attributed the low success rate to students' lack of prior knowledge and exposure in engineering. Another factor perceived to be a major contributor of low student achievements was attributed to students' general negative attitude towards their own learning. The finding confirmed the results reported in chapter 5 where lecturers had perceived their teaching outcomes expectancy efficacy with uncertainty, which suggested that they had low confidence that their teaching efforts would yield good student achievements since they believed that they had no control on students' attitudes towards learning.

Learning styles: The interview results revealed that most lecturers did not know or understand how their students generated meanings of the engineering concepts they taught in class. Some of the lecturers did not consider that it was important to know the kind of learning styles their students used to make sense of the subject matter taught in class. When asked about how they recognised diversity in learning, lecturers' responses revealed that embracing diversity in student learning varied from lecturer to lecturer. Recognition of student diversity in teaching was done more on a personal level. The implication of these findings for learning is that teaching approaches selected by lecturers need to take student diversity in learning styles into cognisance during planning and implementation of the lessons. Knowledge of students' learning styles may benefit lecturers in the sense that it provides guidance and awareness to about the diversity of learning styles within their classes. Furthermore, it helps lecturers to design instructional strategies that address the learning needs of all students (Felder & Spurlin, 2005). Allie, et al. (2009) suggest that teaching approaches such as participative discursive communities, which integrate variety of teaching, learning and assessment strategies into a topic or theme, are very good at stimulating diverse groups of students with various learning styles to learn together and also understand how engineers work in reality.

Prior knowledge: The importance of identifying prior knowledge and misconceptions which students brought to class and teach accordingly were found not to be part of the teaching practice of many lecturers. This finding was not surprising since students' responses on why certain courses were perceived to be difficult (chapter 4) indicated that their lack of adequate prior knowledge in engineering and mathematics was a hindrance to meaningful learning. Lecturers acknowledged students' lack of prior knowledge in fundamental knowledge areas such as mathematics. However, results revealed that lecturers did not have mechanisms in place to diagnose and address students' lack of prior knowledge. The findings suggest that the lecturers had inadequate pedagogical content knowledge to identify their students' prior knowledge (Treagust, et al. 1996) and thus teach accordingly. This finding has twin implications on the effective teaching and meaningful learning of engineering concepts. First, identification of students' prior knowledge on concepts in any topic in engineering is important because it highlights the differences in conceptions between students and lecturers. Secondly, it provides the lecturers with awareness about their own shortcomings with respect to teaching knowledge, especially in addressing knowledge about strategies which could be employed to diagnose and address students' lack of prior knowledge or alternative conceptions. Knowing how to address students' prior knowledge is an important feature of constructivists' teaching approaches and pedagogical content knowledge (Treagust, et al. 1996). Lecturers can to broaden their pedagogical content knowledge in order to change their teaching practice to accommodate diagnosis and challenge students' prior knowledge.

Assessment: The results revealed that lecturers had different views about what assessment was supposed to achieve in engineering. On the main, the majority believed that it was about grading and promotion of students in terms of checking how much engineering theoretical knowledge/content the students have mastered. Hence the predominant assessment approaches and techniques used were pencil and paper tests and examinations. Fewer lecturers understood assessment to be a process to evaluate student understanding of concepts and diagnose any possible learning problems. The finding confirmed that many lecturers, even though they have been involved in student assessment for a long time in their teaching career, did not have

adequate knowledge of the purpose of assessment as defined by constructivists' learning theories.

Secondly, all agreed that assessment was the main driver of teaching and learning in their courses. This finding was corroborated by students' views that in some courses assessment were not aligned with teaching strategies in the classroom. The finding suggest that lecturers could have limited pedagogical content knowledge to address the challenges associated with selection of appropriate and effective assessment approaches to evaluate learning. The implications of these findings are that teachers ought to broaden their assessment knowledge base in order to provide students with a large and diverse range of assessments opportunities for the purposes of gathering some knowledge of whether students have understood concepts correctly. This is in line with principles of assessment within the constructivists' theories of learning. However, only teachers with adequate pedagogical content knowledge are more inclined to use a variety of assessment techniques to assess their student understanding of concepts and their progress in developing meaningful learning.

Knowledge of students learning difficulties: Knowledge of student learning difficulties and the need to provide support to assist students varied amongst lecturers. The results suggest that additional support from lecturers was done at a personal level, depending on the passion, commitment and level of trust between the lecturers and students. Waghid (2000) reported that engineering learning environments lacked a special teaching and learning relationship based on passion and trust amongst students and lecturers. Waghid (2000) referred to this teaching and learning relationship as dialogical agape. According to Waghid (2000) incorporation of dialogical agape in engineering teaching and learning environments could improve interactions between students and lecturers and consequently increase students' positive learning experiences and academic achievement.

In response to Research Question 2, the overall findings indicated that lecturers had both positive and negative views about their teaching knowledge. Quantitative results revealed that lecturers were highly positive about their teaching knowledge. On the contrary, lecturers were less positive about their expectations of their students' achievement. The qualitative information provided deeper and contradictory views about lecturers' perceptions of their own teaching knowledge. In

addition, the information revealed that lectures teaching knowledge bases were not adequate to facilitate meaningful learning, confirming the concerns raised by students in Chapter 4. Understanding of how student learn is a concept not understood and practiced by these engineering lecturers (Shepstone, 2009).

Lecturers have acknowledged their limitations in teaching knowledge. Acknowledgement of inadequate teaching knowledge signalled the need for lecturers broaden their teaching knowledge bases. For engineering lecturers to broaden their teaching knowledge base they need to engage with modern teaching and learning theories ascribed to constructivism and pedagogical content knowledge principles. This change requires a paradigm shift of beliefs and practices about teaching.

8.3.3 Findings for Research Question 3

Research Question 3: What are the lecturers' perceptions of their professional development?

In response to Research Question 3, two sources of data were used, the TBTLE questionnaire part C (professional development scale) provided quantitative results (in chapter 6) whereas the qualitative findings (in chapter 7) were generated from the interviews with select lecturers.

