Learning Styles, Teaching Methods, and Student Performance in Industrial Engineering at a University of Technology

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I, Hester Jackson, do declare that this dissertation is a representation of my own work in both conception and execution.

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Submission approved for final examination.

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List of acronyms and definitions

CHE:	Council on Higher Education
DOE:	Department of Education
DUT:	Durban University of Technology
ELT:	Experiential learning theory
FSLSM:	Felder and Silverman learning style model
HEI:	Higher Education Institution
HSRC:	Human Sciences Research Council
IE:	Industrial Engineering
MBTI:	Myers Briggs Type Indicator
NPHE:	National Plan for Higher Education (South Africa)
NSC:	National Senior Certificate, the certificate obtained by students in their final year of school, before entering tertiary education
OBE:	Outcomes-Based Education
PI:	Peer instruction
QDA:	Quality Data Analysis
SA:	South Africa
SPSS :	Statistical Package for the Social Sciences
UJ:	University of Johannesburg
VUT:	Vaal Triangle University of Technology

Abstract

Student success and throughput rates remain a challenge at South African higher education institutions (Strydom, Mentz and Kuh, 2010) and the results in Industrial Engineering at the Durban University of Technology are no exception. Statistics released by the Department of Management Information Systems at this university in November 2012 on the graduation rates of students registered for the National Diploma: Industrial Engineering from 2009 to 2011 bear testimony to this, as the average graduation rate is between 10% and 21%. This research study investigated the learning styles, teaching methods and student performance in Industrial Engineering at a selected university of technology in South Africa by examining the preferred learning styles of students, and lecturers' preferred teaching styles at various levels. The Felder and Silverman Model (1988) which was specifically designed to capture significant differences in learning styles amongst engineering students, was employed as the framework for the study.

Using a mixed-methods research approach, the target population for the study was the 200 students registered for the National Diploma: Industrial Engineering at the Durban University of Technology in 2013. The lecturers were identified through convenience sampling. The sample comprised five lecturers and 150 students. The participants were recruited by sending letters to inform them about the study and its purpose. Student participation was completely voluntary. The data was collected through questionnaires, and semi-structured interviews. The study used the ILS Questionnaire developed by Felder and Solomon to assess the four scales of leaning style preference among engineering students. The questionnaire was adapted to include some demographic information such as race and gender. After the lecturers were interviewed, direct observation took place in the class room in order to determine their teaching style. The researcher ensured validity of the data through triangulation and tested the reliability of the ILS questionnaire by running a pilot study. In order for the questionnaire to be reliable, the results should be the same on both occasions. The Statistical Package for the Social Sciences was used to analyse the data from the ILS questionnaire and the data from the interviews were analysed using NVivo™ software.

After the learning styles and teaching styles were identified, the quasi experiment was used to determine if changes in the lecturers' teaching methods had any influence on the students' learning styles and performance. It was found that this was indeed the case. In some instances such as Engineering Work Study 1, changes in the teaching method had a positive effect on student performance, but in modules such as Costing 2 and Production Engineering 2, the changes negatively impacted student performance. The study therefore confirmed that teaching styles and learning styles influence student performance. This knowledge could be used by lecturers to familiarise themselves with their students' learning styles and to match their teaching to these learning styles in a manner that benefits all students. Students also need to be aware of their preferred learning styles and to be guided on how to use these to improve their performance in each of their modules.

Contents

List of Figures

List of Tables

CHAPTER 1: STATEMENT OF THE PROBLEM

1.1 Introduction

According to O'Shea (2007), educational systems are non-linear, and are more than the sum of their parts. He adds that the behaviour of the learning system is dynamic and is not only determined by the behaviour of its individual parts but their interaction. We live in a world characterised by rapid changes in industry; as educators, we need to prepare our students to adapt and act on these changes. As Hinde-McLeod and Reynolds (2007) observe in their book on *Quality Teaching for Quality Learning,* "we are teaching and learning in times of overwhelming change – change in the way we know, changes in the way we teach and changes what is expected of us as teachers and learners." Mutemeri (2010) notes, that, in order to produce a workforce with appropriate and relevant skills, teachers need to offer quality and rigorous education.

Taking all these overwhelming changes into consideration educators in the teaching environment may need to adapt their teaching strategies in order to keep up-to-date with these changes. This study therefore explores how educators view their current teaching methods, and the influence it has on the students' learning styles. We need to adjust the teaching and learning system to benefit our students. We have long passed the stage where we can teach our students in the manner in which we were taught. While we might not be aware of it, as educators we play a significant role in our students' perceptions of learning and academic performance.

Various researchers such as Eftekhar (1998) and Veenstra, Dey and Herrin (2009) has concluded that factors that can influence student success include student motivation, preparedness for tertiary education, educators' perceptions, learning preferences and the manner in which lecturers teach.

All these factors are linked and addressing one or more will automatically influence the rest. This in turn will have either a positive or negative effect on students' academic performance. Figure 1.1 presents an overview of the link between these factors, and student academic performance.

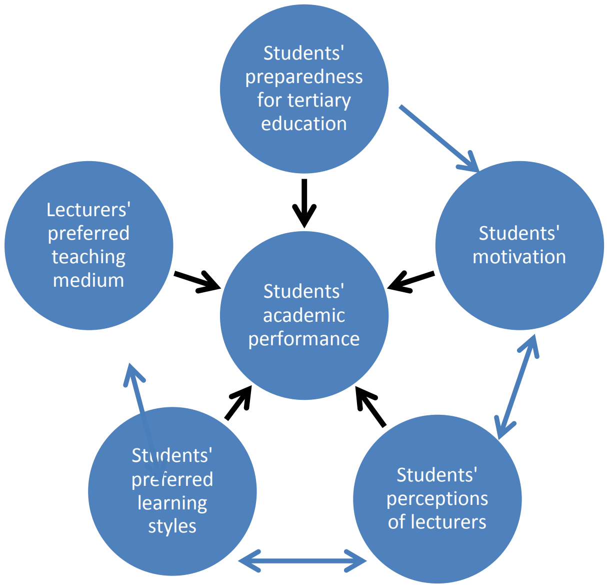

Figure 1.1: Factors impacting on students' academic performance

This study focuses on the impact of student learning preferences and lecturers' teaching methods on students' academic performance.

1.2 Background

Student achievement is a key contributor to academic throughput and graduation rates. The graduation rates for the undergraduate programme in Industrial Engineering (IE) at the Durban University of Technology (DUT) reflect an unfavourable picture of students' academic performance. Table 1.1 shows the graduation rates of IE students from 2009 up to and including 2013.

Table 1.1: Graduation rates of Industrial Engineering students at DUT

Year	Headcount	Graduates	Graduation rate	% decrease/increase
2009	226	48	21%	2.19%
2010	277	40	14%	(7%)
2011	250	28	11%	(4%)
2012	263	42	16%	5%
2013	287	64	22.%	6%

Source: Department of Management Information Systems, DUT (2013,2014)

Letseka and Maile (2008) note that, according to the National Plan for Higher Education (NPHE), South African universities have the lowest graduation rate in the world at 15%. The NPHE also notes that benchmark targets were set unrealistically high and were adjusted in 2004. Letseka and Maile (2008) of the Human Sciences Research Council (HSRC) included the adjusted benchmark targets in their study. The adjusted targets are presented in Table 1.2. Comparing Tables 1.1 and 1.2 it is noted that the target was missed by 0.5% in 2013.

Table 1.2: Benchmarks for graduation rates in 2001 and 2004 set by the NPHE

Qualification type	Benchmark target for graduation rate (contact)		Benchmark target for graduation rate (distance)	
	2001	2004	2001	2004
Up to 3 years undergraduate	25%	22.5%	15%	13.5%``
4 years or more undergraduate	20%	18%	10%	9%
Post graduate up to honours	60%	54%	30%	27%
Masters	33%	30%	25%	22.5%
Doctoral	20%	Not specified	20%	Not specified

Source: Department of Education (2001, 2004)

It is evident that we are challenged to meet the graduation target. According to the South African government (2008), it is clear that countries with sustained economic growth are those that have prioritised education. Furthermore, graduates with high level skills in the sciences and engineering are crucial for national development (Wolmarans, Smit, Collier-Reed and Leather, 2010). Mutemeri (2010) observes that, in order to produce a workforce with appropriate and relevant skills, teachers need to offer quality and rigorous education. She adds that higher education institutions (HEIs) assume that all first-year students have received a good general education at school and that they are therefore ready for specialised study.

Even though the graduation rates have been adjusted, universities and universities of technology need to improve their throughput rates. A Council on Higher Education (CHE) report notes that engineering education in South Africa is particularly vulnerable with regard to throughput. The "Council report indicates a national throughput of only 17% of university of technology students after 5 years of study" (Kanakana, Pretorius and van Wyk, 2012). For the purpose of this study, information was obtained from the Department of Management Information Systems at DUT in November 2014 on the throughput rates of IE undergraduate students since 2008. Tables 1.3 – Table 1.6 show the cohort study of students who entered the National Diploma: IE for the first time.

Table 1.3 shows that, in 2008, the department registered 56 "first time" students and that only five (9%) of these students completed their studies within the minimum period of three years in 2010. After four years of study another 10 students (18%) completed their studies, and after five years nine students (16%) completed their studies. Twenty five students (45%) dropped out completely from the programme and seven (13%) are still in the system. In 2009 (Table 1.4), 67 students registered for the first time and only four completed in the minimum period of time, while 32 (48%) dropped out of the system and two (4%) registered again in 2014. In 2010 (Table 1.5) the department registered 96 students for the first time and only 11 (11%) completed their studies in the minimum time. In 2014 15 of these students (16%) were still in the system. In 2011 (Table 1.6) 68 students were registered, but only five (7%) graduated in the minimum time. As shown in Tables 1.3 and 1.4, the average throughput rate for undergraduate IE students at DUT after five years is16%. This is in line with Kanakana, Pretorius and van Wyk's findings.

Table 1.3: Cohort studies of first-time national diploma students for 2008

Department	No. First-time Entering 2008	No. Graduated in:			No. Enrolled in 2013	No. Dropped out	Dropout Rate	Throughput Rate			Still in Progress
		2010	2011	2012				Min Time	Min Time + 1	Min Time + 2	
ND: ENGINEERING: INDUSTRIAL	56	5	10	9	7	25	45%	9%	18%	16%	13%

Source: Department of Management Information Systems at DUT (2014)

Table 1.4: Cohort studies of first-time entering national diploma students for 2009

Department	No. First-time Entering 2009	No. Graduated in:			No. Enrolled in 2014	No. Dropped out	Dropout Rate	Throughput Rate			Still in Progress
		2011	2012	2013				Min Time	Min Time + 1	Min Time + 2	
ND: ENGINEERING: INDUSTRIAL	67	4	18	11	2	32	48%	6%	27%	16%	3%

Source: Department of Management Information Systems at DUT (2014)

Table 1.5: Cohort Study of First-time Entering National Diploma Students for 2010

Department	No. First-time Entering 2010	Graduated in:		No. Enrolled in 2014	No. Dropped out	Dropout Rate	Throughput Rate		Still in Progress
		2012	2013				Min Time	Min Time + 1	
ND: ENGINEERING: INDUSTRIAL	96	11	25	15	45	47%	11%	26%	16%

Source: Department of Management information Systems at DUT (2014)

Table 1.6: Cohort Study of First-time Entering National Diploma Students for 2011

Department	No. First-time Entering 2011	Graduated in 2013	No. Enrolled in 2014	No. Dropped out	Drop out Rate	Throughput Rate Min time	Still in Progress
ND: ENGINEERING: INDUSTRIAL	68	5	35	28	41%	7%	51%

Source: Department of Management Information Systems at DUT (2013,2014)

The high drop-out rate within the department is clearly visible in Tables 1.3 to 1.6. The dropout rates were: 2008 = 45%, 2009 =48%, 2010 = 47% and 2011 = 41%.

There are various reasons why students drop out of programmes at tertiary level. Letseka and Maile (2008) study on the effect of high drop-out rates in South Africa (SA) found that a fair number of students failed some or all of their modules. Letseka (2009) found that these students battled with concepts and terminology and eventually lost interest; about one-third dropped out. Various factors can influence student performance. Felder and Silverman (1988), and Singer (2010) attribute poor performance to a mismatch between students' learning styles and lecturers' teaching styles. A study conducted by Kanakana *et al.* (2012) found that factors relating to the academic schedule, the learning environment, and teaching, and learning ability, contribute significantly to student performance.

1.3 Research question guiding the research

Do the different learning styles of students and teaching methods of lecturers have an influence on student performance?

The aim of this study was to investigate learning styles, teaching methods and student performance in IE at a selected university of technology in SA. In order to achieve this aim, the following objectives were set:

- To determine the preferred learning styles of students in the selected levels 1, 2, and 3 modules in IE at the DUT;
- To determine the lecturers' preferred teaching styles in the selected levels 1, 2, and 3 modules in IE at the DUT;
- To determine the effect of lecturers' teaching styles and students' learning styles on student performance in the selected modules;
- To determine the student performance before and after adapting teaching styles in the selected modules in IE at the DUT; and

- To determine the correlation between students' learning styles and lecturers' teaching styles on student performance.

Based on the study's findings, recommendations are made to improve lecturers' teaching methods in order to improve student learning and performance.

1.4 Demarcation of the problem

As a lecturer in the IE department at DUT and a teacher of undergraduate students, the researcher has noted that sometimes even 'very bright' students experience problems in passing certain modules the first time round. In terms of the DUT's G17 rule (General Rulebook for Students, 2014), if a student fails the subject twice, s/he may be refused re-registration due to unsatisfactory academic process. A student who fails a subject more than once and is granted permission to re-register will not complete his/her studies within the specified three years. According to Letseka and Maile (2008), the Department of Education (DoE) benchmarked the graduation rate for a three-year programme at 25% in 2001. This was revised to 22.5% in 2004. Table 1.1 shows that from 2009 to 2011, there was a steady decline in the graduation rate at the IE department at DUT. The researcher investigated students' academic performance in order to identify techniques to improve the education process and student performance.

There is a paucity of research on IE at HEI. Mines' (2013) study on undergraduate student satisfaction with IE education notes that most research focuses on a combination of engineering courses. Nel and Mulaba-Bafubiandi (2009) conducted research at the University of Johannesburg (UJ) in order to identify the key interventions that are required to improve the IE throughput rate at the university. They stressed that the throughput of IE undergraduate students should be a priority because IE was classified as a national scarce and critical skill in 2006.

1.5 Methodology

This study was based on quasi experimental research. Quasi experimental methods have often been used in classrooms to study the effects of different treatments or teaching techniques; the pre-testing and post-testing of students who have been assigned to a treatment group, to a non-treatment group or to various kinds of treatment groups, provides evidence of learning and /or changes between or among treatment groups (Arhar, Holly and Kasten, 2001: 34). For the purpose of this study, the researcher used a control and an experimental group.

Purposive sampling was employed to sample IE students enrolled for level 1, 2 and 3 modules for 2013 in the Department of Industrial Engineering. Check and Schutte (2011: 148) describe purposive sampling as a sampling method that may involve the entire population of a limited group or subset of a population. The sample was estimated at a total of 120 students based on the number registered for levels 1 to 3 over two semesters in 2012; this data was retrieved from the ITS Integrator 3 system at DUT (Faculty of Engineering and the Built Environment. 2012, Dept. Industrial Engineering – class list, Durban Campus Full-time Calendar Year: 2012 Block Code: 21). Convenience sampling was used to select the lecturers, as the lecturers for the selected modules were automatically included. Ruben and Babbie (2012: 146) define convenience sampling as a sampling method that select elements simply because of their ready availability and convenience.

Questionnaires and interviews were administered in order to identify students' learning styles and lecturers' teaching styles. The data was analysed using SPSS and NVivo™ software. NVivo™ is a qualitative data analysis (QDA) computer software package produced by QSR International and SPSS is a statistical programme for analysing quantitative data.

1.6 Overview of the study

This study consists of five chapters. Chapter 2 reviews the literature related to this study and discusses the theoretical framework that underpins it. The chapter focuses on students' academic performance at tertiary institutions and the influence of different learning styles on such academic performance. Theories of learning and teaching are also discussed.

Chapter 3 provides a detailed outline of the methodology and research approach employed by this study. It discusses the rationale for the selection of the research design and methods. The methods used to collect data are discussed as well as those used to test for reliability and validity.

Chapter 4 presents the study's findings based on the objectives set out in chapters 1 and 3. The findings are analysed in order to determine whether teaching methods and learning styles play a role in students' academic performance.

Chapter 5 discusses the findings presented in chapter 4 according to the objectives identified in chapter 1. These include the learning styles over the different study levels, the lecturers' different teaching styles and students' performance after lecturer interventions. Thereafter conclusions are drawn and recommendations are made to improve student performance.

1.7 Summary

This chapter presented an overview of the education system and its most important features. It was noted that graduation rates for the undergraduate programme in IE at the DUT do not meet national standards. The chapter also presented the research question and the study's aim and objectives. In terms of the demarcation of the problem, the importance of this study was highlighted and previous research in this field was briefly discussed. The research methodology employed was also summarised. The literature relevant to this study is reviewed in the following chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

“The major purpose of a literature review is to increase the researcher's awareness and understanding of the most important issues, practices and research associated with his or her area of study” (Eftekhar, 1998). The aim of this study was to investigate if students’ preferred learning styles and lecturers’ teaching methods have an impact on student performance in IE at a university of technology in SA.

This chapter begins by discussing the background of the South African education system and how it has developed since 1994. The historical background is important in understanding why students perform in the way that they do. This is followed by an investigation into the performance of IE students internationally as well as nationally in order to identify common problems that can influence their performance. South African and international initiatives to increase student performance and throughput rates at various universities and universities of technology are discussed, as well as learning theories and teaching approaches. These theories provide a better understanding of how different people learn differently; and the impact of lecturers’ different perceptions of teaching. This will enable recommendations to be made to improve teaching and learning at DUT. The theoretical framework underpinning this study is also discussed in detail in this chapter and the rationale for selecting Felder and Silverman’s teaching and learning model is highlighted.

2.2 Brief Historical Background of education in SA

South Africa is a country with a history of racism and racial suppression - a country where black people endured approximately 50 years of domination by a white regime that skilfully manipulated every facet of their lives through the apartheid system (Morar, 2006). Education was significantly affected by this system. The Bantu Education Act (No 47 of 1953) classified and separated education along racial lines and during apartheid the higher education sector was predicated on the persistence of inequality (Mdepa and Tshiwula, 2012). Morar (2006) notes, that, Bantu education prepared learners for the lower and middle levels of the labour market during the mid-1970s.