Research Question 3.1. Is the professional development scale reliable for use in a higher education institution to explore the perceptions of engineering lecturers on their professional development?

The findings in chapter 6 revealed that the professional development scale attained Cronbach's alpha coefficient value of 0.95. The high reliability coefficient value confirmed that the scale was reliable for use with the sample of engineering lecturers used in this study.

Research Questions 3.2: Is there a relationship between the professional development scale with the qualifications the lecturers taught, the highest qualifications held by the lecturers and the period of participation in professional development activities?

The ANOVA statistics results revealed that there was no statistically significant difference between lecturers' perceptions on professional development scale when defined by the qualifications taught by lecturers, the highest qualification held by lecturers and the period of participation in professional development activities. The findings suggest that the lecturers profiles such as qualifications they taught, the highest qualification held by lecturers and their participation in professional development activities did not have any effect on perceptions about their sources for teaching knowledge professional development.

*Research Question 3.3***:** *What were the most predominant opinions about sources of professional development the lecturers preferred to participate in?*

There are various sources of professional development lecturers could use in broadening their teaching knowledge. The overall quantitative results (Table 6.1) revealed that lecturers perceived their professional development sources and activities positively. The predominant sources and activities for professional development which were perceived highly by lecturers were those that involved attending activities organised by the various engineering professional bodies, reading scientific materials in engineering disciplines, talking to students, reviewing own teaching materials and receiving support and sharing of resources from colleagues. Student Involvement as a source of professional development for teaching knowledge was found to be only limited to mandate institutional student course evaluation surveys. However, not all lecturers used the feedback from surveys to improve their teaching practices.

Collegial activities and reading of educational materials were perceived less positively compared to external sources and student involvement sources. The findings from the interviews corroborated the results from quantitative data. Collegial activities such as peer evaluation, visits to colleague's classes, team teaching, and collaborative teaching were found not to be part of the culture in the Faculty of Engineering. Collegial activities were only limited to sharing of teaching resources where it was necessary. The interview results revealed that collegiality was not practiced because there was a measure of mistrust amongst the lecturing colleagues. The implication of mistrust amongst academic colleagues is that it hinders good possible collective efforts through collegial activities which would

have benefitted lecturers regarding sharing of experiences and expertise to enhance their teaching knowledge. Goddard et al. (2000) suggest that teacher efficacy is positively related to trust in colleagues. Where there is no trust there is likelihood that collective teacher efficacy levels about teaching task orientation may be low. Highly trusting teachers offer enhanced level of collegiality and more opportunities for learning than are found in teaching and learning environments where teachers perceive less trust. This suggestion by Goddard et al. (2000) if applied to the engineering environment where this research study took place it has a potential of shaping the collective beliefs of the lecturers on teaching knowledge competence development and its subsequent effects on the common decisions taken to broaden their teaching knowledge.

There was acknowledgement from lecturers that their teaching knowledge competences were inadequate and thus needed to be broadened. However, when lecturers were asked to identify their most preferred sources of teaching knowledge professional development, there were differences in how lecturers responded. Participation in professional board activities continued to be at the top of their preferred list of sources. There was a shared view by most lecturers that advancement of discipline knowledge was a priority rather than teaching knowledge competences. Advancement of the discipline knowledge at the expense of pedagogical knowledge is unlikely to bring improvement in teaching competences and subsequent expected student achievement (Grossman, 1990; Jang, 2011). Knowledge of how to present the subject content in order help students learn meaningfully is also important. Pedagogical content knowledge integrates both subject knowledge and pedagogical knowledge. Therefore, a lecturer committed to effective teaching and consequently meaningful learning, would ensure that advancement in discipline knowledge is balanced with broadening of teaching knowledge.

Professional boards are known to be mostly involved with establishment of frameworks for the engineering competences or graduate attributes to be taught in universities in order to produce competent graduate engineers (Mills, 2002; Shepstone, 2009). However, there is very little information available to show that all engineering professional boards are rigorously involved in the development of engineering lecturers as professional teachers. This is a concern since the results

from this study had shown that the most predominant source of professional development was the activities organised by the professional boards. The implication of this finding is that lecturers will continue to ignore the importance of growing as teachers but only focus of improving their discipline knowledge.

The results revealed that there were lecturers who preferred to participate in teaching knowledge development programmes tailor-made for engineering educators. Generic teaching knowledge development courses were reported to have no value on improving teaching knowledge for engineering learning environments. The findings suggested that teaching engineering was viewed as an occupation with special tools of the trade. Thus, engineering lecturers needed more special teaching knowledge development programmes to broaden their knowledge and skills appropriate for teaching engineering content.

The overall findings in response to Research Question 3 indicate that lecturers perceived their professional development positively. However, there were signals that engineering lecturers recognised that they had inadequate teaching knowledge competences and would therefore benefit from participating in contextualised teaching development programme which would address their needs in engineering education. A suitable engineering professional development in this regard, I would argue, should integrate teaching and learning principles ascribed to constructivism and pedagogical content knowledge. Pedagogical content knowledge was reported to be able to integrate seven domains of pedagogical knowledge which has relevance to teaching content in a specific subject or discipline such as in school science (Tuan, et al. 2000) and a physics learning environment in a higher education institution (Jang, 2011). Therefore, the findings from this study have profound implications for the conceptualisation and implementation of teaching knowledge professional development programmes earmarked for broadening teaching knowledge of engineering lecturers.

8.3.4 Perceptions about Curriculum Structure and Behavioural Factors of Affective nature

Findings related to the curriculum structure and factors of affective nature emerged from the analysis of responses from the students' two open ended questions (in

chapter 4) and lecturers' interviews (in chapter 7). Although curriculum structure and affective factors did not form part of the constructs of investigation in this study, the findings revealed some concerns worth reporting. The discussions of the major findings on perceptions about curriculum structure and behavioural factors of affective nature and their implications on teaching and learning are presented in Appendix 6.

8.4   Limitations of the Study

There is no research project that is without limitations. Even though findings in this study are supported by literature from previous studies there are limitations which need to be taken into account.

Sample of participants and generalisation of findings: The major limitation of this study was the small sample of lecturers who participated in the study. Small samples have a tendency to reduce the validity of the findings on generalisation (Cohen, et al. 2007). In addition, the participants in this study were all lecturers and students at one campus of the university. It is possible that perceptions of teaching knowledge of students and lecturers in engineering at other distant campuses of the university may differ with the findings in this study. This limitation contributed towards making the results of this study not to be generalizable to the entire engineering lecturers and students with the university and in other South African higher education institutions offering engineering programmes. Due to this limitation, the data collected by the Teacher Beliefs about Teaching and Learning in engineering (TBTLE) questionnaire in this study was therefore more exploratory in nature. In order to increase reliability of the results to be generalizable in other engineering learning environments outside of this study, further research is recommended for more studies to be conducted using the questionnaires with a larger and diverse sample of engineering lecturers and students.

Timing of administering student surveys: The survey was coincidentally conducted at the same time with the end of first term series tests. It was difficult to get all participants to cooperate, though they had initially agreed to participate in the research. Hence, I had experienced difficulties in getting all the identified participants to return the completed questionnaires.

Bias and subjectivity: Possible personal biases of the researcher as a practitioner in teaching development and quality assurance in higher education could have indirectly influenced the interpretation of findings. In addition, a closer working relationship between the researcher and the engineering lecturers might have indirect influence on how they responded to the interviews questions. According to Cohen, et al. (2007) interviewers and interviewees alike bring their own experiential and biographical baggage into the interview situation unconsciously. Even though the researcher has followed guidelines on improving validity and reliability of interviews by for example using an interview question schedule, research with human beings is a dynamic social process hence limitations would always ensue.

Data collection instrument and validation of scales for higher education learning environments: The teacher knowledge and professional development scales used in the TBTLE and SPOTK questionnaires were used for the first time in higher education engineering environment. In addition, the constructs investigated in this study on teaching knowledge and professional developments are fairly new within the research history in engineering education in South Africa. The original scales and items in the two questionnaires used in the study were rigorously validated for use with primary and secondary school science teachers. Even though at first attempt of use in this study, the Cronbach's alpha coefficients values were found to be high and revealed acceptable reliability, the tests were only limited to a small sample in the case of the lecturers.

Limitations on the use of questionnaires to collect data: The qualitative data from students and lecturers shed more light into the issues about teaching and learning in engineering than the quantitative data. This shows that the questionnaire items were limited in eliciting some of the important issues such as curriculum knowledge in teacher knowledge within the engineering teaching and learning environment. This is a fair shortcoming of the current questionnaires, taking into account that the questionnaires were initially designed for use with primary and secondary schools' science learning environments. It is recommended that the findings generated from the qualitative data in this study could be used to construct more scales and items to include curriculum knowledge in the SPOTK and TBTLE questionnaires to make

them more suitable to address other aspects of teacher knowledge peculiar to Higher Education Institutions' engineering learning environments.

8.5   Recommendations for Future Research

1. Literature survey revealed that research studies in teacher knowledge, especially in pedagogical content knowledge and the teaching professional development of engineering lecturers is limited. There is a need to conduct more studies in this area in order to build a robust body of knowledge in teacher knowledge and engineering education.

2. The development, implementation and evaluation of an intervention programme in pedagogical content knowledge using the findings of this study could further advance knowledge in how engineering educators develop their teaching knowledge and skills. In addition, a research project linked to such an intervention of professional development would provide more insights into how improved teaching knowledge impacts on student outcomes and improved learning outcomes.

3. The limitations of the use of questionnaires described earlier may be resolved by conducting research to examine lecturers' pedagogical content knowledge through case studies with lecturers and focus groups of students. In addition research could be conducted to investigate how perceptions of students' teacher knowledge relate to variables such as student performance and academic outcomes

4. The scope of this study was only limited to eliciting perceptions about teaching and learning knowledge from the perspective of lecturers and students as participants. However, the results revealed that there were teaching and learning concerns which may require involvement of other stakeholders beyond lecturers and students. Therefore, future studies on engineering teacher knowledge views from the perspectives of engineering curriculum developers, practicing engineers and engineering education policymakers could shed more light on what is perceived as engineering education within the context of South African economic and post- school educational contexts, what does it aim to achieve and how should teaching and learning be addressed?

5. Lecturers could use SPOTK to conduct self-assessment of one's teaching and ask researchers to play third party to evaluate the lecturers' response so that they can discover in-depth data on the lecturers' core PCK.

8.6   Significance of the Findings

There are several major findings of significance for the benefit of engineering teaching and learning environments which emerged from this study.

1. Knowledge of engineering students' and lecturers' perceptions about teaching and learning is significant in classroom teaching practice. Students and lecturers, because they experience teaching and learning differently due to their different roles in the teaching and learning process, are bound to have differences in how they perceive their classrooms. It is important to collect feedback from both role players frequently. Therefore the findings in this study add to the body of knowledge in studies on teacher knowledge of engineering educators.

2. It was the first time that the SPOTK questionnaire, personal teaching efficacy beliefs and teaching outcomes expectancy beliefs scales from STEBI questionnaire and a teaching professional development scale were used with students and lecturers respectively in one study. Previously these tools were used in primary and secondary schools science classrooms worldwide. Therefore, the use of these tools in this study broadened the use of these instruments not only in engineering learning environments but within higher education sector as well.

3. Findings from a study such as this has potential value for engineering educators to reflect on how they teach and identify their short comings in terms of teaching knowledge and skills. Subsequently they may decide to do something to change their teaching based on a new knowledge gained from themselves and their students. For instance engineering educators may decide to improve their teacher knowledge in order to create a balance between their personal teaching efficacy and student outcomes expectations efficacy.

4. The results from this study had revealed that in many instances lecturers teaching knowledge was perceived to be inadequate. The study provides valuable information in conceptualising a more relevant teaching professional

development programme for engineering lecturers. It is recommended that the design of the professional development programme should take into cognisance the integration of the social constructivist theories of teaching and learning and the pedagogical content knowledge principles. In addition, the success of a good professional development programme needs to be a collaborative project between the lecturers and those entrusted with teaching development of staff within the university.