Bantu education lagged far behind white education with respect to per capita spending and teacher: pupil ratios. After 1994, African National Congress (ANC) leaders criticised the introduction of Bantu education in ever more strident terms, suggesting that it should be considered a destructive intervention (Giliomee, 2012). Giliomee (2012) notes, that, in 1953, the then Minister of Native Affairs, Hendrik Verwoerd said in a speech that it did not make sense to teach black students mathematics and science, because they would not use them in their careers.

Table 2.1 Kirlidog and Zeeman (2011) shows that the resources allocated to white educational institutions were significantly higher than those allocated to institutions for other race groups. This led to white students achieving a school pass rate of 96%. These students were therefore better prepared for tertiary education. This created serious educational inequalities in South Africa.

Table 2.1: Resources allocated for the education of different race groups in 1989 by the DOE

	White education	Indian education	Coloured education	Black education
Pupil-teacher ratios	1:19	1:22	1:23	1:42
Under-qualified teachers	0%	2%	45%	52%
Per capita expenditure, including capital expenditure	R3082	R2227	R1360	R765
High school pass rate	96%	93.6%	72.7%	40.7%

Equity in South African higher education after apartheid (2011: 49)

According to Kirlidog and Zeeman (2011), in 1959 the Education Act prohibited white universities from accepting “non-white” students and it was only in 1983 the universities were given partial freedom to accept students from different race groups. Apartheid was introduced after the 1948 elections by Hendrik Frensch Verwoerd (1901 to 1966) as Minister of Native Affairs. Verwoerd was the “creator of the Bantu education” and schools for African people were not recognised if they did not practice Bantu education. After the release of Nelson Mandela in 1994, education was high on the ANC’s list of priorities because it had been used to divide society. In July 1997, the DOE announced its programme to transform higher education. According to the CHE (CHE, 1997) the objective was to establish a single national higher education system and to redress past inequalities, not only in terms of race but gender, social class and geographic location.

Apartheid policies created a large and complex system, which was discriminatory and inefficient. There were 21 universities and 15 technikons (Gultig, 2000). Bunting (2006) highlights, that, ten universities and seven technikons were specifically built for black (African, Coloured and Indian) people, with the remainder for the exclusive use of white students. Gultig (2000) observes that access to higher education was inequitable not only in terms of race, but gender, social class and geographic location. Students that were not white who had the potential to perform well were provided with poor educational resources, and therefore did not reach their full potential. The Education White Paper that was released in 1997 aimed to redress these inequalities.

2.3 Curriculum / policy in SA (post-apartheid) higher education.

After South Africa's first national democratic elections in 1994, the government introduced several curriculum-related reforms to democratise education and eliminate inequalities in the post-apartheid education system (Jansen, 1998).

Post-apartheid policy in the education, science and technology and communications fields reflects a strong commitment to an “integrated” approach whether with respect to the education and training system or to joint publicprivate approaches to aid funding and education (Gultig, 2000). The first White Paper on Education laid the foundation for curriculum reform. It called for a complete overhaul of the apartheid curriculum, which was both outdated and discriminatory, and for its replacement with a new and flexible curriculum which would cut across traditional divisions of skills and knowledge, and defined standards in terms of learning outcomes. According to Sayed and Ahmed (2011), one of the major outcomes was a curriculum restructuring exercise in 1997 referred to as Curriculum 2005 or in short the C2005 document. Morar (2006: 251) notes, that, the C2005 document adopts the philosophy of outcomes-based education (OBE) and sets out a series of outcomes which learners should achieve as a result of teaching and learning.

The White Paper acknowledged that the new discrimination-free admission policy could not guarantee successful completion of university programmes by black students because of the poor levels of primary and high school education. Klingbeil, Mercer, Rattan, Raymer and Reynolds (2004) study at Wright State University found that the main factor influencing student success in engineering is a lack of preparation at high school.

The following section discusses student performance in Higher Education.

2.4 Academic performance of students

2.4.1 Academic performance of engineering students in international HEIs

Jacobs (2005) study expressed the concern that the level of preparation at school is not always adequate for engineering modules at first year level, resulting in students being unable to pass. College and universities throughout the U.S. have been concerned about student retention for many years (Haemmerlie and Montgomery, 2012). Montgomery conducted a study on the performance of first year male and female students in one of the engineering majors at the Missouri University of Sciences and Technology. It was found that male and female students' personality traits influenced student success and retention.

Ogot and Okudan (2007) and Wood, Jensen, Bezdek and Otto (2001) found that some engineering students have problems with open-ended assignments because they lack knowledge on which engineering elements to use to address the problem. Ogot and Okudan note, that, undergraduate engineering students lack creativity and cannot always see the relationships between information from different areas (modules). They therefore fail to apply the knowledge obtained in one subject to another relevant subject.

Marra, Rodgers, Shen and Bogue (2012) investigated why students leave engineering at Penn State University. They found that lecturers' teaching format dominates engineering courses which creates a barrier between students and lecturers. Bernold, Spurlin and Anson (2007) conducted a study on the performance of engineering students from their first year until completion of their undergraduate course. They found that students who asked questions such as "why" and "what if" performed worse than those that asked "what" and "how" questions.

Watkins and Mazur (2013) found that the majority of students leaving Engineering or performing poorly complained about poor teaching. The students listed the following poor teaching skills:

- a lack of faculty-student interaction;
- the "coldness" of classroom; and
- dull presentations.

It is clear from the above research that the level of school preparation for entering the engineering field at university is of concern. Engineering students lack some of the basic knowledge and skills required to pass their first year. Gender was also identified as a factor which influences student success in engineering. Some male students still believe that engineering is only for males and tend to make life hard for female students. Female students feel inferior and will then rather change their field of studies. Engineers prefer to work with facts and figures and if they are presented with a problem for which there is more one correct solution, they tend to struggle to solve the problem. Engineering students are also unable to identify the connections between their modules. They tend to categorise and box their modules. Thus, students fail to make use of the skills and knowledge obtained in lower level modules in their higher level modules in order to solve problems. Another issue is the differences between students' preferred learning styles and the manner in which lecturers conduct their lessons. If a lecturer is not teaching in a manner that suits students, they sometimes feel that the lecturer has poor teaching skills, which is not necessarily the case.

The following section investigates the factors which influence the academic performance of students in SA HEIs.

2.4.2 Academic performance of students in SA HEIs

Fraser and Killen (2003) investigated the factors that could influence university students' success or failure at the University of Pretoria. They note that it is assumed that all students admitted to university will successfully complete the course and add that it would be immoral to allow a person into university, knowing that s/he will not be able to complete her/his studies. Fraser and Killen highlight the post-enrolment factors, identified by both students and lecturers, which can influence student success. These include:

- Class attendance: First year students felt that regular attendance of classes would improve their performance whereas senior students did not feel the need to attend lectures on a regular basis.
- Locus of control: Lecturers expected that learners should be able to manage their time efficiently and take responsibility for their performance.
- Examinations: Students were not properly prepared for exams and/or the examination techniques were inadequate.

> Nel, Troskie-de Bruin and Bitzer (2009) observe that successful transition from high school to university is very important for student success, and that this is particularly true for first year students. Various studies have found that the majority of students are under-prepared. Scott, Yeld and Hendry (2007) study on the "improvement of teaching and learning", concluded that the South African school system produces students that are unsuccessful at university level.

The evidence suggests that the majority of South African schools are currently not providing schooling that prepares students for tertiary education. The responsibility therefore falls on tertiary institutions to prepare students for successful academic performance. These institutions need to adapt their infrastructure and provide students with the proper tools during their first year of studies in order for them to succeed.

Drop-outs from higher education normally take place in the first six months of the first year. Nel et al. (2009) note, that academic, social, financial and cultural factors as well as student expectations influence student success.

2.4.3 Academic performance of engineering students in SA HEIs

Govender and Moodley (2012) investigated the effect of National Senior Certificate (NSC) mathematics results for 2008 on the physics pass rates of first year engineering students. They suggested that the new high school mathematics curriculum had fallen short in providing students who wished to study engineering at university, with the necessary skills and techniques. According to Maree, Aldous, Hattingh, Swanepoel and Van der Linde (2006) institutions and employers highlighted matriculants' lack of basic mathematics skills and literacy. Poor matric results are reflected in poor preparation for university and high drop-out rates. Abdullah-Al-Mamun, Hasan and Amin (2012), Smink (2001), and Huang (2001) define a drop-out as a student who fails to meet the minimum requirements for promotion more than once and thus incurs penalties; such a student will eventually leave university.

MacGregor (2009) notes that the Vice-Chancellors of SA universities have warned the government that universities can expect high drop-out rates. She adds many first year students are unable to read, write or comprehend properly. This suggests a decline in matric standards. The article adds that while undergraduate enrolment has grown by 5% each year; the drop-out rate was as high as 50%. The graduation rate was very low and only a third of students received their qualification within five years. Scott *et al.* (2007), and Kanakana *et al.* (2012) also indicated that only 17% of engineering students enrolled for a three-year degree would graduate after five years. They added that 14% would re-register in an attempt to pass, while 50% would have already dropped out and 10% would have switched disciplines. “Engineering programs are considered cognitively demanding and require at least two years of mathematics, and matriculants who wrote the NSC are not equipped to manage at university level” (Wolmarans, Smit, Collier-Reed and Leather 2010).

Watkins and Mazur (2013) note that a study conducted by the Higher Education Institute in 2010 found that, while that the proportion of students that are interested in Science, Technology and Engineering Technology (STEM) was increasing, the number of students who graduated was declining. Kanakana *et al*.’s (2012) study of all the engineering programmes offered at Tshwane University of Technology (TUT) found that throughput is affected by student performance. Furthermore, teaching and the ability to learn, influence engineering students’ performance. From the above research it is evident that if students were guided on how to learn effectively, they would perform better and this would lead to more students being able to complete their studies within the specified time, leading to improved throughput and graduation rates in the engineering department.

2.4.4 Student performance and learning styles

Mines (2013) notes, that, although research has been conducted on the collegiate of engineering there is a paucity of research on IE education. She investigated learning styles and preferences and motivation among IE students at the University of Pennsylvania. Mines found that that the 51 students who completed Felder's ILS were active, sensing, visual, and sequential learners. She also found that students in an online learning environment were less satisfied than students in a traditional teaching environment and therefore did not perform satisfactorily.

Various research studies have been conducted on the influence of learning styles on students' performance, not only in engineering but other disciplines. Boatman, Courtney and Lee (2008) found that Introductory Economics students are strong visual learners and being taught visually improved their performance. They also found that ethnicity and gender do not influence student performance. Karns (2006) investigated marketing students' learning styles and performance and found that students can learn through multiple modalities and that their learning styles preferences are not the only factor that influence student performance. Karns suggested that further research be conducted on the influences of teaching styles and class sizes on student performance.

Broberg, Lin, Griggs and Steffen (2008) sought to determine whether engineering technologists and engineering students at the University of Purdue had different learning style preferences in order to enhance their teaching methods to improve student performance and student retention. They found that freshers (first year) students in Engineering Technology preferred more visual learning which changed to a preference for sequential learning in their senior years of study. Engineering students' preferences changed from visual learning in their first year, to global learning in their senior years of study. It was found that the students who were taught using their preferred learning style completed their engineering course, while those whose preferred style was not used dropped out of engineering in most cases.

2.4.5 International and SA initiatives that have been employed to improve performance in Engineering

Köksal and Eğitman (1998) used a Quality Function Deployment (QFD) approach at the Middle East Technical University (METU) to improve the quality of education in IE. They constructed a house of quality in order to determine IE education stakeholders' requirements and to translate these into education design. The main stakeholders were identified as students, their parents, and prospective employers. The faculty members were seen as both stakeholders and designers of the education system. The QFD approach has led to an improvement in teaching, counselling and curriculum development, all in favour of students. It considered teaching, counselling, and curriculum design for improvement. Awareness of the need for quality as well as communication has improved in the department. The relationship between industry and the IE department has also improved. Students appreciated the fact that they played a role in quality improvement. As a result, their levels of motivation have improved.

Crouch, Watkins, Fagen and Mazur (2007) found that the Peer Instruction (PI) technique promotes class interaction and engages students to address difficult learning materials, leading to better student performance. Peer Instruction is an instructional strategy to engage students during class through a structured questioning process that involves every student. Crouch identifies the following ways in which PI influences teaching: PI lessons are not as rigid as traditional classes and offer students a completely different outlook on a particular problem. This compels the lecturer to explain concepts better or in a different manner in order for all students to understand. A study conducted at the University of Missouri by (Marra *et al.*, 2012) suggested that peer mentoring can be effective and can provide academic behaviour role models for new students. Students are generally more open to taking advice from their peers.

Nel and Mulaba-Bafubiandi (2009) note, that the Department of Home Affairs has classified IE as a critical and scarce skill**.** Throughput of IE graduates is thus a primary focus of HEIs. Nell and Mulaba-Bafubiandi outline key interventions implemented by the IE department at UJ in order to improve the throughput rate of students. A proper strategic plan was formulated and the curriculum was redesigned, not only to supply manufacturing industry with students but also the service industry. Bottleneck modules were identified and tutors were appointed to assist with these modules. Students at risk after an examination were also identified and the assessment criteria were revisited in order to ensure that students are examined at an appropriate level. The university also implemented a student exclusion policy. If a slow-progress student did not meet certain requirements set by the department and agreed by the student, the student was excluded from the institution. Nel and Mulaba-Bafubiandi observe that UJ doubled the throughput rate in its IE department after the implementation of these interventions.

Bernold *et al.* (2007) investigated why students do not perform well in engineering and sometimes leave engineering programmes. They concluded that if a student’s preferred learning style is compatible with the way in which lecturers teach, this can create a sense of belonging and determination to remain in Engineering.

It is evident that both international and South African institutions are searching for ways to improve student performance. Various methods have been identified to achieve this. The most common intervention was PI. This practice is used at DUT in the form of tutors. These are normally senior students who teach certain modules to junior students. It was found that students feel more at ease asking fellow students to explain work to them. Another point highlighted by researchers such as Nel and Mulaba-Bafubiandi (2009), is that bottleneck modules must be addressed in order to ensure that students pass. These are modules that students struggle with and that might constrain their progress if they fail them. It is therefore important to ensure that bottleneck modules are identified and that students are provided with the necessary skills and knowledge to pass. The literature also notes that if students’ learning styles match their lecturers’ teaching methods, they will perform better than students with mismatched learning styles.

The following sections discuss teaching and learning.

2.5 Teaching and learning

Cobb (2009) defines learning as the lifelong process of transforming information and experience into knowledge, skills, behaviours, and attitudes. In order to acquire knowledge and skills, we need to learn. As we learn, we will also change our attitudes and behaviour. A student who has just completed the NSC and enters university will have a different perspective on life from that of a graduate. The challenge confronting educators is to identify the different ways that different people learn, the obstacles that some learners have to overcome and how they can make use of this knowledge in the learning environment. Cowan (2006) defines teaching as the purposeful creation of situations where motivated learners will not leave without learning or developing.

Prosser and Trigwell (1999) argue that teaching and learning are fundamentally related and that good teaching should be defined in terms of helping students to learn. They created a model in order to better understand teaching and learning (see Figure 2.1).

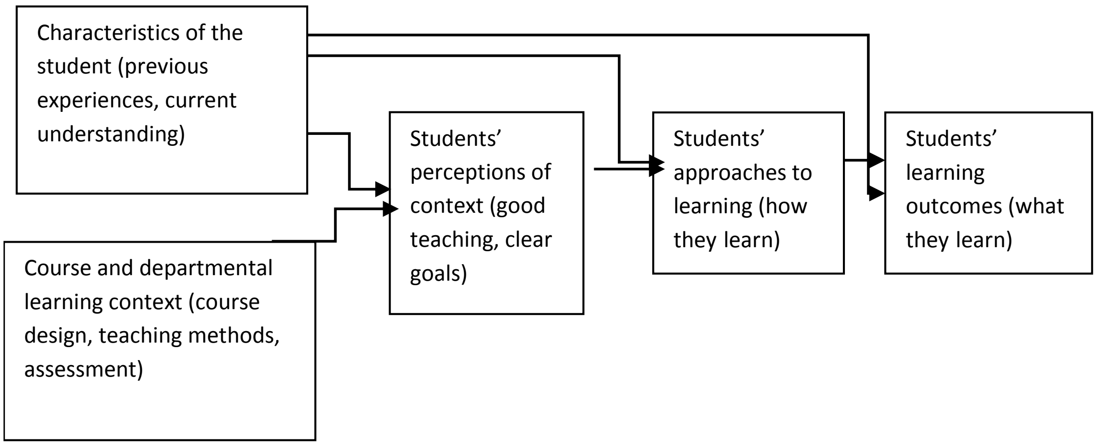

Figure 2.1: Presage-Process model on student learning (Trigwell and Prosser, 1997)

According to Ertmer and Newby (2013) learning is a complex process and there are numerous interpretations and theories of how to accomplish it effectively. Figure 2.1 shows that teaching is an important part of the learning process. Eftekhar (1998) study on the Dynamic Modelling of a

Teaching/Learning System to Aid System Re-engineering investigated how and what should be taught by teaching systems and similarly how and what should be learned by different types of learners. According to Eftekhar (1998), both teaching and learning play an important role in the teaching/learning process. It is therefore important to understand the teaching methods and learning theories that exist and how they engage with one another.

Up until the seventeenth century, teaching methods consisted of recitation, lectures and disputations, with the greatest amount of time and energy being given to recitation. The lowest order of learning skills or pure memory were emphasised, and students were rarely challenged to discuss or analyse issues. “Until the nineteenth century, the recitation method remained at the heart of the teaching” (Eftekhar, 1998). Eftekhar (1998) compared different teaching aspects in a table (*see* Table 2.2) which was based on research conducted by Fuhrmann and Grasha (1983). Table 2.2 shows that lecturers started to change their ways of teaching. However, if lecturers do not know how students are learning, their “improved teaching method” might not suit their students which could lead to high failure rates. It is therefore important to know and understand students’ perceptions of learning.