8.7   Conclusion

The purpose of this study was to investigate the engineering students' and lecturers' perceptions about teaching knowledge. The study was conceived from the personal experiences of the researcher and the concerns of the Faculty of Engineering staff about low success rate in engineering programmes. Its groundwork was further strengthened by review of previous studies in teacher knowledge and engineering education

Though it was the first time that the Student Perceptions of Teachers' Knowledge (SPOTK) questionnaire, the two teaching efficacy scales from the Science Teaching Efficacy Beliefs Inventory (STEBI) questionnaire and a Teaching Professional Development scale were used successfully with students and lecturers respectively in a South African University of Technology environment. The use of a mixed-method research design produced more valuable findings than if only questionnaires were used as tools to collect data. The findings from the qualitative data complimented information from the quantitative data. The study findings revealed that the students and lecturers perceived teacher knowledge, teaching and learning in the engineering classrooms both positively and negatively. In addition, the findings revealed concerns related to the curriculum structure and behavioural factors of affective nature which were perceived by both students and lecturers as negative contributors to the quality of teaching and learning in engineering.

The findings have successfully revealed interesting and important information to add to the body knowledge on teacher's knowledge and professional development. In addition, the findings have practical implications for engineering lecturers, curriculum designers and planning practitioners, engineering academic managers, policy makers, professional boards may also benefit from using the information

about students and lecturers perceptions of teaching and learning to influence curricula reform in engineering education in South Africa.

It is important to ensure that engineering teaching and learning within higher education institutions in South Africa is of good quality. Therefore, continuous engagements in studies about perceptions of teaching and learning knowledge are of utmost importance with a view of improving the quality teaching and learning. Subsequently institutions would achieve higher success, throughput and graduation rates in engineering qualifications. .

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APPENDICES

Appendix 1: Request Letter to The Executive Dean

Tshwane University of Technology

Caroline Selepe
Department Teaching and Learning Development
Soshanguve Campus
Tel: 012 7999748
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24 February 2004

Dean
Faculty of Engineering
Tshwane University of Technology
Rand Campus

Dear Prof F Otieno

RE: **REQUEST TO CONDUCT A SURVEY IN THE FACULTY OF
       ENGINEERING AT TSHWANE UNIVERSITY OF TECHNOLOGY**

I hereby request for permission to conduct a survey through questionnaires and
interviews with some staff and students within the faculty. The participants will be the
academic staff and S2 to S6/ final year students in the following departments:

- Architecture
- Building Science
- Civil
- Surveying
- Electrical
- Mechanical
- Chemical Engineering

Data will be collected during the month of March. Both teaching staff and students will
complete the questionnaire (student version attached). Staff version will be made
available to you as soon as it has undergone expert review. Selected staff members and
students will be interviewed a few days after completion of questionnaires. The detailed
plan of data collection schedule will be presented to you once permission has been
granted.

We empower people

Tel. 0861 102 422, Tel. (012) 318-5911, Fax (012) 318-5114, www.tut.ac.za • The Registrar, Private Bag X680, Pretoria 0001

I promise to treat all the information that I may collect during the process of research with respect and confidentiality. Therefore the data collected will be used for the purpose of enabling me to perform my research.

Principles on ethics will be strictly adhered to. I have attached a copy of approval for my doctoral candidacy, by the higher degrees and ethics committee of Curtin University of Technology.

I am hoping that the outcome of this study will contribute towards enhancement of excellence in engineering education at TUT. The outcome of the study will be made available to any member of the faculty of engineering on request, and only if it will be used for teaching and learning purposes.

The title of my doctoral thesis: *Engineering lecturers and Students Perceptions about Teaching and Learning Practices in a South African University of Technology*

Your written response to the above request will be greatly appreciated.

Yours sincerely
Caroline Selepe, Ms

Appendix 2: Request to conduct survey with engineering lecturers

SOSHANGUVE CAMPUS
Private Bag X07
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0116

DEPARTMENT TEACHING AND LEARNING DEVELOPMENT

Caroline Selepe
Senior Academic Development Practitioner
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24 March 2004

REQUEST TO CONDUCT RESEARCH SURVEY IN THE FACULTY OF

ENGINEERING

Dear colleagues

I am currently conducting a study on improving the quality of science, engineering and technology education in tertiary institutions. The survey forms part of my doctoral studies with Curtin University of Technology.

I therefore request you to complete the attached lecturers' questionnaire, Teachers Beliefs about Teaching and Learning in Engineering and return it to me before we go on vacation on **2 April 2004**.

Please be rest assured that once the data have been entered into the database all links between your name and your reply will be removed and of course your views will not be revealed to your colleagues or anyone.

I will really appreciate your support on this endeavour since the main goal of the study is to identify areas of development for academic development and support for the faculty and to develop customized negotiated developmental programs.
Hopefully, the results of this study will help the faculty to prepare and implement strategies of quality assurance in teaching and learning, as promoted by the Higher Education Quality Committee and professional bodies.

I hope you will want to collaborate in this investigation. A feedback session of the summary of the results when they are published will be organised with the faculty or departments.

If you are able to give me the benefit of your views by returning the completed questionnaire in the next few days, please accept my thanks.

Yours sincerely
M C Selepe.

Appendix 3: Student perceptions of teachers' knowledge questionnaire

STUDENT PERCEPTIONS OF TEACHERS' KNOWLEDGE QUESTIONNAIRE

Questionnaire ID Code: (Office use only) Column 1

The purpose of this questionnaire is to ascertain the perceptions and views that you have concerning teaching and learning in engineering. You will not be graded on these results. It is very important that the researcher find out about your ideas of teaching and learning in your class.

The questionnaire contains statements about practices which could take place in your class. There are no right or wrong answers. Your opinion is what is wanted. Think about how well each statement describes what teaching and learning in engineering is like for you. Some statements are fairly similar to other statements. Do not worry. Simply give your opinion. Consider your options carefully. If you feel one or more options are only half correct, avoid choosing such an answer. Look for the responses that summarises your view.

The information contained in this questionnaire will be treated confidentially**.** The use of code numbers will guarantee anonymity.

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. YOUR ASSISTANCE AND COOPERATION IS HIGHLY VALUED.

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**STUDENTS PERCEPTIONS OF TEACHER'S KNOWLEDGE (SPOTK)
QUESTIONNAIRE**

PART A: BACKGROUND

Please tick in the correct box

1.   Campus: Soshanguve   ☐1   Pretoria   ☐2

2.   Engineering qualification enrolled: Architecture   ☐1

                                                      Building   ☐2

                                                      Civil   ☐3

                                                      Chemical   ☐4

                                                      Electrical   ☐5

                                                      Mechanical   ☐6

                                                      Surveying   ☐7

3.   Year of study   Semester 2 (S2)   ☐1

                                            Semester 3 (S3) ☐2

                                            Semester 4 (S4) ☐3

                                            Year 2   ☐4

                                            Year 3   ☐5

                                            Year 4   ☐6

4.   Gender**:**   Male ☐1   Female ☐2

5.   Race: Black   ☐1   Asian   ☐2   White ☐3   Coloured ☐4

PART B:

Instructions

  ❖ *Encircle the number representing your answer*

       1.   *if the practice takes place*   *almost never*
       2.   *if the practice takes place*   *seldom*
       3.   *if the practice takes place*   *sometimes*
       4.   *if the practice takes place*   *often*
       5.   if the practice takes place   **almost always**

PART B: Please choose one response from the scale that represents your closest view about the statements below.

IR	Almost Never	Seldom	Some Times	Often	Almost Always
1 .My lecturer's teaching methods keep me interested in engineering	1	2	3	4	5
2. My lecturer provides opportunities for me to express my point of view.	1	2	3	4	5
3 My lecturer uses different teaching activities to promote my interest in learning.	1	2	3	4	5
4. My lecturer uses appropriate models to help me understand engineering concepts.	1	2	3	4	5
5. My lecturer uses interesting methods to teach engineering topics.	1	2	3	4	5
6. My lecturer's teaching methods make me think hard.	1	2	3	4	5
7 My lecturer uses a variety of teaching approaches to teach different topics.	1	2	3	4	5
8. My lecturer shows us activities that I can use to continue my study of a topic.	1	2	3	4	5
RR	**Almost Never**	**Seldom**	**Some Times**	**Often**	**Almost Always**
9 .My lecturers uses familiar examples to explain engineering concepts.	1	2	3	4	5
10. My lecturer uses appropriate diagrams and graphs to explain science and engineering concepts.	1	2	3	4	5
11. My lecturer uses demonstrations to show science and engineering concepts.	1	2	3	4	5
12 .My lecturer uses real objects to help me understand science and engineering concepts.	1	2	3	4	5
13. My lecturer uses stories to explain science and engineering ideas.	1	2	3	4	5

14. My lecturer uses analogies with which I am familiar to help me understand science and engineering concepts.	1	2	3	4	5
15. My lecturer uses familiar events to describe scientific and engineering concepts.	1	2	3	4	5

SMK	Almost Never	Seldom	Some Times	Often	Almost Always
16 .My lecturer knows the content (s) he is teaching.	1	2	3	4	5
17. My lecturer knows how science theories or principles have been developed.	1	2	3	4	5
18. My lecturer knows the answers to questions that we ask about engineering concepts.	1	2	3	4	5
19. My lecturer knows how engineering is related to technology.	1	2	3	4	5
20. My lecturer knows the history behind engineering discoveries.	1	2	3	4	5
21. My lecturer explains the impact of science, engineering and technology on society.	1	2	3	4	5

KUS	Almost Never	Seldom	Some Times	Often	Almost Always
22. My lecturer's tests evaluate my understanding of a topic.	1	2	3	4	5
23. My lecturer's questions evaluate my understanding of a topic.	1	2	3	4	5
24. My lecturer's assessment methods evaluate my understanding.	1	2	3	4	5
25. My lecturer uses different approaches (questions, discussion, etc.) to find out whether I understand.	1	2	3	4	5
26. My lecturer assesses the extent to which I understand the topic.	1	2	3	4	5

27. My lecturer uses tests to check that I understand what I have learned.	1	2	3	4	5
28. My lecturer's tests allow me to check my understanding of concepts.	1	2	3	4	5

PART C.

1.   Which courses do you find difficult to learn? Give reasons.

Reasons:

2.   Which courses do you find easy to learn? Give reasons.

Reasons:

Thank you for your participation

Appendix 4: Teachers' beliefs about teaching and learning in engineering questionnaire

TEACHERS' BELIEFS ABOUT TEACHING AND LEARNING IN ENGINEERING QUESTIONNAIRE

The purpose of this questionnaire is to ascertain the perceptions and views that you have concerning teaching and learning in engineering. The results will be used to increase knowledge about teaching and learning as well as enhancing the responsiveness of professional development programmes in engineering. It is very important that the researcher find out about your ideas of teaching and learning.

There are no right or wrong answers. Your opinion is what is wanted. Think about how well each statement describes what teaching and learning in engineering is like for you. Simply give your opinion. Consider your options carefully. If you feel one or more options are only half correct, avoid choosing such an answer. Look for the responses that summarise your view.

The information in this questionnaire will be treated with confidentiality. Code numbers will be used to guarantee anonymity. Once data has been captured and analysed, code numbers will be deleted.