Table 2.2 Comparison of different teaching aspects over the centuries

Aspects of teaching	Before the revolution	Up until the end of the 19th century	20th century
Purpose of university teaching	Discipline rather than meaningful learning. Training selected people (sons of elite) for ministerial and clergy positions.	A means for getting ahead. A university education is for more than a highly elected student population. A university education should prepare people for a job	Development of new knowledge. Production of a well-educated person trained in the liberal arts tradition. Vocational and career training as an important mission.
Role of the teacher	Paternalistic: The teacher knows what students need to learn. The students should learn what the teacher thinks is important.	Democratic: The teacher took a less directive role in prescribing what the students should learn.	Revolutionary: The teachers are less directive, and act more as facilitators in students’ learning.
Curriculum	Rigid: A single prescribed curriculum composed of ancient languages (Latin	Specialization: Appeared in the curriculum which gave a potential free choice of	First half: Development of divisions. Physical and social sciences and

	and Greek), mathematics and philosophy.	electives. Evolution of the various scientific disciplines: geology, biology, physics, chemistry and social specialities.	humanities led to the development of a curriculum based on major and non-major courses. Students have to master the basics (with a combination of prescribed electives) in each division before selecting an area of specialization. Second half: Curriculum reforms especially sciences and technology.
Teaching methods	Recitation Lecturing Disputation (Greatest amount of time and energy was given to recitation and the emphasis was on the lowest order of cognitive skills – pure memory)	Increased use of lectures Increased use of demonstrations and seminars. Laboratory methods and research papers become a popular teaching method.	Development of teaching methods and practices based on learning theories.
Student – teacher interaction	Teacher should have the last word in resolving debates on content and should prescribe in detail the course content.	Teachers can learn from their students. Teachers helping students to develop the capacity to become independent learners.	Teachers help students to develop problem solving and decision making skills. Teachers personalize their instructions to meet the unique needs of their students.
Type of delivery	Single instructor who was usually a recent graduate of the institution and was marking time until he received his call to the ministry.	Different teachers for different disciplines. Some supporters of the recitation method and some of the lecture method.	Different teachers for different courses. Some supporters of traditional, some supporters of non-traditional and the rest of the supporters a combination of both.
Access to information	Teachers' notes Books were not abundant.	Instructors' notes as well as hands-on experiences. Laboratories emerging, research papers, books and other settings.	Text books, reference books, research papers. Conference proceedings and journal publications. Data bases and computerized information banks.
Methods of testing	Oral questioning of each student in public by examiners who were university personnel and other learned citizens from the local community. No marks, but judgement was passed	Introduction of written exams with marks (0–100) and grades (A–E).	Introduction of nominal distribution curves in marking and grading. Allocation of different weight percentages to assess leaning activities. Written short tests and

	on both the student and his tutor.		long exams (mid-term and final) Individual or group assignments. Seminars and oral presentations.

Source: Dynamic Modelling of a Teaching/learning System to Aid System Re-engineering (1998: 21)

There are various theories on how people learn; some of these are presented below.

2.6 Learning theories relevant to this study

2.6.1 Experiential (Kolb) learning theory

Kolb's experiential learning theory (ELT) is based on a learning cycle driven by the resolution of the dual dialectics of action/reflection and experience/abstraction (Kolb and Kolb, 2012). This holistic theory defines learning as a major process of human adaption involving the whole person that is applicable to all areas of life.

Kolb identified three stages of development. A person's learning preferences will change in each stage as they mature. Almeida, de Jesus and Watts (2011) note that the three stages are:

1. Acquisition: students ask questions that are related to simple facts and concepts.
2. Specialization: students go beyond the mere search for information and start to develop a preferred learning style, which is shaped by the social, educational and organisational environment in which they grow up.
3. The integration stage that occurs later in a person's life. At this stage the person will ask higher level questions.

Kolb's learning style cycle is illustrated in Figure 2.2. Kolb and Kolb (2012) summarised the learning style cycle as follows:

Diverging style: a person with a diverging style is dominant in Concrete Experience (CE) and Reflective Observation (RO). People who fall into this category perform well in “brainstorming”, have a broad interest field and like to collect information. The diverger is open-minded and works well in groups.

Assimilating style: an assimilating person is dominant in Abstract Conceptualisation (AC) and Reflective Observation (RO). The assimilating person focuses on ideas and abstract concepts rather than people. The assimilator wants to think things through and prefers readings and lectures.

Converging style: the converger is dominant in Abstract Conceptualisation (AC) and Active Experimentations (AE) and is orientated towards the practical. The converger is technically-orientated and likes to experiment with new ideas. They are not very socially-orientated.

Accommodating style: accommodators are dominant in Concrete Experience (CE) and Active Experimentation (AE). They are very active and learn through “hands-on” experience. Accommodators get the work done and set their own goals.

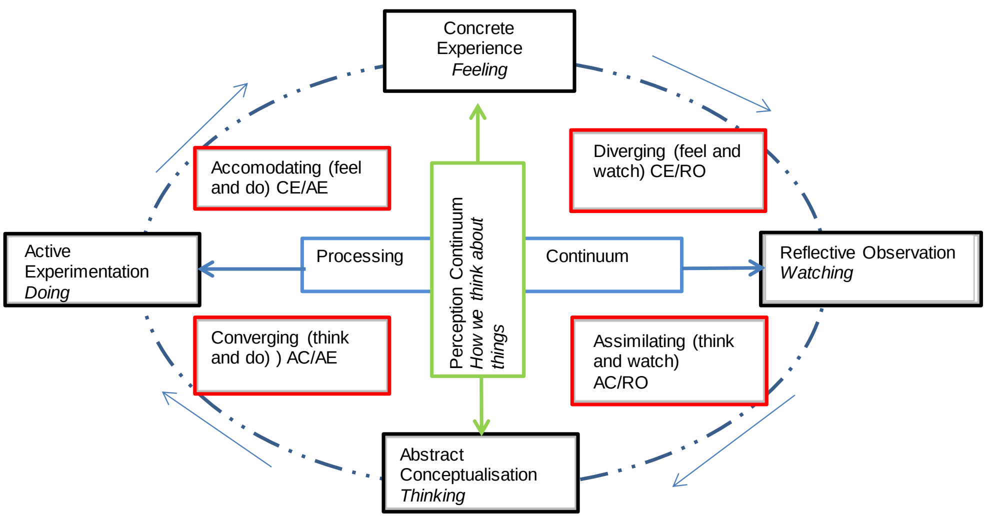

Figure 2.2 Kolb’s learning cycle

Source: Image adopted from http://www.businessballs.com/kolblearningstyles.htm (2005)

According to Manolis, Burns, Assudani and Chinta (2013), Kolb’s experiential learning model is based on six propositions:

1. Learning should be seen as a process and not in terms of outcomes.

2. Learning is a continuous process grounded in experience.
3. Learning requires the resolution of conflict between dialectically opposed modes of adaption to the world.
4. Learning is a holistic process of adaption.
5. Learning results from synergistic transactions between the person and the learning environment.
6. Learning is the creation of knowledge.

From the above, it is evident that Kolb saw the learning process as never ending. Furthermore, a person's preferred learning style will change as they mature and develop in their personal life and work environment. Learning is the process of knowledge. Experiential learning theory proposes a constructivist theory of learning whereby social knowledge is created and recreated in the personal knowledge of the learner. This stands in contrast to the "transmission" model on which much current educational practice is based where pre-existing fixed idea are transmitted to the learner" (Kolb and Kolb, 2012).

Felder (1996) observes that traditional engineering instruction focuses on the formal presentation of material which only fits comfortably with abstract and reflective learners who are assimilators. According to Felder, the professor or educator needs to incorporate all types of learning styles when they teach. In the first instance, they need to explain the relevance of each topic (diverger); then they need to present students with the basic information and methods associated with the topic (assimilators). Thereafter, students need to be given the opportunity to practice (converger), and lastly, the professor or educator needs to encourage students to explore all these applications (accommodator).

2.6.2 Behaviourist learning theory

Various researchers such as Watson, Thorndike and Skinner have discussed the behaviourist learning theory. Skinner, cited by Weegar and Pacis (2012) believed that everything human beings do is controlled by their experience. He therefore posited that the "mind" (not the brain) has nothing to do with how people behave. The behaviourist learner focuses on control and adaptive responses. Forrester and Jantzie (2001) article on learning theories notes, that behaviourisms are observable indicators that learning is taking place. In contrast, cognitive psychologists equate learning with the mind's mental processes. Behaviourists do not deny the existence of these mental processes. In fact, they acknowledge their existence as an unobservable indication of learning.

Weegar and Pacis (2012) compared the behaviourist and constructivist learning theories. Behaviourists believe that learning is influenced by changes in behaviour. If students are in the correct environment, they should all acquire the same understanding of the topic. Bush (2006: 14) observes that, for behaviourists, only observable, measurable and outward behaviour is worthy of scientific enquiry. Weegar and Pacis (2012) cites Gonzalez (n.d.), who states that teachers who are behaviourists would present lessons in a linear fashion and guide students to the desired behaviour. The behaviourist introduces lower-level cognitive skills and builds up to higher level cognitive skills. Gonzalez notes that the problem with this teaching approach is that learning occurs in isolation. Students are therefore not involved in problem solving, as lecturers only use methods such as direct instructions. The lecturer believes that the students do not know anything and thus they are not required to respond to the lecturer, unless addressed by him/her.

2.6.3 Constructivist learning theory

According to Forrester and Jantzie (2001), constructivists believe that all humans have the ability to construct knowledge in their own minds through a process known as problem-solving. Ileris's (2009) book on Contemporary Theories of Learning agrees with Piaget (1954) and Papert (1980) that constructivist learners build their own mental structures when they interact with an environment. The constructivist is hands-on and prefers activities that can teach them something new.

According to Weegar and Pacis (2012), the constructivist views learning as a search for meaning and also believes that students gain knowledge and understanding through experience. The learning theory of constructivism evolved from the theory of cognitive development posited by Swiss psychologist, Piaget and the Russian psychologist, Vygotsky. Draper (2002: 22) notes, that the constructivist believes, that learners interact with the environment and other people in order to gain knowledge. Kearsley (1994) notes, that the constructivist uses open-ended problems, experiments and student participation to learn. The constructivist theory shows students the relevance of what they are learning (Carbonell, 2004) and (Weegar and Pacis, 2012). Table 2.3 highlights the differences between constructivism and behaviourism (Forrester and Jantzie, 2001).

Table 2.3 Differences between Behaviourism and Constructivism

Behaviourism	**Constructivism**
1. Directed Instruction	1. Non-directed instruction
2. Objectivist	2. Constructivist
3. Teacher-centred	3. Learner-centred
4. Behavioural observations	4. Cognitive observations
5. Focus on the individual	5. Group work is emphasised
6. More focused on one approach	6. More holistic in approach

Source: Learning Theories (2001: 9)

2.6.4 Paulo Freire's banking concept of education

Micheletti (2010) article on Freire's banking theory of education observes that this approach contributed to the shaping of modern approaches to education. According to Freire, the so-called banking concept hinders students' intellectual growth because they receive information which has no real connection with their lives. Freire stated that:

> "Implicit in the banking concept is the assumption of dichotomy between human beings in the world: a person is merely in the world, not with the world or others; the individual is a separator, not re-creator. In this view the person is not a conscious being (corpo consciente); he or s/he is

> rather the possessor of a consciousness: an empty ‘mind’ passively open to reception of deposits of reality from the world outside.” (Micheletti, 2010)

The most important concept of Freire’s *Pedagogy of the Oppressed* was the “culture of silence”. The oppressed feel that their opinion does not count and they start to rely more on the oppressors and their experience. Freire added that teachers assume the roles of depositors and the students are mere receptors. Students are thus unable to rationalise and conceptualise at a personal level. Freire claimed that the banking concept dehumanises people. He therefore developed problem-posing education to overcome these deficits. The intention was to allow both students and teachers to become less structured in order to ensure dialogue where the parties share knowledge. Students are thus no longer regarded as objects, but as modules with a consciousness.

2.7 Learning styles

Some studies on learning styles in engineering education have raised concerns about the use of learning style theory (Price 2004; Holvikivi 2007). The literature also notes, that being aware of learning styles may improve educational performance and assist in retaining a diverse student population (Cagiltay, 2008).

A learning style can be defined as the cognitive, effective, and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact and respond to the learning environment (Romanelli, Bird and Ryan, 2009). Fatt (2000) investigated how learning styles influences lecturers’ behaviour in class and argued that how students learn and perform at university is influenced by their preferred way of learning. According to Fatt (2000), it is important that students be made aware of their learning styles. This may encourage them to adopt appropriate styles for different disciplines or modules and change their styles to suit changing learning situations.

Various learning styles have been developed over the years, five of which are specifically used for engineering education. Three of these learning style models are discussed in Felder and Brent's (2005) paper on student differences: the Myers-Briggs Type Indicator, Hermann's learning style model and the Felder and the Silverman model.

2.7.1 Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) system is a means of establishing an individual's personality profile and is widely used in aptitude testing for employment. Designed as a tool to investigate the many different strands of personality type, the MBTI also offers insights that are of value to teachers (Pritchard, 2013: 45). According to Pritchard (2013) and Felder and Brent (2005) the Myers-Briggs Model classifies individuals according to their preferences on scales originally designed by Jung (1875 to 1961) based on the theory of psychological types (McCaulley, 1981). The Myers Briggs model classifies people as extraverts/introverts, sensors/intuitors, thinkers/feelers or judgers/perceivers. Most engineering instruction is oriented toward introverts (lecturing and individual assignments rather than active class involvement and cooperative learning), intuitors (an emphasis on science and math fundamentals rather than engineering applications and operations), thinkers (with an emphasis on objective analysis rather than interpersonal considerations in decision-making), and judgers (where the focus is on following the syllabus and meeting assignment deadlines rather than on exploring ideas and creative problem solving) (Felder and Brent, 2005).

2.7.2 Hermann Brain Dominance model (HBDI)

According to Herrmann (1991), thinking can take place in four different modes and is based on how the brain functions when given specialised tasks. Hermann identified the following four dimensions in the brain:

- Quadrant A: logical, analytical, fact-based and quantitative

- Quadrant B: organised, sequential, planned, detail
- Quadrant C: interpersonal, feeling-based, kinaesthetic and emotional
- Quadrant D: holistic, intuitive, integrating, synthesising

Lumsdaine and Lumsdaine (1995) conducted a study at the University of Toledo using the HBDI to identify the impact of students' thinking preferences on curriculum restructuring. They found that engineering lecturers are in quadrant A and therefore the instruction focuses on quadrants A and B, both located on the left-hand side of the brain. These lecturers are therefore concerned only with analysis (quadrant A) and methods and procedures (quadrant B). The right-hand side is completely neglected. Their study further found that between 20% and 40% of students fall into the right-hand side of the brain which focuses more on teamwork, creative problem-solving and systems thinking.

2.7.3 Felder-Silverman model

The Felder-Silverman model divides learners into four categories (Felder and Silverman, 1988), namely:

- sensors (practical) or intuitive (conceptual) learners;
- visual or verbal (written) learners;
- active or reflective learners;
- sequential or global learners

The characteristics of the four dimensions of the Felder and Silverman (1988) ILS model are shown in Table 2.4.

Table 2.4: Characteristics of the four learning styles dimensions of Felder and Silverman

Dimensions	Complementary learning styles	
Perception	**Sensing style** • Practical and observing • Facts and data are important • Students prefer repetition when learning	**Intuitive style** • Student are interpretative and they use their imagination • Prefer theory and modelling • Want variation in class activities
Input	**Visual style** • Students want to see how to do something. • Students prefer to have diagrams and pictures when they study	**Verbal style** • Students want to be told what to do • Students prefer written and spoken explanations
Processing	**Active style** • Students learn by doing • Learn by working with others	**Reflective style** • Students want to think about what they have learned. • Prefer to work alone or in pairs
Understanding	**Sequential style** • Understand in continual and incremental steps. • Convergent thinking and analysis	**Global style** • Understand in large leaps • Systems thinking and synthesis

Table created making use of learning styles in Engineering Education (1988)

According to Felder and Silverman (1988), most engineering students' learning styles are incompatible with their lecturers' styles of teaching in several dimensions. Many or most engineering students are visual, sensing, active learners; some of the most creative students are global learners. On the other hand, engineering lecturers are auditory, abstract (intuitive), passive, and sequential. These mismatches lead to poor student performance, professorial frustration, and the loss to society of many potentially excellent engineers.

Felder and Brent (2005) suggest that one should try and find a correlation between learning styles, orientation to study and levels of intellectual development. Boatman *et al.* (2008) study on the influence of learning styles on student performance in an economics course found that learning styles influence student performance. Naimie, Siraj, Abuzaid and Shagholi (2010) investigated the relationship between learning style preferences and achievement scores in matched teaching/learning styles and mismatched teaching/learning styles. The study found, that students performed better when there was a match between learning styles and teaching styles than if there was no match.

Desmond, Chen and Randa (2010) study at the University of Oklahoma found that there is a difference in the learning style preferences of students in different engineering programmes. The study found that IE students at this university were predominantly visual and active learners.

Broberg *et al.* (2008) research found that female engineers prefer reflective and verbal learning more than their male counterparts. Male students tend to be more visual and active learners. Rosati (1999) found that the female engineering students tend to be more sensory learners, while their male counterparts are more intuitive learners. Female students are more open to ideas, while male students prefer real life situations and facts.

The learning styles models discussed above have one thing in common; students prefer to learn differently. The MBTI, the HBDI and the Felder-Silverman models classify learning styles preferences in four categories which are fairly similar. It is evident that the majority of engineering lecturers focus on only one of the four categories in each of the three models. Students falling in the other three categories of learning are neglected when it comes to teaching. From the models, it is evident that lecturers prefer to convey facts only and to perform formal lectures, with little or no student involvement.

Approaches to teaching and different types of teaching styles are discussed in the following section.

2.8 Teaching approaches and styles

2.8.1 Teaching approaches

Improving educators' teaching skills requires an understanding of how students learn. In the first instance, schools and universities should adopt a theory of learning on which to base their classroom approach. Fatt (2000) suggests that lecturers offers students a chance to learn in a way that suits their learning styles instead of students having to adapt themselves to their lecturers' different teaching styles. Lecturers need to consider the group learning style and teach according to this style instead of having to adapt to students' varied learning styles. Fatt cites Pask (1976) who suggests that extreme teaching styles could be disadvantageous to students with mismatched learning styles.

Knowles (1975) identified two main categories of teaching styles, namely, the lecturer/teacher-centred or the student/learner-centred approach. Huba and Freed (2000) note, that in a teacher-directed learning environment, students receive information passively, without actively participating. In Table 2.5 Huba and Freed compared teacher centred and student centred approaches of teaching. Huba and Freed's The lecturer is there to provide information and to evaluate. In a lecturer /teacher centred learning approach, students do not have the opportunity to grow personally. On the other hand, McCombs and Whisler (1997) describe the student/learner-centred approach as one that focuses on students' experiences, interests, backgrounds and needs. Lecturers should be encouraged to adopt a student/learner-centred approach in their teaching, in order to involve students more in their quest to learn about their discipline. Ahmed (2013) study on the differences between the lecturer/teacher-centred approach and the learner/student-centred approach concludes that by shifting from teacher-centred teaching to a more learner-centred teaching style, students will become more active participants in class and will learn better.