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Thank you for your cooperation

PART A: BACKGROUND INFORMATION

Questionnaire ID code:

(office use only)

Please tick in the box (where applicable)

1. Campus: Soshanguve ☐1   Pretoria ☐2

2. Which qualification are you teaching :   Architecture   ☐1

    Building   ☐2

    Civil   ☐3

    Chemical   ☐4

    Electrical   ☐5

    Mechanical   ☐6

    Surveying   ☐7

3. Position: Head of department   ☐1

    Senior lecturer   ☐2

    Lecturer   ☐3

    Junior lecturer   ☐4

4. Gender: Male ☐1   Female ☐2

5. How old are you?   Under 30 ☐1   between 30–45 ☐2   over 45 ☐3

6. How many years have you been employed as a lecturer in engineering?

    Under 2   ☐1

    Between 2 – 5   ☐2

    5 to 10   ☐3

    over 10   ☐4

7. What is the highest qualification that you hold?

    National Diploma   ☐1

    National Higher Diploma   ☐2

    B. Tech   ☐3

    B.Sc   ☐4

    B.Sc (Hons)   ☐5

    Masters   ☐6

    Doctorate   ☐7

8. Do you have a formal teaching qualification?   Yes ☐1   No ☐2

9. Are you currently involved in a professional development course? Yes ☐1   No ☐2

    Please give details

10.   When last did you participate in a professional development programme?

        None   ☐1

        More than 12 months   ☐2

        Less than 12 months   ☐3

        Monthly   ☐4

The following sections of the questionnaire require you to indicate your level of agreement or disagreement with a number of statements. There are no right or wrong answers. Your opinion is what is wanted

Tick or make a cross or draw a circle around your option:
    1   If you **strongly disagree** with the statement
    2   if you **disagree** with the statement
    3   if you neither **agree or disagree** with the statement or are unsure
    4   if you **agree** with the statement
    5   if you **strongly agree** with the statement

PART B: Teachers Beliefs about teaching and learning

		Strongly	Disagree	Neither	Agree	Strongly
1	When a student does better than usual in engineering it is often because the lecturer has exerted a little extra effort	1	2	3	4	5
2	I am continually finding better ways to teach engineering	1	2	3	4	5
3	Even if I try hard I do not teach engineering well	1	2	3	4	5
4	When the engineering marks of students improve it is often due to a more effective teaching approach	1	2	3	4	5
5	If students are underachieving in engineering it is most likely due to ineffective teaching	1	2	3	4	5
6	I know the steps to teach engineering concepts effectively	1	2	3	4	5
7	I generally teach engineering ineffectively	1	2	3	4	5
8	The inadequacy of student's engineering background can be overcome by good teaching	1	2	3	4	5
9	When the low achieving student progress in engineering it is usually due to extra attention given by the lecturer	1	2	3	4	5
10	The low engineering achievement of some students cannot be blamed on their lecturers	1	2	3	4	5
11	I understand engineering concepts well enough to be effective in teaching	1	2	3	4	5
12	Increased effort in engineering teaching produces little change in some students' achievement	1	2	3	4	5
13	If a student is showing more interest in engineering it is probably due to the performance of the lecturer	1	2	3	4	5
14	I find it difficult to explain to students why experiments work	1	2	3	4	5

		Strongly	Disagree	Neither	Agree	Strongly
15	I am typically able to answer students engineering questions	1	2	3	4	5
16	I wonder if I have the necessary skills to teach engineering	1	2	3	4	5
17	Effectiveness in engineering teaching has little influence on the achievement of students with low motivation	1	2	3	4	5
18	When a student has difficulty understanding an engineering concept, I am usually at loss as to how to help the student understand it better	1	2	3	4	5
19	I would not invite colleagues to evaluate my teaching	1	2	3	4	5
20	I usually help the students who have difficulty in understanding engineering better	1	2	3	4	5
21	When teaching engineering I usually welcome students' questions	1	2	3	4	5
22	I do not know what to do to motivate students to learn engineering	1	2	3	4	5
23	Even lecturers with good engineering teaching abilities cannot help some students to learn engineering	1	2	3	4	5
24	I do not know what to do to turn students on to engineering	1	2	3	4	5
25	Students' achievement in engineering is directly related to their teacher's effectiveness in science teaching					

PART C.   BELIEFS ABOUT PROFESSIONAL DEVELOPMENT

In my opinion, the best teaching development occurs when:

		Strongly	Disagree	Neither	Agree	Strongly
1	Talking with other lecturers	1	2	3	4	5
2	Reading education material	1	2	3	4	5
3	Reading scientific and engineering material	1	2	3	4	5
4	Listening to a lecture	1	2	3	4	5
5	Trying out new teaching activities	1	2	3	4	5
6	Acquiring new ideas for teaching	1	2	3	4	5
7	Sharing teaching resources with others	1	2	3	4	5
8	Having support of other lecturers	1	2	3	4	5
9	Attending a course	1	2	3	4	5
10	Thinking about what I will do in class	1	2	3	4	5
11	Visiting other lecturers' classes	1	2	3	4	5
12	Having support of my head of department or dean	1	2	3	4	5
13	Talking with students	1	2	3	4	5
14	Evaluating the success of my lessons	1	2	3	4	5

		Strongly	Disagree	Neither	Agree	Strongly
15	Getting feedback from other teachers	1	2	3	4	5
16	Writing a new teaching and learning resource or unit of work	1	2	3	4	5
17	Watching another lecturer teach?	1	2	3	4	5
18.	Sharing problems with other lecturers	1	2	3	4	5
19	Analysing tests and examination results	1	2	3	4	5
20	Getting feedback on changes I have made to my teaching	1	2	3	4	5

PART D

1.	Which subject/courses are you currently teaching in the programme/Diploma?

	1……………………………………..
	2………………………………………
	3……………………………………….
	4. ……………………………………...

2.	What are your teaching styles in the classroom? Explain

NB: You are welcome to provide any other additional information of interest regarding teaching and learning in engineering at the back of this questionnaire or use additional clean sheets.

**THANK YOU FOR COMPLETING THIS QUESTIONNAIRE.
YOUR COOPERATION IS HIGHLY VALUED.**

Appendix 5: Lecturers' interview questions schedule

Tshwane University of Technology
Faculty of Engineering
Lecturer Interview Guide Questions

Name: _____

Department: _____

Course Offerings: _____

Date: _____

1. *What are your general feelings about Engineering teaching?

2. *What are the general feelings about student learning in Engineering?

3. *When introducing a new teaching activity, are you concerned if other teachers in your department are not using the same activity? Explain. *(Teaching)*

4. *In your opinion, what is the purpose of student assessment in Engineering teaching? *(Ass)*

5. *How important is it for you to cover the teaching curriculum? Explain. *(Teaching).*

6. *What influence do examinations have on your teaching? *(T + Assessment)*

7. *In your opinion, what are the major barriers in your department to student learning in Engineering? *(Learning)*

8. What role, if any, do you have in providing teacher development activities for other teachers? (*professional development*)

9. *What are your most predominant teaching strategies? *Explain. (teaching)*

10. What do you do to inform students of course/subject requirements and help them understand the reasons for them?

11. *How do you build upon students' life experience in your subjects, the ways of your teaching? (teaching)

12. Do you ensure that there is consistency between your subject objectives, the ways you teach and the ways you assess?

13. What opportunities do you give students to choose aspects of course work or assessment, which are relevant to their interests and experience?

14. *Do you take note of the gender, ethnicity and other characteristics of students in your classes and respond to their learning needs?

15. *In what ways do you provide personal assistance to students, and/or refer them to the range of resources and agencies, which are available to assist them? To learn better

16. What approaches do you use to induct students into research and other forms of active scholarly involvement?

17. What steps do you take to extend the range of learning activities that you draw upon in your teaching?

18. *How do you allow for students preferring to learn and participate in different ways?

19. *What approaches do you use to help students to reflect upon their own learning intentions, behaviour, and practice, and to develop effective skills for lifelong learning?

20. How do you frame questions from students and respond in a way that facilitates their learning?

21. How do you check that your explanations are clear to students?

22. How do you respond when students indicate difficulties, which content, pace emphasis or style?

23. *How do you help students develop habits of routinely assessing their own work?

24. What strategies do you use to provide immediate feedback to students to help them improve their performance?

25. *Do you identify for students the specific strengths and weaknesses of their performance and offer precise feedback about how to improve?

26. In what ways do you ensure that your assessment methods accurately assess the learning outcomes that you intended?

27. *What forms of information about your teaching and your subjects do you collect on a regular basis?

28. *How do you change your approaches to teaching and/or your design of your subjects in the light of the information obtained?

29. *How do you find out about the approaches students take to their learning and the ways your teaching and/or your subject design affects that approach?

30. How do you use the information obtained from student assignment and examination work in evaluating your teaching and/or your subjects?

31. *How do you stay in touch with developments in teaching and teaching with or profession?

32. *What opportunities do you make to discuss aspects of learning and teaching with colleagues?

33. *What opportunities do you make to receive feedback on your teaching from colleagues?

34. How do you go about developing your skills and expertise as a teacher?

35. What strategies do you employ to reflect upon your teaching practices and identify areas for development?

36. Do you participate in seminars, courses, or conference, which focus on learning and teaching?

37. * What would be your preferred teaching professional development model?

* Denotes the interview questions which were asked to all interviewees

Source: Questions adapted from HERDSA Teaching Guide

Appendix 6: Findings about curriculum structure and factors of affective nature

Major findings on perceptions about curriculum structure and factors of affective nature

Introduction

The qualitative results from students (in chapter 4) and lecturers (in chapter 7) revealed concerns about the curriculum structure and certain behavioural patterns of affective nature which were perceived to impact negatively on students' experiences of the engineering learning environments.

The engineering curriculum structure

The qualitative results revealed that there were concerns associated with the flaws in design of curriculum structure and the implementation approach used in the Faculty of Engineering. Both students and lecturers perceived the problems associated with curriculum structure as a contributing factor towards teaching and learning problems and the low students' success rate. The major findings are discussed in the next sections.

Misalignment of theory with practical component

The first concern was that participants believed that in some courses, the curriculum structure between theory and practicals was disjointed. The lecturers reported that they were responsible for teaching theory whereas the practical component was mostly taught by the technicians. The practical component implementation plan used by technicians in most cases was reported to be non-aligned with theory lectures in terms of the content topics being taught parallel to theory lessons. Accordingly this led to students failing to create a conceptual link between theoretical knowledge with the technical skills in engineering. Both students and lecturers believed that the misalignment of the two component of the curriculum impacted negatively on the quality of teaching and learning in engineering programmes. Lecturers also thought that even though they were aware of the curriculum structure problems, there was

little they could do since they did not have competences to engage with rigorous curriculum review and design.

Nature of theory component

The second concern was attributed to the abstract nature of the theory component of the curriculum. Both lecturers and students indicated that engineering curriculum was too abstract and theoretical in nature and was sometimes misaligned with the everyday experiences of students about engineering events taking place in the real world of engineering industry. Some lecturers thought that the use of Eurocentric engineering textbooks in their courses also contributed to making theory lessons abstract since the example and case studies used in the textbooks were alien to students. In addition, the English language used was sometimes difficult to understand by the students whose second language was English. Examples and case studies used were reported to be unfamiliar to students. Consequently, this finding led to the perception that engineering the abstract nature of content alienated students from the experiencing engineering courses more positively because they could not relate to the examples used in the books.

Shepstone (2009) reported that high failure rate in New Zealand in engineering programmes at three institutions was contributed amongst other factors by the curriculum structure which excluded the needs of the students during the design stage. Teaching, assessment and curricula structures in engineering courses were not set up based on any solid foundations informed by modern pedagogical theories of teaching and learning but on past experiences of engineers. For students to enjoy learning and succeed well in engineering courses, curricula structures of the programmes would require review so that it reflects and integrates students learning needs with the content and delivery strategies. This finding has implications for curriculum design and learning materials development. However, the shortcoming for rigorous curriculum review to take place lies with the limited knowledge of curriculum design and review by the engineering lecturers. Lecturers in this study were aware of the problems in the current curriculum which impacted negatively on student learning but had accepted to continue teaching it because they were not qualified to conduct a curriculum review. Secondly, they could not temper with the curriculum since it was determined by the engineering professional boards. They felt

that they had to teach what the industry required. Shepstone (2009) argue that engineering educators in universities are not trained in educational theories, have no form of teaching or educational qualifications and therefore are not qualified to suggest significant changes to existing curriculum structures. Albeit lecturers' shortcomings on curriculum development matters, knowledge of curriculum design is a personal attribute that starts with the educator being able to understand what is important for his or her students to know and what is the best way to learn it (Shepstone, 2009). This statement implies that all educators, including engineering lecturers, should broaden their knowledge of curriculum design. Curriculum design and review knowledge is an important feature of pedagogical content knowledge. Therefore, in view of these findings and its consequences on teaching and learning in engineering, it is recommended that lecturers engage in teaching knowledge activities or courses that could help them acquire knowledge and skills in curriculum design.