Table 2.5: Differences between lecture/teacher centred or student/learner centred approaches

Teacher- directed learning	**Self-directed learning**
Knowledge is transmitted from professor to students.	Students construct knowledge through gathering and synthesizing information and integrating it with the general skills of inquiry, communication, critical thinking, problem solving.
Students passively receive information.	Students are actively involved.
Professor's role is to be primary information giver and primary evaluator	Professor's role is to coach and facilitate. Professor and students evaluate learning together
Teaching and assessing are separate.	Teaching and assessing are intertwined.
Assessment is used to monitor learning.	Assessment is used to promote and diagnose learning.
Emphasis is on right answers.	Emphasis is on generating better questions and learning from errors.
Desired learning is assessed indirectly through the use of objectively scored tests.	Desired learning is assessed directly through papers, projects, performances, portfolios.
Focus is on a single discipline.	Approach is compatible with interdisciplinary investigation.
Culture is competitive and individualistic.	Culture is cooperative, collaborative, and supportive.
Only students are viewed as learners.	Professor and students learn together.

Source: http://assessment.uconn.edu/docs/TeacherCenteredVsLearnerCenteredParadigms.pdf
(accessed: 19 March 2015)

Trigwell and Prosser (1997) identified the following five teaching approaches:

- A teacher-focused strategy with the intention of transmitting information to students: transmission focuses on facts and skills, and it is assumed that students do not need to be active in the teaching-learning process.
- A teacher-focused strategy with the intention that students acquire the concepts of the discipline: it is assumed that students do not have to be actively involved in class in order to learn.
- A teacher/student interaction strategy with the intention that students acquire the concepts of the discipline: lecturers believe that students gain knowledge by actively engaging in the teaching-learning process.
- A student-focused strategy aimed at students developing their own conceptions: the student is assumed to construct their knowledge and change their conceptions.
- A student-focused strategy aimed at students changing their conceptions: the teacher encourages self-directed learning and provides time during formal lessons to interact and discuss any problems they are experiencing. The lecturer provokes debate with students and encourages them to express their ideas.

2.8.2 Teaching styles

Visser, McChlery and Vreken (2006) compared the learning styles and teaching styles of a university in SA and one in the United Kingdom. A teaching style is the combination of teaching methods and techniques that a lecturer/teacher prefers (Visser *et al.*, 2006). Visser cites Van Hamburg (2006) who affirms the principles of good teaching, including encouraging student-lecturer contact and cooperative and active learning, and the need to respect diverse learning styles.

Student learning is an outcome of teaching. Fenwick (2001) raises the question of whether student learning can be used to improve teaching in today's complex academic environment.

According to Visser *et al.* (2006) teaching styles are a combination of the teaching methods and techniques used by a lecturer. Fatt (2000) notes, that in order for educators to improve the teaching skills, they need to know how students learn. He adds that the quality of teaching is measured by how effectively the lecturer's teaching style reinforces the learning theory.

As with learning styles, extensive research has been conducted to determine lecturers' preferred teaching styles. Grasha (1994) study at the University of Cincinnati initially identified five teaching styles, namely, expert, formal authority, personal model, facilitator and delegator. For the purpose of this study the researcher made use of the Grasha-Riechmann teaching style questionnaire (Grasha and Riechmann-Hruska, 1996), which tests the teaching styles identified by Grasha. The researcher selected this test because many researchers in the field of education are still using it. For example, Behnam and Bayazidi (2013) used the Grasha-Riechmann teaching style questionnaire to identify the relationship between personality types and teaching styles among Iranian educators who teach English as a foreign language (TEFL). A short description is provided of each teaching style.

The formal authority lecturer feels that s/he is responsible for controlling the way and the speed at which a learner receives knowledge. S/he does not bother to get to know each learner individually. The formal lecturer is also concerned about doing things correctly. S/he sets clear goals for students, but is also very rigid in managing them.

The demonstrator models or demonstrates what is expected of the learner and coaches students in what is required of them. With a demonstrator educator, learners need to actively participate. The lecturer is hands-on and acts as a role model for the students. However, students who cannot live up to the lecturer's expectations could feel inferior.

The facilitator has a learner-focused approach, and the educator needs to oversee all activities. The leaner must take the initiative to achieve the set outcomes. An independent learner will do very well in this type of environment. The lecturer will ask questions, suggest alternative approaches, and help students make informed decisions.

The delegating educator makes learners responsible for learning. This type of educator plays a consultative role in providing feedback or advice to a learner when requested to do so. Students see themselves as independent learners. However, some students might not be ready to work on their own and will become anxious.

Felder and Silverman (1988) found that mismatches exist between the common learning styles of engineering students, and the traditional teaching styles of engineering professors. They note that this is why students become bored and inattentive in class, do poorly in tests, get discouraged about their courses, the curriculum, and themselves, and in some cases, change to other curricula or drop out. Broberg *et al*. (2008) note that being aware of students' preferred learning could encourage them to remain in their technical curricula.

Based on the Felder-Silverman model, Felder (1996) offers the following suggestions on how to teach students with different learning styles:

1. Address the sensing, inductive and global learning preferences first. The lecturer should first teach the theoretical material and make use of problems that relate to the theory, in order for students to understand how the theoretical content links to the tools to solve certain problems.
2. Conceptual information (intuitive) should be linked with concrete information (sensing).
3. Make use of physical analogies and demonstrations to illustrate the magnitudes of calculated quantities (addressing both sensing and global learning styles).
4. Provide class time for students to think about the material presented (reflective) and request active student participation. Allow some time for thinking and formulating questions.

The following section addresses the research problem.

2.9 The problem this research is addressing

Industrial Engineering students at DUT have not performed well in recent years, negatively affecting throughput and graduation rates. No previous research has been conducted on student performance in the department of IE at DUT. This study investigated the effects of the correlation between students' preferred learning styles and lecturers' teaching styles on student performance, in the Department of IE at a university of technology (DUT).

The researcher sought to determine whether or not student academic performance is influenced by how students prefer to learn and by the methods used by lecturers to conduct their lectures.

2.10 Theoretical framework informing this research

Sekaran and Bougie (2010) describe a theoretical framework as a model that enables a researcher to make logical sense of the relationships between the factors that are important to the research problem.

This study adopted the Felder-Silverman model (1988) in order to determine students' preferred leaning styles and lecturers' preferred teaching styles. The Felder and Silverman learning style model (FSLSM) is one of the few models that describe students' learning styles in detail. Graf, Viola, Leo and Kinshuk (2007) found that the FSLSM is mainly used in technology-enhanced learning and that it is specifically designed for traditional teaching and to capture significant differences in engineering students' learning styles (Felder and Brent, 2005). The model identifies four dimensions within students' preferred learning styles, namely:

- Sensing(concrete, practical) / intuitive learners (innovative, orientated towards theories)
- Visual learners (prefer pictures, diagrams) / verbal learners (prefer written, spoken explanations)
- Active learners (try things, work with others) / reflective learners (think things through, lean by themselves)
- Sequential learners (linear, orderly) / global learners (holistic, learn in large leaps)
- Inductive (presentations from specific to general) / deductive (presentations from general to specific)

Felder and Silverman (1988: 675) proposed that students' learning styles and lecturers' teaching styles can be defined by answering the five questions set out in Table 2.6.

Table 2.6: Questions determining students' learning styles and lecturers' teaching styles

Five questions for students	Five questions for lecturers
1. How does the student prefer to receive information: external – sights, sounds and physical sensations or internal – possibilities, insights and hunches?	1. How does the lecturer convey information: concrete – factual or abstract – conceptual and theoretical?
2. Which sensory channel perceives external information the most effectively: visual – pictures, graphs and demonstrations or auditory – - sounds and words?	2. What mode of presentation is mostly used: Visual – pictures, diagrams and demonstrations or auditory – verbal readings and discussions?
3. How does the student organise the information the easiest: inductive – facts and observations are provided or deductive – principles are given and consequences and applications are deduced?	3. How does the lecturer organise the information provided to students: inductively – phenomena leading to principles or deductively – principles leading to the phenomena?
4. How does the student prefer to process information: actively – engaging in physical activity or reflectively – through introspection?	4. What mode of participation is facilitated by the presentation mode: active – students talk, move and reflect or passive – students only listen?
5. What action does the student use to understand things: sequentially – in continual steps or globally – in large jumps and more holistically?	5. How does the lecturer provide information: sequential – step-by-step progression or global – context and relevance of the work?

Learning and teaching styles in engineering education (1988:675)

The Felder-Solomon ILS questionnaire is based on the FSLSM and tests student's preferred learning styles. The questions in the ILS are grouped according to the similarity of the semantic groups in each dimension. The learning style model classifies students according to where they fit on a number of scales as seen in Figure 2.3, in terms of the ways they receive and process information. If a student fall between 7A and 11A on the scale between active and reflective learning styles, the student will be classified as an active learner.

ILS REPORT FORM

ACT	11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b	REF
SEN	11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b	INT
VIS	11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b	VRB
SEQ	11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b	GLO

Figure 2.3: ILS form **(Soloman and Felder, 1999)**

If a student’s score on a scale is 1-3, s/he is fairly well balanced on the two dimensions of that scale. If the student’s score on a scale is 5 or 7, s/he has a moderate preference for one dimension of the scale and will learn more easily in a teaching environment that favours that dimension. Finally, if a student’s score on a scale is 9 or 11, s/he has a very strong preference for one dimension of the scale and may have real difficulty learning in an environment which does not support that preference.

The researcher made use of the Grasha and Riechmann-Hruska (1996) teaching style survey, because Felder does not provide a survey specifically designed to identify lecturers’ preferred teaching style.

2.11 Summary

This chapter reviewed relevant literature in order to better understand the complexity of teaching and learning processes. As the world develops and evolves, the new “kids on the block” have different needs from those of the past and as current learners grow and develop, they need also change. Educators need to take these needs into consideration when teaching students. We are past the stage where "chalk and talk" was enough to educate people. In today's world, various teaching and learning mediums, such as videos, e-learning, action learning and so on, are available. This study focuses on students' learning methods as well as the teaching methods used by lecturers.

Chapter 3 discusses the research methods used to address the research problem.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Chapter 2 examined the link between students' preferred learning styles, lecturers' preferred teaching methods and student performance within engineering departments and more specifically, the IE department. It also explored local and international initiatives to improve IE student performance and throughput at HEIs. This chapter presents the research design and approach used to conduct the study. The sampling approach, data collection instruments and data collection methods are discussed. Finally, it considers the ethical concerns related to this study, data analysis and tests for reliability and validity.

3.2 Research aims, objectives and design

Research question:

Do the different learning styles of students and teaching methods of lecturers have an influence on student performance?

The aim of this study was to investigate learning styles, teaching methods and student performance in IE at a selected university of technology in SA. In order to achieve this aim, the following objectives were addressed:

To determine:

- the preferred learning styles of students in the selected levels 1, 2, and 3 modules in IE at DUT;
- lecturers' preferred teaching styles in the selected levels 1, 2, and 3 modules in IE at DUT;
- the effect of lecturers' teaching styles and students' learning styles on student performance in the selected modules.

Henn, Weinstein and Foard (2009) describe a research design as a programme for research that involves initial specification of the research problem to be investigated, and the plan for collecting and analysing data.

Since this research study focused on the impact of learning styles and teaching methods on students' performance; descriptive and experimental research was conducted. According to Williams (2011), the descriptive research approach is a basic research method that examines a situation as it exists in its current form. He adds that descriptive research involves the identification of the attributes of a particular phenomenon based on observation, or exploring the correlation between two or more phenomena. In this study, descriptive research was conducted through research questionnaires and interviews. The questionnaires were used to determine students' preferred learning styles, while the interviews sought to determine individual lecturers' preferred teaching methods.

Experimental research was conducted through quasi experimental research, which consists of an experimental and control test. The basis of the experimental method is the experiment, which can be defined as a test under controlled conditions that is undertaken to demonstrate a known truth or examine the validity of a hypothesis (Eugene, 2004). The purpose of the experimental research was to determine if students' preferred learning styles and lecturers' preferred teaching styles impact on student performance.

The research methodology adopted for this study is discussed in the following section.

3.3 Research methodology

According to Coolican (2014), research methodology refers to the selection of the research questions, the theoretical framework and the research methods. This study made use of the quasi experimental design. The quasi experimental design made use of both Qualitative and quantitative data sources. The data sources and the quasi experimental research are discussed in the following sections.

3.3.1 Data sources

Henn *et al.* (2009) explain that quantitative research is associated with positivist perspectives in social research; the logic is to collect structured and quantifiable data using standardised approaches on a range of variables. Henn *et al.* (2009) add that, on the other hand, qualitative research cannot be associated with an interpretive perspective in social research but instead aims to understand human behaviour. The data are usually semi-structured and textual in nature, and are collected from a small number of cases using a range of methods.

Quantitative research was conducted by administering questionnaires to the selected students, while qualitative research was conducted through semi-structured interviews with the selected lecturers. These data collection instruments are discussed later in this chapter. Once the data had been collected, the researcher used quasi experimental research to determine the effect of lecturers' teaching styles and students' learning styles on student performance in the selected modules.

3.3.2 Quasi experimental research

Muijs (2004) observes that quasi experimental research is appropriate in investigating the effects of an educational intervention, a project to improve a specific element, or a professional development plan. One of the main advantages of quasi experimental research is that external factors can be controlled and the researcher can manipulate the treatment or the intervention required to improve the outcome.

In this study the treatment was to change the lecturers' teaching styles and methods to suit their students' preferred learning styles. The primary objective of quasi experimental research is to assess the benefits of a specific intervention. Quasi experimental methods have often been used in classrooms to study the effects of different treatments or teaching techniques. "The pre-testing and post-testing of students who have been assigned in a treatment group, to a non-treatment group or to various kinds of treatment groups, provides evidence of learning and / or changes between or among treatment groups" (Arhar, Holly and Kasten, 2001: 34).

The researcher used a control group and experimental group for the purpose of this study. The quasi experimental research consisted of three phases, namely, the pre-test, the intervention phase and the post-test. The experimental and the control groups took both the pre-test and the post-test, but only the experimental group received intervention prior to the post-test. The phases are discussed below.

3.3.2.1 Phase one: Pre-test

During the first phase of the experiment, the student participants in this research study were assembled together in a lecture venue. The lecturer of the selected modules in Table 3.1 presented a lecture on a small section of one of the chapters that needed to be covered in the syllabus for the specific subject.

Table 3.1: Selected modules and chapters used for the Pre-test

Level	**Subject**	**Chapter**
Level 1	Production Engineering 1	Chapter 2: Competitiveness, strategy and productivity. The focus was on ways to determine productivity and how to improve productivity within industry.
	Qualitative Techniques 1	Chapter 8: Probability. The focus was on the application of the rules of addition and multiplication as well as the enumeration of outcomes.
	Engineering Work Study 1	Chapter 6: Record, examine, and develop the stages of a method study. The focus was to test the students' ability to perform a method study on a specific task.
Level 2	Production Engineering 2	Chapter 5: Maintenance. The focus was on the different types of maintenance found in manufacturing facilities, and the importance of maintenance of equipment.

	Engineering Work Study 2	Chapter 2: Worker-Machine Systems. The focus was on cycle time analysis and determining the number of machines to allocate.
	Costing 2	Chapter 2: Cost concepts and behaviour. The focus was on understanding the theory. Cost estimation calculations using two methods, viz. High/Low Method and Scatter diagram. Chapter 3: Material Valuation methods The focus was on material valuation using the perpetual and periodic inventory systems.
Level 3	Operations Research 3	Chapter 3: Decision analysis. The focus was on the use of decision trees to make operational decisions. Chapter 9: Linear programing graphical system: The focus was on using linear programming to take decisions.
	Automation 3	Chapter 7: CNC Machining The focus was on open loop control using stepper motors.

A day after the lesson was presented, the students wrote a test on it. Each subject test consisted of 1-4 questions. In Engineering Work Study 1, students were required to design a method study for a specific task; therefore only one question was required. Each lecturer marked the tests and recorded the results.

The researcher then arranged a meeting with each lecturer to discuss the students' preferred learning styles, obtained from the ILS questionnaire results. During this meeting, the lecturers were also informed about the outcome on their preferred teaching styles, determined through the semi-structured interviews. The researcher and the lecturers studied their students preferred learning styles and identified ways of adapting their teaching style/method in order for it to be more compatible with their students.

3.3.2.2 Phase 2: Intervention

The researcher divided each subject group into two groups, namely, the control group and the experimental group. Students registered for more than one subject in a level were kept in the same group for all the modules. The students were divided equally into the experimental and control groups, unless there was an uneven number. The researcher took care to ensure that the experimental and control groups had the same number of each type of learning style. The number of learning style types per control and experimental group for each subject is set out in Table 3.2.

Table 3.2: Learning style types per control and experimental group

	Modules	Quasi experimental groups	Active learners	Reflective learners	Sensory learners	Intuitive learners	Visual learners	Verbal learners	Sequential learners	Global learners	Indifferent learners
LEVEL1 = 38 STUDENTS	Production engineering 1	Control group	2	1	4	0	3	1	2	1	5
		Experimental group	3	1	3	0	4	1	2	0	5
	Engineering work study 1	Control group	3	1	3	0	3	1	1	1	3
		Experimental group	3	1	4	0	3	1	1	0	4
	Quantitative techniques 1	Control group	3	2	2	0	3	1	1	1	3
		Experimental group	3	2	2	0	3	1	1	0	4
LEVEL 2 = 40 STUDENTS	Production Engineering 2	Control group	1	1	2	0	3	0	0	1	4
		Experimental group	2	1	2``	0	3	1	1	0	4
	Engineering work-study 2	Control group	1	0	1	0	2	0	0	1	3
		Experimental group	0	0	2	0	1	1	0	2	3
	Costing 2	Control group	2	0	2	0	3	0	0	0	4
		Experimental group	1	1	2	0	2	1	0	1	3
LEVE L 3 = 17 STUDENTS	Operational research 3	Control group	2	0	2	0	2	0	0	0	1
		Experimental group	1	0	2	1	2	0	0	0	0

	Automation 3	Control group	2	0	2	0	2	0	0	0	1
		Experimental group	1	0	2	1	1	0	0	0	0

Adapted from the Felder-Silverman learning style model (1988)

The lecturer was required to redo the same lesson with both groups at different times. During the lesson with the control group, the lecturer taught in his/her usual style. In the lesson with the experimental group, the lecturer was required to make some type of intervention in his/her teaching style/ method. The initial teaching style/methods and the adjusted teaching style/methods for each subject are shown in Table 3.3.