Mathematical knowledge and skills

One of the major barriers to learning was identified by lecturers as students' lack of necessary foundations in mathematics to can understand the engineering content inherent in mathematical applications. The results indicate that both the students and the lecturers were not satisfied with the quality of teaching and learning in mathematics. They both raised concerns and frustrations about the inadequate mathematical knowledge and skills the students had from first year to final years of undergraduate studies and its negative consequences on understanding the broader engineering curricula. This was considered as the key contributing factor towards high failure rate in most of the programmes. Some senior students were reported to have failed to apply the mathematical concepts in problem solving even though they had passed the mathematics courses in first or second year level. Lecturers and students believed that this problem emanated from the flawed curriculum design and use of ineffective teaching methodologies which promoted surface learning which led to subsequent forgetfulness on what was learnt in the previous years.

Mathematical knowledge forms the core of the engineering curriculum and practice. Engineers use mathematics knowledge and skills to seek solutions to various types of technological and societal problems within the scope of their profession.

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Therefore, deeper understanding of knowledge of mathematics is important in enabling students to understand the relationship between mathematical concepts, their meanings and contexts in which they are applied in the engineering education and the profession (Shepstone, 2009).

Shepstone (2009) reported that the engineering curriculum structure was mostly disjointed in terms of integration between various subjects and courses and how the subjects were taught. Consequently students failed to see the relationship between various subjects and therefore failed to apply concepts learned in mathematics, for example, in other situations within the curriculum. Shepstone (2009) suggest that concepts in mathematics should be taught at the time when students require the knowledge to solve a specific problem in the engineering projects. In this way students would be able to see the value of mathematics in engineering from a broader perspective. This suggestion was also echoed by some of the lecturers in this study.

The implication of this finding is that engineering curriculum structures and implementation plans have to be revised to accommodate what is required to be taught from the content to the students' learning needs and the contexts in which the subject matter would be applied in real engineering practice. Students would be able to see the connection within a bigger picture and thus be motivated to learn. This in turn, would lead to improved students achievement and success rate. Shepstone (2009) suggest that improvement of mathematical knowledge and skills could be attained through use of diagnostic testing to determine the students' level of mathematics. In addition, curriculum design and implementation strategy should be targeted to address the identified mathematical knowledge and skills shortcomings amongst students.

Caring and motivating learning environments

Results revealed that both students and lecturers had concerns about affective factors associated with the learning environment. Most of the findings on why some courses were reported to be easy to learn by students were related to attitudes of lecturers towards students. Students perceived their lecturers to be caring about their learning, helped them to understand difficult concepts and addressed their learning difficulties. Students perceived courses to be easy to learn because the lecturers were always

patient, dedicated to teaching students and assisted students to solve difficult engineering problems.

On the contrary, students perceived some courses to be difficult to learn because the lecturers had poor presentation and communication skills, and hence students experienced difficulties in understanding their lessons. Some lecturers were perceived to be relentless and often became angry if students interrupted their lectures by asking questions. Negative attitudes such as lecturers becoming angry or impatient with students could lead to students feeling alienated by the educational processes and thus learning may be compromised. Educational processes which do not take affective factors into consideration, especially on students who are struggling with higher education provisioning due to their inadequate prior knowledge background, the impact of negatively perceived affective factors may cause attrition through academic exclusions and demoralisation among students. This would eventually lead to students dropping out of university education (Scott, Yeld, & Hendry, 2007) a consequence which in most South African public higher education institutions has become a controversial issue.

In the case of difficult courses, students indicated that the lecturers did not care whether they understood concepts or not. Lecturers were perceived to be only interested in completing the syllabus and conducting assessments to comply with institutional policies. Some lecturers corroborated the students' views that the teaching and learning environments were not motivating for both lecturers and students. These lecturers felt that it was important for them to facilitate learning in a caring environment so that students could be motivated to learn. Some lecturers saw themselves as engineering role models, and thus tried to motivate their students by using various teaching and learning approaches which took into consideration the learning difficulties of their students into account.

A caring environment takes into account lecturers' sensitivity towards students' characteristics such as diversity, cultural backgrounds, learning needs and gender awareness. Taking cognisance of affective factors was found to improve learning and success rate amongst diverse groups of students in engineering (Felder, Felder, & Dietz, 2002). Waghid (2000) referred to this kind of caring attitude in engineering teaching as dialogical agape. A learning environment has an effect on how students

view teaching and learning in a course. Caring learning environments are linked to success. Therefore, even in engineering, teachers are expected to make learning environments as caring as possible in order to awaken curiosity, motivation and interest in learning (Shepstone, 2009). Previous studies in learning environments such as Fraser (in press) have emphasised the importance of providing a caring environment for student to learn as a prerequisite for successful learning. The implication of this finding is that if lecturers want to see improved success rates in their courses, they should learn to create a caring and motivating learning environment for their students.

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Scott, I., Yeld, N., & Hendry, J. (2007). *A case for improving teaching and learning in South African higher education* (No. 6). Pretoria: Council on Higher Education.

Shepstone, N. M. (2009). *A critical examination of electrical engineering curricula across three institutions in New Zealand.* Unpublished Doctoral thesis, Curtin University of Technology, Perth.

Waghid, Y. (2000). Reconceptualising engineering education:creating spaces for outcomes and dialogical agape. *Higher Education, 40*, 259-276.