Table 3.3: Initial teaching style/ method vs intervention in teaching style/method per subject

Levels	**Modules**	**Initial teaching method**	**Interventions**
Level 1	Production Engineering 1	PowerPoint slides and "chalk and talk" (with the chalk and talk technique the lecturer simply uses white board markers to write on the board while conducting the lecture)	Video, with the initial power point presentation. Student interaction was obtained by asking questions of individuals
	Qualitative Techniques 1	Chalk and talk	Interactive class activity
	Engineering Work Study 1	Chalk and talk	Interactive class activity
Level 2	Production Engineering 2	PowerPoint slides	Interactive class activity
	Engineering Work Study 2	PowerPoint slides	Class interaction
	Costing 2	Advise on chapter outcomes through knowledge awareness and problem solving without student involvement Students were given	Engaging students in class exercises by solving problems on the board to enable the lecturer to identify areas for improvement. This approach helped to enhance the students'

		tutorials to work through after class exercises	confidence that they could approach problems better rather than taking notes Students were also asked to verify their colleagues' answers and to correct them where necessary
Level 3	Operations Research 3 Automation 3	PowerPoint presentation PowerPoint presentation	Class interaction Class interaction through a practical

3.3.2.3 Phase 3: Post-test

A day after the interventions, the students were required to rewrite the same test written during the pre-test phase. The test was marked by the lecturer and the marks were recorded. The two test results, in conjunction with the teaching intervention, were compared in order to determine if there was an improvement in the results of the students in the experimental group.

Before the data collection instruments used in this study are discussed, it is important to consider the sampling approach used.

3.4. Sampling approach

According to Cohen, Manion and Morrison (2007) a sample is the part of a study's total population which is used to collect data; the knowledge obtained from the sample data, is therefore representative of the total population. "The sampling approach is an important step in the research process because it helps to inform the quality of inferences made by the researcher that stem from the underlying findings" (Onwuegbuzie and Collins, 2007). The sampling approach consisted of the identification of the target population, and the sampling frame and sampling method used in the study.

3.4.1 Target population

A target population (or the sampling frame) is the group of individuals (or a group of organizations) with some common defining characteristics that researchers can identify and study (Creswell, 2008: 152). This study was conducted at the IE Department at DUT from June 2013 to December 2013. The target population of students and staff is shown in Table 3.4. The target population of students consisted of undergraduate students, in the National Diploma: Industrial Engineering.

Table 3.4: Students' and lecturers' target population in the IE Department at DUT

Target population	Target size
National Diploma: Industrial Engineering students	111
National Diploma: Industrial Engineering lecturers	5

After the target population was identified the researcher selected the sampling frame and method.

3.4.2 Sampling frame and method

The sample is the group of participants selected from the target population from which the researcher generalises to the target population (Creswell, 2008: 393). This study made use of purposive and convenience sampling which are discussed in the following sections.

3.4.2.1 Purposive sampling

Check and Schutt (2011: 148) explain that purposive sampling may involve the entire population of a limited group or a subset of a population. The number of students identified in this sample was 111 students. These students were registered for the National Diploma: IE in the modules identified and selected for the purpose of this study. Information to identify the modules used was retrieved from the ITS system at DUT (Faculty of Engineering and Built Environment, 2013, Department of Industrial Engineering – class list, Durban Campus Fulltime Calendar Year: 2013 Block Code: 21 and 22). The overall student pass rate in all IE modules which are offered in-house was determined. The modules were then ranked from the highest pass rate to the lowest pass rate. The researcher selected the modules in which students obtained the highest overall pass rate (80% to 100%), those in which students obtained an average overall pass rate (60% to 79%) and modules in which students obtained a low overall pass rate (40% to 59%) (see Table 3.5).

Table 3.5: Modules per study level

Student level	Modules	Pass-rate
Level 1	Production Engineering 1 Qualitative Techniques 1* Engineering Work Study 1*	lowest middle highest
Level 2	Costing 2 Production Engineering 2 Engineering Work Study 2	lowest middle highest
Level 3	Automation 3 Industrial Accounting 3 Operational Research 3	lowest middle highest

The researcher arranged a convenient time with the respective lecturers to speak with the students. The students were informed about the study and the reasons for the study, and they received an information letter with a consent form which they were required to sign if they agreed to participate. Of the 111 students, only 95 agreed to participate in the study (see Table 3.6). Therefore, 85% of students identified for the study agreed to participate. Those who preferred not to participate were excused from the class, for the duration of the study.

Table 3.6: Sample sizes per study level

Number of students per level	Level 1	Level 2	Level 3
Actual number of student registered	41	40	30
Number of students that agreed to participate	38	40	17
% participants	93%	100%	57%

Students were identified per module as well as per study level. Table 3.7 presents a breakdown of the number of students per subject. Students in each level were registered for more than one subject within the specific level.

Table 3.7: Student numbers per subject and subject level

	Level 1			Level 2			Level 3	
	PEIN102	EWOR102	QTES101	PEIN203	EWORK203	COST201	AUMA301	OPS301
Actual number of students registered	41			33	32	23		
Number of studen agreed to particip	38	36	31	27	18	22	12	13
% participants per subject	92.68%			81.81%	56.25%	95.56%		

After the researcher had identified the student sample, she identified the lecturer sample and recruited the identified lecturers to participate in the study.

3.4.2.2 Convenience sampling

Convenience sampling was used to select the lecturers to participate in this study. Rubin and Babbie (2012: 146) define convenience sampling as a sampling method that selects elements simply because of their ready availability and convenience. The five lecturers who offered the selected modules received an information letter and a letter of consent informing them about the study and its purpose. All the selected lecturers agreed to participate and signed the consent form. However, in the end one was not available.

The next stage was data collection. The data collection instruments are discussed in the following section.

3.5 Data Collection

According to Blaikie (2000) and Zheng (2009), data collection is one of the core activities in the research process. The primary data collected for this study helped the researcher to identify students' different learning styles and lecturers' different teaching styles/methods. The following data collection instruments were used for the purpose of this study.

3.5.1 Data collection instruments

Both primary and secondary data were collected. "Primary sources refer to your data: whether you have to collect it yourself or whether it already exists in one form or another. Secondary resources on the other hand refer to written sources which discuss, comment and interpret primary sources of information" (Mouton, 2001). Both primary and secondary sources are required to ensure that the research questions are answered. In this study, the primary data were collected by means of a questionnaire administered to students, while the lecturers were interviewed. Before the researcher commenced the main study, a pilot study was run on the primary data collection instruments. The pilot study is discussed later in this chapter.

3.5.2 Design of the collection instruments

3.5.2.1 Adapted Index of Learning Style (ILS) questionnaire

A questionnaire is a document that contains questions and other types of items that are designed to solicit appropriate information for analysis (Rubin and Babbie, 2012: 94). The students were required to complete the adapted ILS questionnaire. The ILS questionnaire created by Soloman and Felder (1999) is a closed questionnaire specially developed for engineering students in order to determine their preferred learning styles. It was adapted by the researcher to identify certain biographical information. A copy of the ILS questionnaire can be found in Appendix A.

The adapted ILS questionnaire consisted of 44 items and the questionnaire was divided into five sections:

- Section A: Biographical data – This section focused on the student's age and gender.
- Section B: Active learning styles vs. reflective learning styles – this section aimed to determine whether the students prefer an active or a reflective style of learning.
- Section C: Sensory learning styles vs. intuitive learning styles – the purpose of this section was to determine whether the students prefer a sensory or an intuitive style of learning.
- Section D: Visual learning styles vs. verbal learning styles – this section sought to determine whether the students prefer a visual or a verbal style of learning.
- Section E: Sequential learning styles vs. global learning styles – the purpose of this section was to determine whether the students prefer a sequential or a global style of learning.

3.5.2.2 Lecturer structured interview design

An interview is generally defined as a two-way conversation in which the interviewer asks the respondents questions in order to collect data and learn about their ideas, beliefs, views, opinions and behaviours (Nieuwenhuis, 2007); (Mutemeri, 2010).

The lecturers' guide of interview questions consisted of 13 items and two sections. Section 1, questions 1 to 3 were designed to determine the modules offered by each lecturer and what type of subject it is, i.e., theory or practical. Section 2, questions 4 to 13 sought to determine each lecturer's preferred teaching method. The questions were designed in such a manner as to promote discussion. The guide of interview questions can be found in Appendix B.

3.5.3 Administration of collection instruments

3.5.3.1 Administration of the adapted ILS Questionnaire to students

The designers and authors of the ILS questionnaires were contacted and permission was sought from the relevant copyright authorities to use the ILS Questionnaire and make it available to the students who took part in this study on Survey Monkey, an online survey tool used by DUT. The information letter and consent form with the adapted ILS Questionnaire were uploaded to Survey Monkey by the researcher.

The researcher arranged for a convenient time to see the students for the selected modules: Production Engineering 1, Engineering Work Study 1, Qualitative Techniques 1, Production Engineering 2, Engineering Work Study 2, Costing 2, Operational Research 3 and Automation 3. The students were supplied with a hard copy of the information letter as well as the consent form. An example of the information letter and consent form can be found in Appendices C and D. The students were informed of the purpose of the study and were assured that their answers would be anonymous and confidential. Thereafter the researcher supplied the students with the Survey Monkey link, in order to access the ILS questionnaire. The information and consent form were also available on Survey Monkey, and the students could not access the questionnaire unless they had agreed and accepted the consent form. The students were allocated 60 minutes to complete the adapted ILS Questionnaire.

3.5.3.2 Administration of interviews with lecturers

Times were identified that were convenient for both the interviewer and the selected lecturer.

Wiersma (1985: 222) observes that it is necessary to obtain a respondent's cooperation and to send them a letter that informs them about the purpose of the study and the importance of their contribution. The researcher circulated an information letter (Appendix E), and a copy of the guide of interview questions (Appendix B) to each identified lecturer. At the beginning of the interview, the lecturer's consent to record the interview was obtained and they were assured of the confidentiality of the interview.

After consent was obtained, all interviews were recorded on a PDR. Voss, Tsikriktsis and Frohlich (2002) note, that recordings provide an accurate rendition of what was said. Together with the interview survey completed by each lecturer, the researcher used these recordings to analyse the data by making use of the software programme NVivo™. This programme is discussed in the section on data analysis.

3.6 Pilot study

"It is important to conduct a pilot study in order to identify possible issues that can influence your study negatively such as unclear questions in questionnaires or maybe too small sample sizes. Pilot studies fulfil a range of important functions and can provide valuable insights for other researchers" (van Teijlingen and Hundley, 2001).

The ILS questionnaire was pilot tested with 30 students registered for the National Diploma: Industrial Engineering at DUT. The purpose of the pilot study was to determine reasonable time frames required to complete the questionnaire and whether or not the questions were clear and understandable.

From the pilot study feedback, no changes were required to the questions. It also came to light that an hour was sufficient time for students to complete the questionnaire online. After this favourable feedback, the researcher commenced the main study. The data from the pilot study was not included in the main study. The students and the lecturers identified to participate in the main study were recruited using purposive and convenience sampling techniques.

After the students completed the questionnaires and the quasi experiment, and the lecturers completed the semi-structured interviews, the researcher commenced data analysis.

3.7 Data analysis

Data analysis involved making sense of data and discovering what it had to say about teaching and learning (Mutemeri, 2010).

According to Trochim and Donnelly (2008), in most social research, data analysis involves three major steps, done in roughly the following order:

- Cleaning and organising the data for analysis (Data Preparation)
- Describing the data (Descriptive Statistics)
- Testing hypotheses and models (Inferential Statistics)

This study used SPSS software to analyse the quantitative data and NVivo™ to analyse the qualitative data. The correlation between teaching styles, learning styles and student performance was analysed using SPSS.

3.7.1 Data preparation

Hair, Money, Samouel and Page (2007) note, that the raw data collected from questionnaires and interview is meaningless if it is not processed and meaning drawn from it. Data collected by means of questionnaires needs to be coded, captured and edited; this includes checking and handling inconsistencies and blank responses, if any (Sekaran and Bougie, 2010). Version 21.0 of SPSS was used to analyse the data from the questionnaire, while NVivo™ software was used to analyse the qualitative data from the interviews. As Nvivo™ allows researchers to work with a wide variety of data and adopt whatever methodology best suits their research question, it is advocated that the researcher, rather than the software used, determines the results found (Bazeley and Jackson, 2013); (Wiltshier, 2011).

The coded data in the spread sheet was entered into the SPSS version 21 statistics package. Various statistical analyses were conducted in order to achieve some of the study's objectives. The purpose of the statistical analysis was to determine whether each IE student has different learning styles and if each individual student has a preferred learning style. The analysis also examined the possibility that age and gender can influence a student's preferred learning style. Furthermore, the purpose was to determine if a combination of preferred learning styles and the lecturer's preferred teaching method could influence student performance.

Nvivo™ software was used to gather all data (audio recordings of interviews, interview questionnaires, PDFs, and web-based sources) in one place. Nvivo™ software allows for qualitative inquiry beyond coding, sorting and retrieval of data. It was also designed to integrate coding with qualitative linking, shaping and modelling (Wong, 2008). The purpose of the Nvivo™ analysis was to identify the lecturers' preferred teaching styles.

3.7.2 Descriptive statistics

Descriptive statistics are used to describe the basic features of the data and summaries of the sample and the measures (Trochim and Donnelly, 2008). The descriptive statistics for the qualitative data are presented in the form of graphs, cross tabulations and other figures.

3.7.3 Inferential statistics

Inferential statistics investigate questions, models and hypotheses. Inferential statistics were used to make judgements on the probability that an observed difference between groups is dependable or might have happened by chance (Trochim and Donnelly, 2008). Inferential techniques include correlations and chi square test values, which were interpreted using the p-values. The reliability and validity of the research instruments are discussed in the next section.

3.8. Reliability and validity

Researchers need to ensure that their data collection instruments are valid and reliable for the purpose of their study. Any measurement must be both reliable - measurement yields consistent, repeatable results, and valid - it measures what it is supposed to measure (Trochim and Donnelly, 2008).

"Reliability means that the individual scores from an instrument should be nearly the same or stable on repeated administrations of the instrument and they should be free from sources of measurement error and consistent" (Creswell, 2008: 646) . According to Zywno (2003), reliability can be tested through inter-rater reliability, i.e., whether the two rates are consistent through test-retest reliability, by assessing the consistency of a measure at one point in time and another, and through internal consistency reliability that assesses the consistency of the results across items within a test.

Validity refers to the 'truthfulness', 'correctness' or accuracy of research data (Burton, Bartlett, 2009: 25). According Trochim and Donnelly (2008), construct validity refers to the degree to which inferences can be made from operationalisation in the study to the theoretical constructs on which they were based. Construct validity includes evidence and a rationale that supports the trustworthiness of score interpretations in terms of explanatory concepts that account for both test performance and relationships with other variables.

3.8.1. Internal consistency reliability

A reliability coefficient of 0.70 or higher is considered "acceptable". Table 3.8 below reflects the Cronbach's alpha scores for all the items that constituted the ILS questionnaire.

Tuckman (1999) suggests that an alpha of 0.75 or greater is acceptable for instruments that measure achievement and 0.5 or greater is acceptable for attitude assessments. Accordingly $\alpha = 0.5$ was taken as the criterion for acceptability for the ILS. Two observations are made. Some of the values exceed or are close to the recommended value of the acceptable reliability score of 0.50. This indicates a level of consistent scoring for these sections. In those sections where the scores are lower, the primary reason was the decrease in the sample size. It is also noted that the construct is newly developed and that interpretations of questions might have resulted in lower scores. The other observed pattern is the reversal of the scores for Level 3 students with those of Levels 1 and 2. While Levels 1 and 2 scored consistently (Section E), Level 3 did not. This is also observed in Section C. A possible reason could be that only a few Level 3 students completed questionnaires. This could imply that students at Level 3 have developed their learning preferences since their Level 1 studies.

Table 3.8: Internal consistency reliability for ILS Cronbach's alpha

	Student Level		
	1	2	3
Section B - Active learning styles vs Reflective learning styles	0.556	0.523	0.075
Section C - Sensory learning styles vs Intuitive learning styles	0.245	0.236	0.555
Section D - Visual learning styles vs Verbal learning styles	0.407	0.400	0.478
Section E – Sequential learning style vs Global learning style	0.415	0.402	0.184
Overall	0.400	0.401	0.296

3.8.2 Construct validity

The ILS questionnaire was structured in such a manner that it only tested the students' learning styles, and did not deviate from this purpose. According to Maxwell (2012), validity is a relative term that refers to the credibility of explanation, interpretation and conclusions reached. In this study, the researcher compared the learning styles of IE students with those of engineering students at other universities who also completed the ILS questionnaire. The results, shown in Table 3.9, indicate that engineering students are consistently predominant in the active, sensing, visual and sequential learning styles.

Table 3.9: Comparison of the learning styles of IE students with the learning styles of engineering students at other universities

Study	Number	Active (%)	Sensing (%)	Visual (%)	Sequential (%)
Durban University of Technology					
Level 1	38	55.4	65.9	61.4	56.8
Level 2	48	55.9	65.3	61.8	57.2
Level 3	17	56.5	63.1	68.9	55.1
University of Western Ontario	858	69	59	80	67
University of Technology, Kingston, Jamaica	33	55	60	70	55
University of Michigan, Michigan	143	67	57	69	71

Given the results presented in Table 3.9, the researcher concluded that the ILS is suitable to assess the learning styles of IE students.

3.8.3 Interview validity and reliability

Silverman (2013) observes that the most popular approaches to analyse data from interviews are to treat the respondents' answers as facts, events (external reality) or as feelings and meanings (internal experience). He adds that various devices need to be built into the research design to ensure the accuracy of one's interpretation, and in order to check the accuracy of what respondents tell one by conducting other observations. The researcher took notes during the interviews with the lecturers and also used a recorder in order to guarantee the accuracy of the information collected. The researcher also compared the literature review on engineering educators' preferred teaching styles with the interview responses.

3.9 Ethical considerations

According to Mouton (2001), ethics is concerned with what is wrong and what is right in the conduct of research. The researcher has the right to search for the truth, but not at the expense of the rights of other individuals in society.

The respondents were assured of confidentiality and anonymity before the study commenced. A letter of informed consent (Appendices A and B) was given to each participant in order to make them aware of:

- The type of information required by the researcher
- The reason why this information is required by the researcher
- The purpose of their participation in the study
- Expectations of how participants should take part in the study

3.10. Summary

This chapter presented the study's research method and design, sampling techniques and data collection instruments, which consisted of closed questionnaires and semi-structured interviews. The Cronbach's Alpha test was performed to test the questionnaire's reliability. The data from the ILS Questionnaire was captured and analysed using SPSS21 software, whereas the data from the semi-structured interviews were captured and analysed using Nvivo™ software. The correlations between student performance and their preferred learning styles and lecturers' preferred teaching styles were analysed using SPSS 21.

The study's results are presented and discussed in chapter 4.

CHAPTER 4: RESEARCH ANALYSIS AND FINDINGS

4.1 Introduction

Chapter 3 discussed the research aims and objectives and the research design. The research methodology, approach to data collection and the research instruments were also discussed.

This chapter presents an analysis of the data gathered through the ILS questionnaires, interviews with the lecturers and the quasi experiment. The ILS Questionnaire was designed to determine students' preferred learning styles and the interviews were used to determine the preferred teaching styles of the lecturers. Thereafter, the quasi experiment was conducted to determine if intervention in the teaching styles would influence student performance. The ILS questionnaires and the results of the quasi experiment were analysed using SPSS version 21, while the qualitative data collected through the semi-structured interviews were transcribed and coded in NVivo™. The analysis of the data is presented as follows: students' biographical data, their preferred learning styles within each level and within the department, lecturers' preferred teaching styles and finally the results of the quasi experiment.

4.2 Students' biographical data

4.2.1 Gender of the students

Figure 4.1 indicates the gender of the IE students. It is clear that the IE programme at DUT is dominated by male students. Across each level, the student population was made up of 60, 5% to 62.5% of male students, while female students represented only 37% to 39.9%.

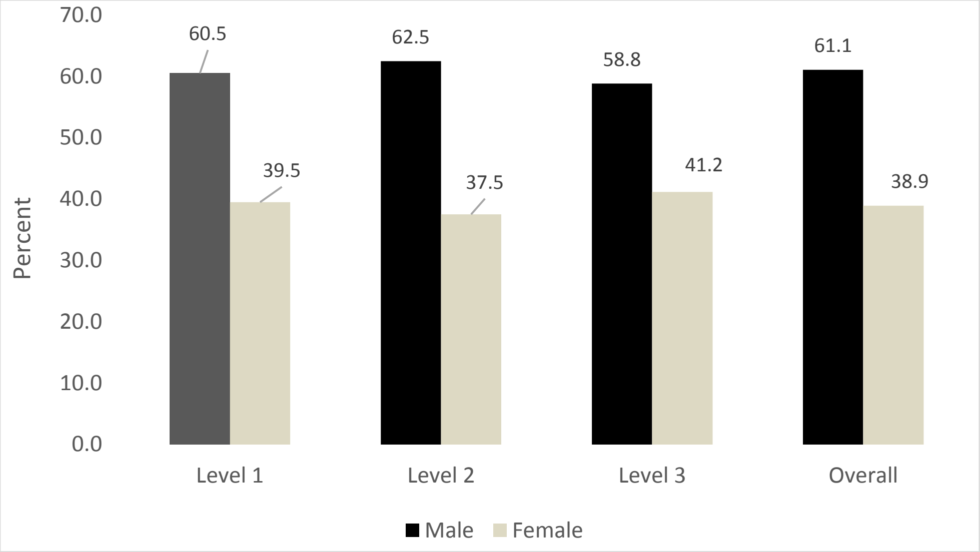

Figure 4.1: Gender of the respondents

4.2.2 Age of the students

Figure 4.2 shows the age of the students across each level. The majority (about 85.5% to 86.8%) of the IE students fall within the age group 18 – 23 years. Only about 15% of the student population is older than 23.

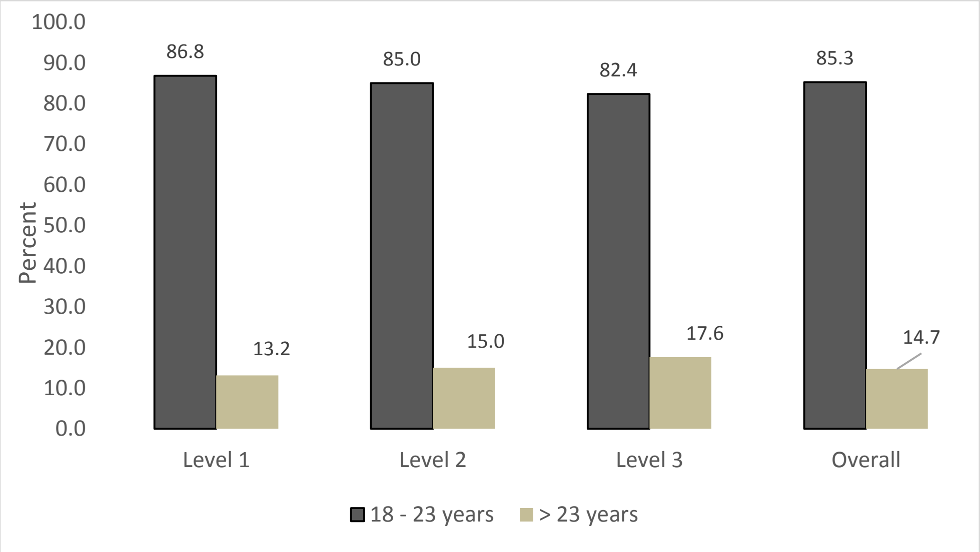

Figure 4.2: Age of student respondents

Table 4.1 provides a summary of the overall gender composition by age. The ratios for age and gender are similar across the levels. The male respondents in the age group 18 to 23 years constituted just over half of the entire sample (50.5%). Within the age group 18 to 23 years, males constituted 59.3% of the sample. Amongst the males, 82.8% were in the age group 18 to 23 years. This suggests that the majority of these students entered higher education directly after they completed matric. Only 14.7% of the entire sample was 23 and older. This could be due to various reasons, such as the fact that a student might have studied another programme before they decided to study IE. A student might also have decided to work first and then decided to study IE. The data below also suggest that there are more male students that are older than 23.

Table 4.1: Overall gender composition by age

Age groups			**Gender**		**Total**
			Male	Female	
Age	18 - 23 years	Count	48	33	81
		% within Age	**59.3%**	40.7%	100.0%
		% within Gender	**82.8%**	89.2%	85.3%
		% of Total	**50.5%**	34.7%	85.3%
	> 23 years	Count	10	4	14
		% within Age	71.4%	28.6%	100.0%
		% within Gender	17.2%	10.8%	14.7%
		% of Total	10.5%	4.2%	14.7%
Total		Count	58	37	95
		% within Age	61.1%	38.9%	100.0%
		% within Gender	100.0%	100.0%	100.0%
		% of Total	61.1%	38.9%	100.0%

4.3 Students' preferred learning styles

4.3.1 Category 1: How students prefer to process information

Table 4.2 presents the questions and students' answers across each level in order to determine the most preferred learning style in category 1, namely active learning styles vs reflective learning styles. All questions with an "a" value indicate an active learning style and a "b" value indicates a reflective learning style. Table 4.2 shows that the majority of the students opted for "a" value answers to the questions. Questions 1, 3 and 8 had significantly high "a" values. Therefore, it is clear that the students prefer "to do" in order to learn.

Table 4.2: Questions testing active learning style preference against reflective learning style preference across all levels

Questions	Responses		Level 1	Level 2	Level 3
I understand something better after I	try it out	1a	83.8	84.6	70.6
	think it through	1b	**16.2**	**15.4**	**29.4**
When I am learning something new, it helps me to	talk about it	2a	52.6	52.5	23.5
	think about it	2b	47.4	47.5	76.5
In a study group working on difficult material, I am more likely to	jump in and contribute ideas	3a	**78.9**	**77.5**	**76.5**
	sit back and listen	3b	21.1	22.5	23.5
In classes I have taken	I have usually gotten to know many of the students	4a	**70.3**	**71.8**	**88.2**
	I have rarely gotten to know many of the students	4b	29.7	28.2	11.8
When I start a homework problem, I am more likely to	start working on the solution immediately	5a	**18.9**	**20.5**	**35.3**
	try to fully understand the problem first	5b	**81.1**	**79.5**	**64.7**
I prefer to study	in a study group	6a	47.4	45.0	41.2
	Alone	6b	52.6	55.0	58.8
I would rather first	try things out	7a	26.3	30.0	41.2
	think about how I'm going to do it	7b	73.7	70.0	58.8
I more easily remember	something I have done	**8a**	**81.6**	**82.5**	**88.2**
	something I have thought a lot about	**8b**	**18.4**	**17.5**	**11.8**

When I have to work on a group project, I first want to	have "group brainstorming" where everyone contributes ideas	9a	40.5	41.0	35.3
	brainstorm individually and then come together as a group to compare ideas	9b	59.5	59.0	64.7
I am more likely to be considered	Outgoing	10a	50.0	50.0	62.5
	Reserved	10b	50.0	50.0	37.5
The idea of doing homework in groups, with one grade for the entire group,	appeals to me	11a	59.5	59.0	58.8
	does not appeal to me	11b	40.5	41.0	41.2

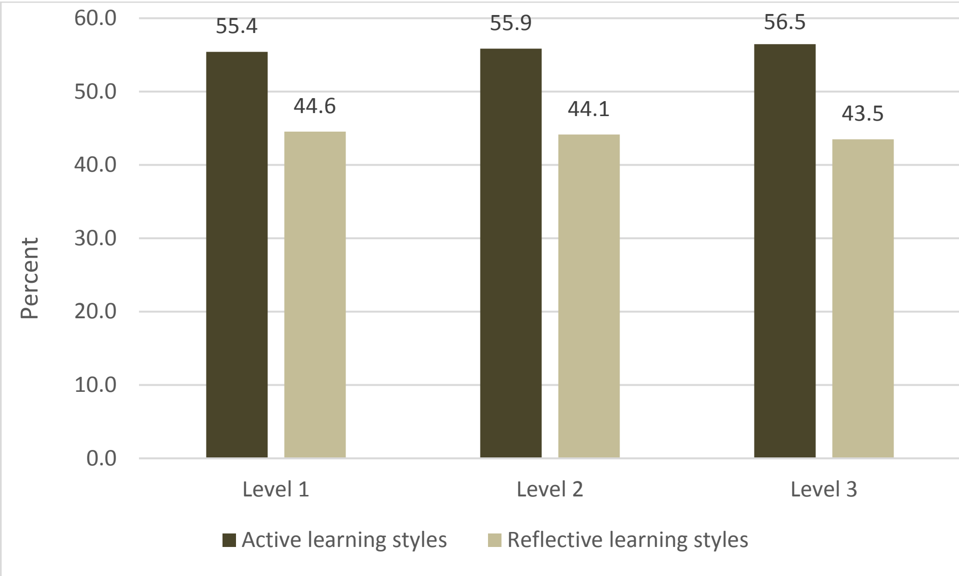

Figure 4.4: Summarised graph on active learning and reflective learning

Figure 4.4 provides an overview of the student responses to category 1 questions. It shows that between 55% and 57% of all IE students are active learners, and only between 43% and 45% are reflective learners. The active learners prefer to work problems out for themselves, prefer group work, and enjoy taking part in physical activities such as class discussions. It is also clear that the level 3 students have a slightly higher preference for active learning than level 1students. This might be because students who have just finished high school still need to adjust to higher education where they do not receive as much assistance with learning as at school level.

4.3.2 Category 2: Type of information that a student perceived best

Table 4.3 presents the questions and students' answers across each level in order to determine the most preferred learning style in category 2: sensory vs intuitive learning styles. All answers with an "a" value indicate a sensory learning style and all answers with a "b" value indicate an intuitive learning style. The majority of the IE students had a higher preference for sensory learning than intuitive learning. It is clear that IE students prefer a logical approach to learning. This is especially true for questions 1, 3, 4, 5, 10, and 11 where the "a" value has a high preference of between 73 and 89%.

Table 4.3: Sensory vs intuitive learning styles

Questions	**Responses**		Level 1	Level 2	Level 3
I would rather be considered	Realistic	1a	**83.8**	**82.1**	**76.5**
	Innovative	1b	16.2	17.9	23.5
If I were a teacher, I would rather teach a course	that deals with facts and real life situations	2a	**81.6**	**80.0**	**87.5**
	that deals with ideas and theories	2b	18.4	20.0	12.5
I find it easier	to learn facts	3a	**76.3**	**75.0**	**70.6**
	to learn concepts	3b	23.7	25.0	29.4
In reading nonfiction, I prefer	something that teaches me new facts or tells me how to do something	4a	43.2	41.0	35.3
	something that gives me new ideas to think about	4b	56.8	59.0	64.7
I prefer the idea of	Certainty	5a	**73.7**	**75.0**	**76.5**
	Theory	5b	26.3	25.0	23.5
I am more likely to be considered	careful about the details of my work	6a	68.4	67.5	64.7
	creative about how to do my work	6b	31.6	32.5	35.3
When I am reading for enjoyment, I like writers to	clearly say what they mean	7a	31.6	30.0	31.3
	say things in creative, interesting ways	7b	68.4	70.0	68.8
When I have to perform a task, I prefer to	master one way of doing it	8a	55.3	55.0	47.1
	come up with new ways of doing it	8b	44.7	45.0	52.9

I consider it higher praise to call someone	Sensible	9a	60.5	62.5	41.2
	Imaginative	9b	39.5	37.5	58.8
I prefer courses that emphasize	concrete material (facts, data)	10a	**73.7**	**75.0**	**75.0**
	abstract material (concepts, theories)	10b	26.3	25.0	25.0
When I am doing long calculations,	I tend to repeat all my steps and check my work carefully	11a	**76.3**	**75.0**	**88.2**
	I find checking my work tiresome and have to force myself to do it	11b	23.7	25.0	11.8

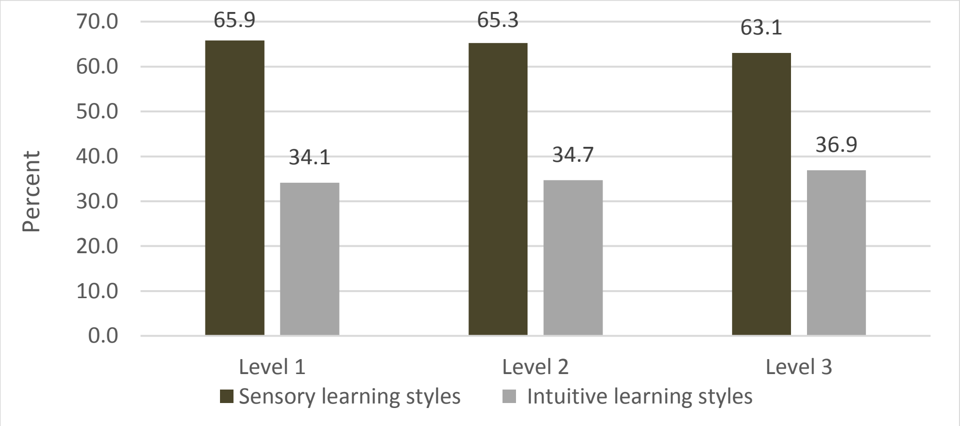

Figure 4.5: Summarised graph on sensory vs intuitive learning styles

Figure 4.5 summarises the responses to the questions on sensory and intuitive learning styles. Over all three study levels the majority of the students' preferred sensory learning to intuitive learning. These students prefer facts over innovation. Jones and Panariti (2010) study notes, that, sensory learners tend to be more practical and prefer a step by step procedure to complete their work. This is true of IE students at DUT. The majority of the students prefer a set procedure on how to complete their work and do not like 'surprises' such as a spot test. On the other hand, intuitive students prefer to reflect and use their imagination when solving a problem. Only a small percentage of the students are intuitive learners, and they might have a problem in the more concrete and rigid engineering study field. It is noted that the preference for intuitive learning is higher at study level 1 than study levels 2 and 3.

4.3.3 Category 3: The process in which information is more effectively perceived

Table 4.4 presents the questions and students' answers across each study level in order to determine the most preferred learning style in category 3: visual vs verbal learning styles. All answers with an "a" value indicate a visual learning style and all answers with a "b" value indicate a verbal learning style.

Table 4 4: Visual vs verbal learning styles

Questions	Answers		Level 1	Level 2	Level 3
When I think about what I did yesterday, I am most likely to get	a picture	1a	**89.5**	**90.0**	**88.2**
	Words	1b	10.5	10.0	11.8
I prefer to get new information in	pictures, diagrams, graphs, or maps	2a	45.9	46.2	70.6
	written directions or verbal information	2b	54.1	53.8	29.4
In a book with lots of pictures and charts, I am likely to	look over the pictures and charts carefully	3a	52.6	52.5	76.5
	focus on the written text	3b	47.4	47.5	23.5
I like teachers	who put a lot of diagrams on the board	4a	36.8	37.5	35.3
	who spend a lot of time explaining	4b	63.2	62.5	64.7
I remember best	what I see	5a	**78.9**	**77.5**	**82.4**
	what I hear	5b	21.1	22.5	17.6
When I get directions to a new place, I prefer	a map	6a	47.4	47.5	70.6
	written instructions	6b	52.6	52.5	29.4
When I see a diagram or sketch in class, I am most likely to remember	the picture	7a	56.8	59.0	41.2
	what the instructor said about it	7b	43.2	41.0	58.8
When someone is showing me data, I prefer	charts or graphs	8a	50.0	52.5	64.7
	text summarizing the results	8b	50.0	47.5	35.3
When I meet people at a party, I am more likely to	what they looked like	9a	60.5	60.0	52.9

remember	what they said about themselves	9b	39.5	40.0	47.1
For entertainment, I would rather	watch television	10a	67.6	66.7	87.5
	read a book	10b	32.4	33.3	12.5
I tend to picture places I have been	easily and fairly accurately	11a	**89.5**	**90.0**	**88.2**
	with difficulty and without much detail	11b	10.5	10.0	11.8

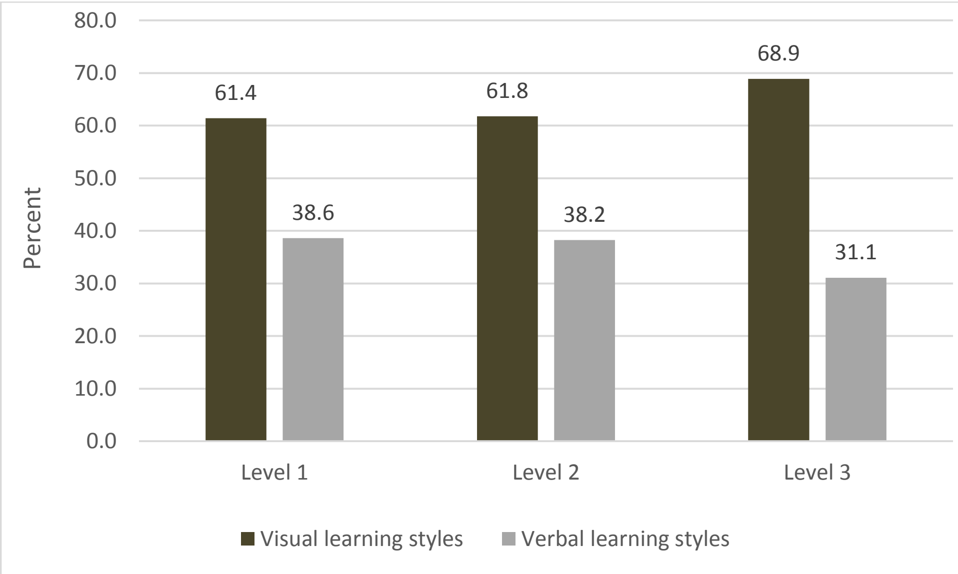

Figure 4.6: Summarised graph on visual vs verbal learning styles

Figure 4.6 indicates that the majority of IE students at DUT are visual rather than verbal students. Visual students prefer diagrams, graphs and videos while verbal students prefer more interactive discussions. From Figure 4.6 it is noted that level 3 students have a slightly higher preference for visual learning at 68.9% while levels 1 and 2 students have an average 61% preference for visual learning.

4.3.4 Category 4: How a student progresses to understanding

Table 4.5 presents the questions and students' answers across each level in order to determine the most preferred learning style in category 4: global vs sequential learning styles. All answers with an "a" value indicate a sequential learning style and all answers with a “b “value indicates a global learning style. Some of the significant choices can be found at questions 3 and 4. The responses to question 3 show that students work their way to math solutions one step at a time. Question 4 answers indicate that students think of incidents in stories and novels, and try to put them together to figure out the themes.

Table 4.5: Sequential vs global learning

Questions	**Answers**		Level 1	Level 2	Level 3
I tend to	understand details of a subject but may be fuzzy about its overall structure	1a	50.0	47.5	41.2
	understand the overall structure but may be fuzzy about details	1b	50.0	52.5	58.8
Once I understand	all the parts, I understand the whole thing	2a	47.4	50.0	41.2
	the whole thing, I see how the parts fit	2b	52.6	50.0	58.8
When I solve math problems	I usually work my way to the solutions one step at a time	3a	**86.8**	**87.5**	**88.2**
	I often just see the solutions but then have to struggle to figure out the steps to get to them	3b	13.2	12.5	11.8
When I’m analysing a story or a novel	I think of the incidents and try to put them together to figure out the themes	4a	**73.7**	**75.0**	**82.4**
	I know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them	4b	26.3	25.0	17.6
It is more important to me that an instructor	lay out the material in clear sequential steps	5a	50.0	52.5	52.9
	give me an overall picture and relate the material to other modules	5b	50.0	47.5	47.1
I learn	at a fairly regular pace. If I study hard, I’ll “get it”	6a	68.4	67.5	70.6
	in fits and starts. I’ll be totally confused and then suddenly it all “clicks”	6b	31.6	32.5	29.4
When considering a body of information, I am more likely to	focus on details and miss the big picture	7a	**21.1**	**20.5**	**17.6**
	try to understand the big picture before getting into the details	7b	78.9	79.5	82.4
When writing a paper, I am more likely to	work on (think about or write) the beginning of the paper and progress forward	8a	58.3	60.5	70.6
	work on (think about or write) different parts of the paper and then order them	8b	41.7	39.5	29.4
When I am learning a new subject, I prefer to	stay focused on that module, learning as much about it as I can	9a	57.9	57.5	52.9
	try to make connections between that subject and related module	9b	42.1	42.5	47.1
Some teachers start their lectures with an outline of what they will cover. Such outlines are	somewhat helpful to me	10a	43.2	41.0	23.5
	very helpful to me	10b	56.8	59.0	76.5
When solving problems in a group, I would be more likely to	think of the steps in the solution process	11a	67.6	69.2	64.7
	think of possible consequences or applications of the solution in a wide range of areas	11b	32.4	30.8	35.3

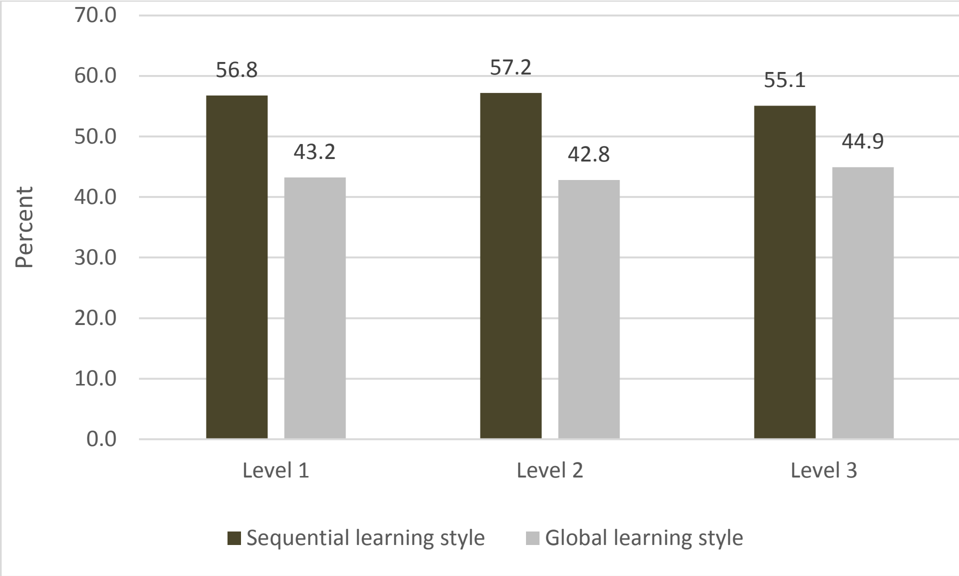

Figure 4:7: Summary of sequential and global learning styles

From Figure 4.7 it is noted that the gap between sequential and global learners is not as large as in the other dimensions. The overall preference is for the sequential learning style at an average of 55%, with the global learning style at 44%. According to Jones and Panariti (2010), the sequential learner absorbs information in a small, connected series of steps, while the global learner tries to achieve understanding in a more holistic manner.

4.4 Influences of study level, gender, age on student choices

The Chi square test was performed to determine whether there was a statistically significant relationship between the variables (level, age, gender) and the choices made by students in the ILS Questionnaire. Table 4.6 illustrates the chi square test results between the level, age and gender of the students participating in this study. In all the cases where the p-value is smaller than 0.05, this indicates that there is a significant relationship between the variables. These significant values are indicated by an asterisk. The students' level of study did not influence their choices in the ILS Questionnaire, which could indicate that students' preferred learning styles are fairly consistent throughout their studies. The same cannot be said of gender and age. It is evident that female and male students have a different approach to certain questions. The students' age also influenced their choices when answering the ILS. The questions with significant differences are across all categories.

Table 4.6: Summary of the results of the chi square tests: level, age, and gender

Questions	Level	Gender	Age
I understand something better after I	.420	.060	0.877
When I am learning something new, it helps me to	.094	.535	.714
In a study group working on difficult material, I am more likely to	.976	.269	**.043***
In classes I have taken	.339	**.002***	0.285
When I start a homework problem, I am more likely to	.377	.089	0.134
I prefer to study	.912	**.045***	.437
I would rather first	.540	.554	0.863
I more easily remember	.822	.666	0.204
When I have to work on a group project, I first want to	.915	.179	0.625
I am more likely to be considered	.660	**.016***	.324
The idea of doing homework in groups, with one grade for the entire group,	.999	.417	.869
I would rather be considered	.810	.130	0.055
If I were a teacher, I would rather teach a course	.803	**.043***	0.725
I find it easier	.902	.105	0.721
In reading nonfiction, I prefer	.858	.959	0.187
I prefer the idea of	.975	.105	0.758
I am more likely to be considered	.964	.974	0.333
When I am reading for enjoyment, I like writers to	.988	**.019***	0.669
When I have to perform a task, I prefer to	.833	.716	.149
I consider it higher praise to call someone	.300	.127	.600
I prefer courses that emphasize	.990	.926	0.087
When I am doing long calculations,	.521	**.009***	0.445
When I think about what I did yesterday, I am most likely to get	0.98	**.047***	0.62
I prefer to get new information in	.188	**.046***	.965
In a book with lots of pictures and charts, I am likely to	.197	.087	.980
I like teachers	.988	.113	.487

I remember best	.919	.356	0.455
When I get directions to a new place, I prefer	.224	**.003***	**.014***
When I see a diagram or sketch in class, I am most likely to remember	.448	.170	.119
When someone is showing me data, I prefer	.588	.432	.765
When I meet people at a party, I am more likely to remember	.856	.073	.056
For entertainment, I would rather	.265	**.016***	0.57
I tend to picture places I have been	0.98	**.047***	0.62
I tend to	.832	.297	**.011***
Once I understand	.830	**.002***	.051
When I solve math problems	0.989	0.289	0.123
When I'm analysing a story or a novel	.777	.052	**.015***
It is more important to me that an instructor	.968	.194	.898
I learn	.974	.095	0.376
When considering a body of information, I am more likely to	.957	.424	0.399
When writing a paper, I am more likely to	.684	.448	0.096
When I am learning a new subject, I prefer to	.937	.989	**.018***
Some teachers start their lectures with an outline of what they will cover. Such outlines are	.357	.281	0.135
When solving problems in a group, I would be more likely to	.946	.349	0.119

The next section discusses the influence of gender on the students' choices.

4.4.1 Learning style category 1 and gender influence

Certain questions that tested the students' preference between active learning and reflective learning indicated that gender played a role in the students' choice. Table 4.7 highlights the questions from category 1, where gender played a role in the learning style preference. More female students than males said that they participate actively in group work, and female students found it easier to make friends throughout their studies. However, it should also be noted that female students prefer to study alone.

Table 4.7: Gender and student choice: category 1

			Male %	Female %	Total %
In a study group working on difficult material, I am more likely to	jump in and contribute ideas	3a	74.1	**83.8**	77.9
	sit back and listen	3b	35.9	16.2	22.1
In classes I have taken	I have usually gotten to know many of the students	4a	62.5	**91.9**	74.2
	I have rarely gotten to know many of the students	4b	37.5	8.1	25.8
I prefer to study	in a study group	6a	**53.4**	32.4	45.3
	Alone	6b	46.6	**67.6**	54.7

4.4.2 Learning style category 2 and gender influence

Table 4.8 shows that 92 % of the female students prefer to deal with facts rather than ideas, and 83% like to read books that are creative, while their male counterparts prefer books that come straight to the point. Almost 92% of the female students stated that they check their calculations to see if they are correct compared with 69% of male students.

Table 4.8: Gender and student choice: category 2

			Male %	Female %	Total %
If I were a teacher, I would rather teach a course	that deals with facts and real life situations	2a	75.4	**91.9**	81.9
	that deals with ideas and theories	2b	24.6	8.1	18.1
When I am reading for enjoyment, I like writers to	clearly say what they mean	7a	39.7	16.7	30.9
	say things in creative, interesting ways	7b	60.3	**83.3**	69.1
When I am doing long calculations,	I tend to repeat all my steps and check my work carefully	11a	69	**91.9**	77.9
	I find checking my work tiresome and have to force myself to do it	11b	31	8.1	22.1

4.4.3 Learning style category 3 and gender influence

The female students relate visually to things they have done in the past, whereas male students prefer to use words to explain what they have done. Yet when female students need directions to a new place they prefer written instructions, while the male students are more likely to prefer a map.

Table 4.9: Gender and student choice: category 3

			Male %	Female %	Total %
When I think about what I did yesterday, I am most likely to get	a picture	1a	**84.5**	**97.3**	**89.5**
	words	1b	15.5	2.7	10.5
I prefer to get new information in	pictures, diagrams, graphs, or maps	2a	58.9	37.8	50.5
	written directions or verbal information	2b	41.1	62.2	49.5
When I get directions to a new place, I prefer	a map	6a	63.8	32.4	51.6
	written instructions	6b	36.2	67.6	48.4
For entertainment, I would rather	watch television	10a	80	56.8	70.7
	read a book	10b	20	43.2	29.3

4.4.4 Learning style category 4 and gender influence

Table 4.10 shows that, in category 4, male students need to understand all the parts before they know the whole thing, while female students need to understand the whole thing, before they see how all the parts fit.

Table 4.10: Gender and student choice: category 4

			Male %	Female %	Total %
Once I understand	all the parts, I understand the whole thing	2a	60.3	27	50
	the whole thing, I see how the parts fit	2b	39.7	73	52.6

4.5 Teaching styles

The interview guide used for the interviews consisted of 11 questions to enable the researcher to determine the lecturer's teaching methods and his/her preferences. Eight of these 11 questions were specifically related to lecturers' teaching preferences. It should be noted that a lecturer could have more than one choice per question.

4.5.1 Lecturer 1

In the Interview with Lecturer 1, he indicated that he believed he was a facilitator. On completion of the questionnaire (see Figure 4.8), it was evident that the lecturer is in fact a combination of formal authority, facilitator and demonstrator when he teaches. Formal authority makes up 36.36% of the lecturer's preferred teaching style and facilitator and demonstrator are each at 27.27%. The modules covered by this lecturer combine theory, practical work and calculations. The lecturer usually makes use of PowerPoint presentations in his class. During certain lessons, he will also show the students videos that are relevant to the subject matter.

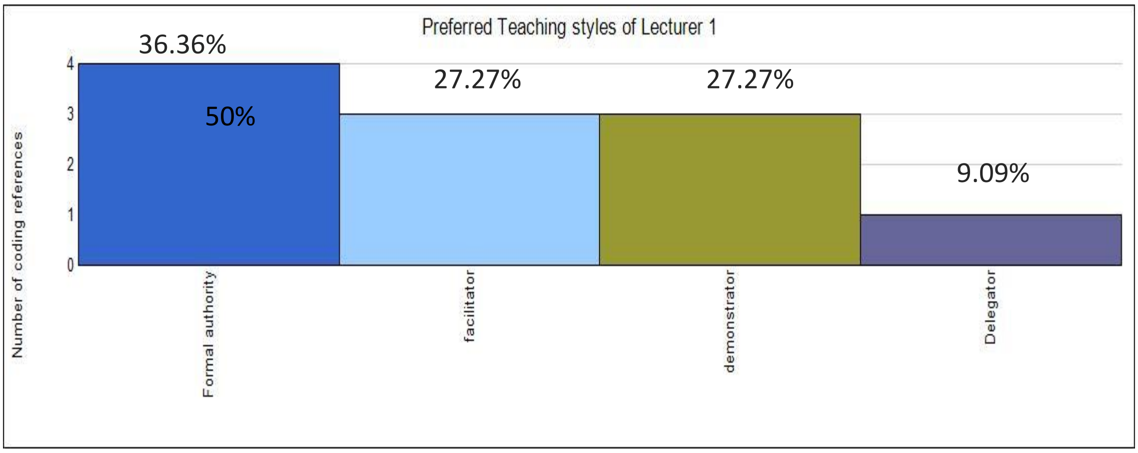

Figure 4.8: Summary of teaching style preferences: Lecturer 1

4.5.2 Lecturer 2

The results from the questionnaire indicated that Lecturer 2 is predominantly a formal educator (see Figure 4.9), who prefers to have structure in her class. This lecturer did not score any points as a demonstrator or delegator. The modules taught by Lecturer 2 are made up of calculations and theory. The lecturer conducts her lessons using PowerPoint presentations and also demonstrates how to complete mathematical problems related to the subject.

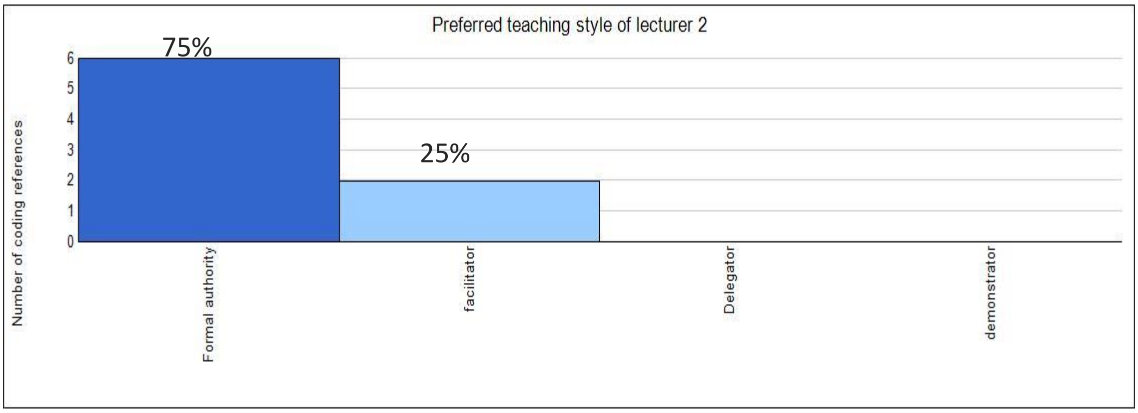

Figure 4.9: Summary of teaching style preferences: Lecturer 2

4.5.3 Lecturer 3

Lecturer 3 indicated during his interview, that he prefers to be a facilitator and delegator. However, Figure 4.10 suggests that he is in fact a formal lecturer who prefers to delegate. This lecturer scored the least in being a facilitator and demonstrator. The lecturer makes use of PowerPoint presentations and also involves the class in discussions.

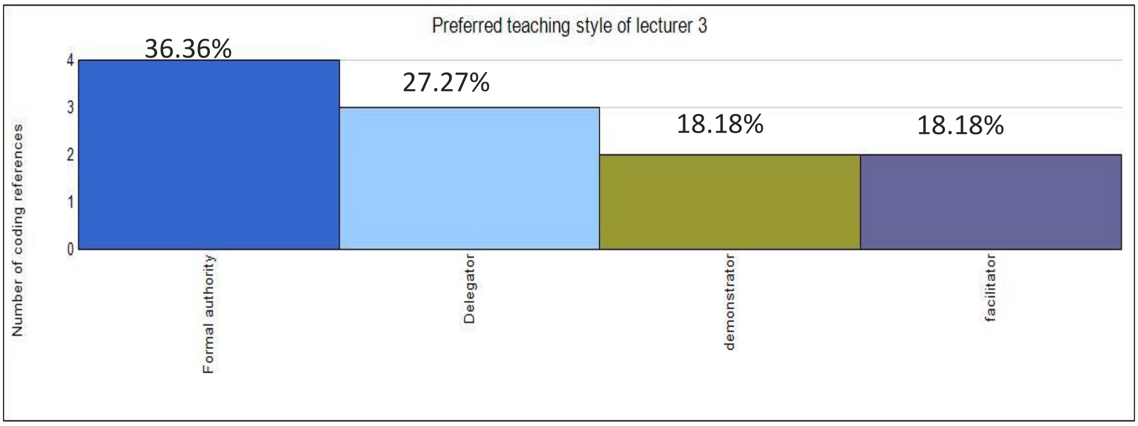

Figure 4.10: Summary of teaching style preferences: Lecturer 3

4.5.4 Lecturer 4

In his interview, Lecturer 4 stated that he believed that he is a demonstrator, because he would normally first demonstrate to students what is expected of them in their practical work, before they do it by themselves. Figure 4.11 indicates that the lecturer shows a strong combination of a demonstrator, facilitator and formal authority in his classes. The lecturer combines his PowerPoint presentations with some laboratory work.

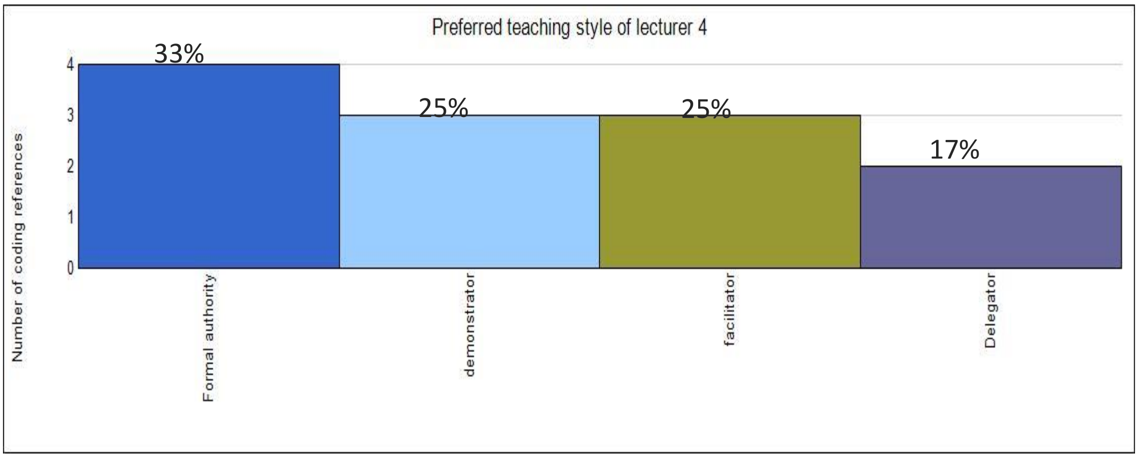

Figure 4.11: Summary of teaching style preferences: Lecturer 4

4.5.5 Lecturer 5

This lecturer believed that he is a demonstrator only, yet the results of the questionnaire indicated that he prefers being a formal lecturer who will sometimes demonstrate, delegate and facilitate when lecturing. Figure 4.12 indicates the lecturer's preferred teaching styles.

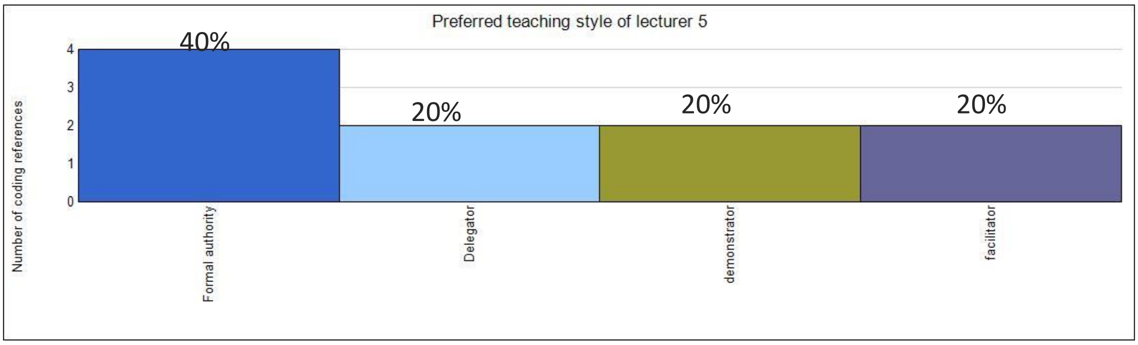

Figure 4.12: Summary of teaching style preferences: Lecturer 5

From the responses to the questionnaire, it is clear that all the lecturers tend to be formal, although they have one other strong preference in teaching. The lecturers' association with their most preferred teaching styles is shown in Figure 4.13. It is noted that the lecturers have diverse teaching styles and that all the teaching style types are reflected in the department of IE. All the lecturers have formal authority within their classes. Lecturers 1 and 4 are demonstrators, lecturer 2 is a facilitator, lecturer 3 is a delegator, and lecturer 4 is a demonstrator.

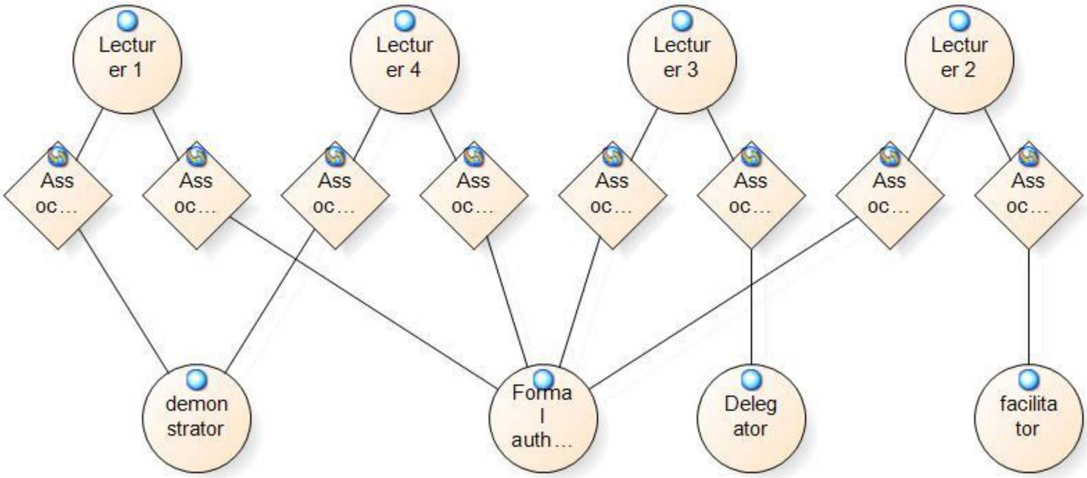

Figure 4.13: Lecturers and teaching style association (Assoc…)

4.5.6 Teaching style preferences per subject

The lecturers that participated in this study lecture across all three study levels; therefore, diverse teaching styles are evident at each level. Figure 4.14 summarises the teaching style preferences in each subject at study level 1. Production Engineering 1 (PEIN 102) has a strong formal and facilitator teaching theme, while both Qualitative Techniques 1 (QTES 101) and Engineering Work Study 2 have a strong formal, facilitator and demonstrator teaching theme.

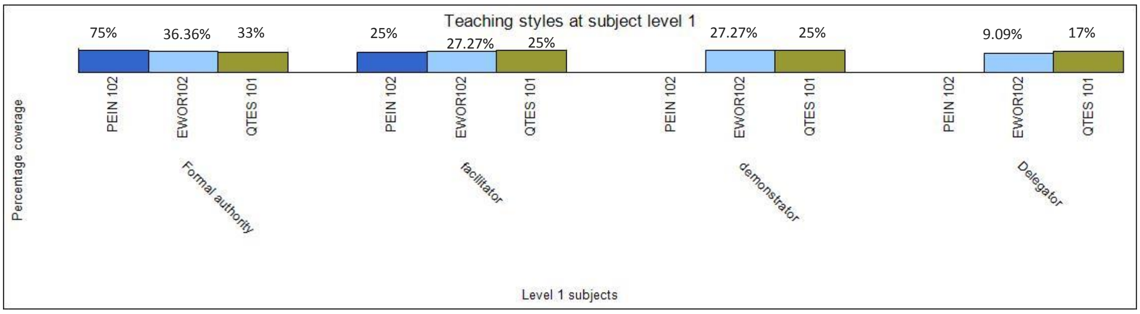

Figure 4.14: Summary of dominant teaching styles per subject, study level 1

Figure 4.15 summarises the teaching styles found at study level 2. It is noted that formal authority plays an important role in all the level 2 subjects. Furthermore, Costing 2 (COST 201) has a high delegator teaching theme, and Production Engineering (PEIN 202) has the lowest occurrence of a delegator teaching theme.

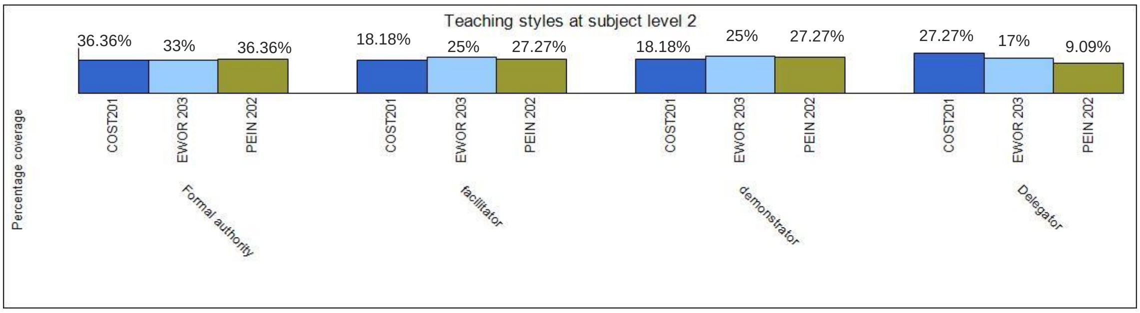

Figure 4.15: Summary of dominant teaching styles per subject, study level 2

Figure 4.16 summarises the teaching style types found at study level 3. It is evident that although both Operations Research 3 (OPS 303) and Automation 3 (AUMA 301) have a formal authority theme, OPS 303 also has a strong delegator teaching theme, while AUMA 301 shows a facilitator and demonstrator theme.

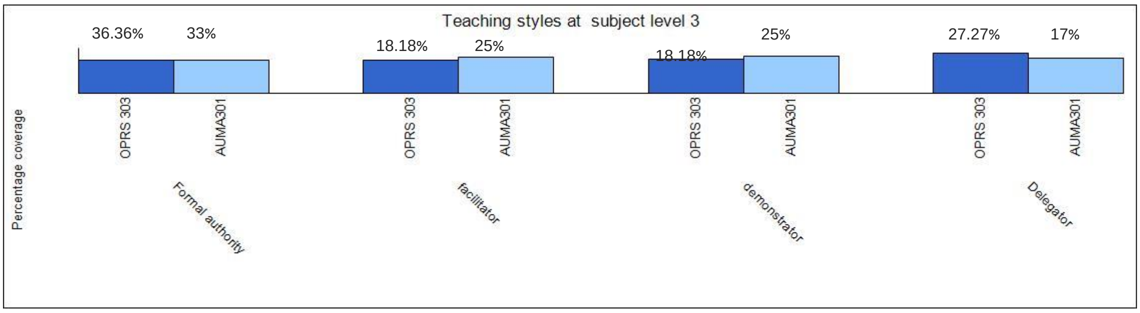

Figure 4.15: Summary of dominant teaching styles per subject, study level 3

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4.6 Results of the quasi experiment

4.6.1 Study level 1 student performance

For the Level 1 modules, the Kolmogorov-Smirnov test was performed in order to determine if the data sets used in this study were normally distributed. The reason for using this test is that it is appropriate for small sample sizes. The results obtained by the Kolmokorov-Smirnov test (refer to Table 4.11) clearly show that, the fact that the students wrote the same test during the pre-test and the post-test did not influence their test results. All the Asymp sig (2-tailed results) were greater than the p-value of 0.05. The researcher can thus state with confidence that the fact that the students repeated the same test did not influence their post-test results.

Table 4.11: Kolmogorov-Simonov Test for Level 1 modules

One-Sample Kolmogorov-Smirnov Test							
		PEIN102 - Pre-test Final	PEIN102 - Post-test Final	EWOR103 - Pre-test - Final	EWOR103 - Post-test - Final	QTES101 - Pre-test - Final	QTES101 - Post-test - Final
N		29	29	29	29	7	6
Normal Parameters[a,b]	Mean	29.66	35.21	25.62	76.17	27.14	16.67
	Std. Deviation	19.081	24.072	11.855	25.898	19.760	18.619
Most Extreme Differences	Absolute	.142	.101	.100	.247	.355	.262
	Positive	.119	.101	.076	.179	.355	.262
	Negative	-.142	-.075	-.100	-.247	-.193	-.185
Kolmogorov-Smirnov Z		.766	.542	.537	1.328	.940	.642
Asymp. Sig. (2-tailed)		.601	.931	.935	.059	.340	.804

The pre-test and post-test results for level 1 subjects are discussed below. It was noted that the students in the control group also improved their post-test results. This could be due to the fact that the lesson completed during the post-test was familiar to them.

4.5.1.1 Results of the Production Engineering 1 group

The initial teaching profile was assessed using the pre-test scores and the changed teaching profile is correlated to the post-test score (Figure 4.17).

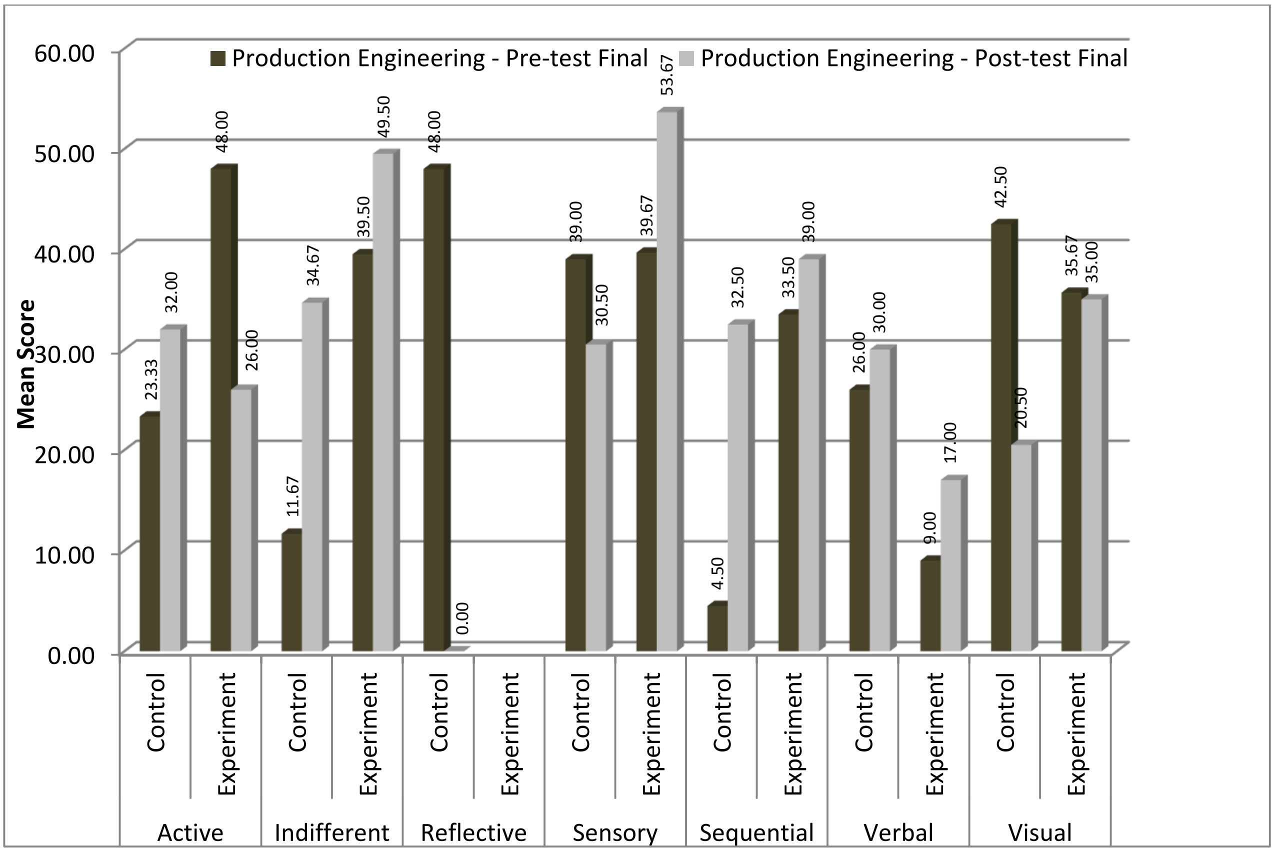

Figure 4.17: Pre-test and post-test results for the Production Engineering group

At first glance, Figure 4.17 shows that the students in the control group performed better in the post-test, in some instances even better than the students in the experimental group. The reason could be that the same lesson used in the pre-test was conducted and they remembered it. Figure 4.17 also shows that the Production Engineering 1 students in the experimental group, who are predominantly sensory students, performed the best in the post-test. The students in the experimental group with no specific preference for learning styles had the second highest score. The active learners in the experimental group performed the worst in the post-test with a mean score of 26% as opposed to the pre-test mean score of 48%. The active learners in the experimental group performed even worse than the students in the control group. The verbal learners in both the control group and the experimental group performed better in the post-test but the visual learners performed worse in the post-test.

This suggests that the teaching intervention of a video and class interaction by the lecturer were not suitable for the active learners.

4.6.1.2 Results of the Engineering Work Study 1 group

Figure 4.18 indicates an overall improvement for the whole Engineering Work Study class during the post-test, although the control group with students who were not subject to the teaching intervention performed better than the students in the experimental group. The difference between the pre-test and post-test results of the active learners is only 2% in favour of the post-test result at 97%. The lecturer decided to add a video on "how to conduct a method study" during the lecture with the experimental group. The students in this group with a verbal preference improved in the post-test from 34% to 68%. The experimental students who are indifferent and do not have a preference for a specific learning style also performed better in the post-test from 30% to 77.33%.

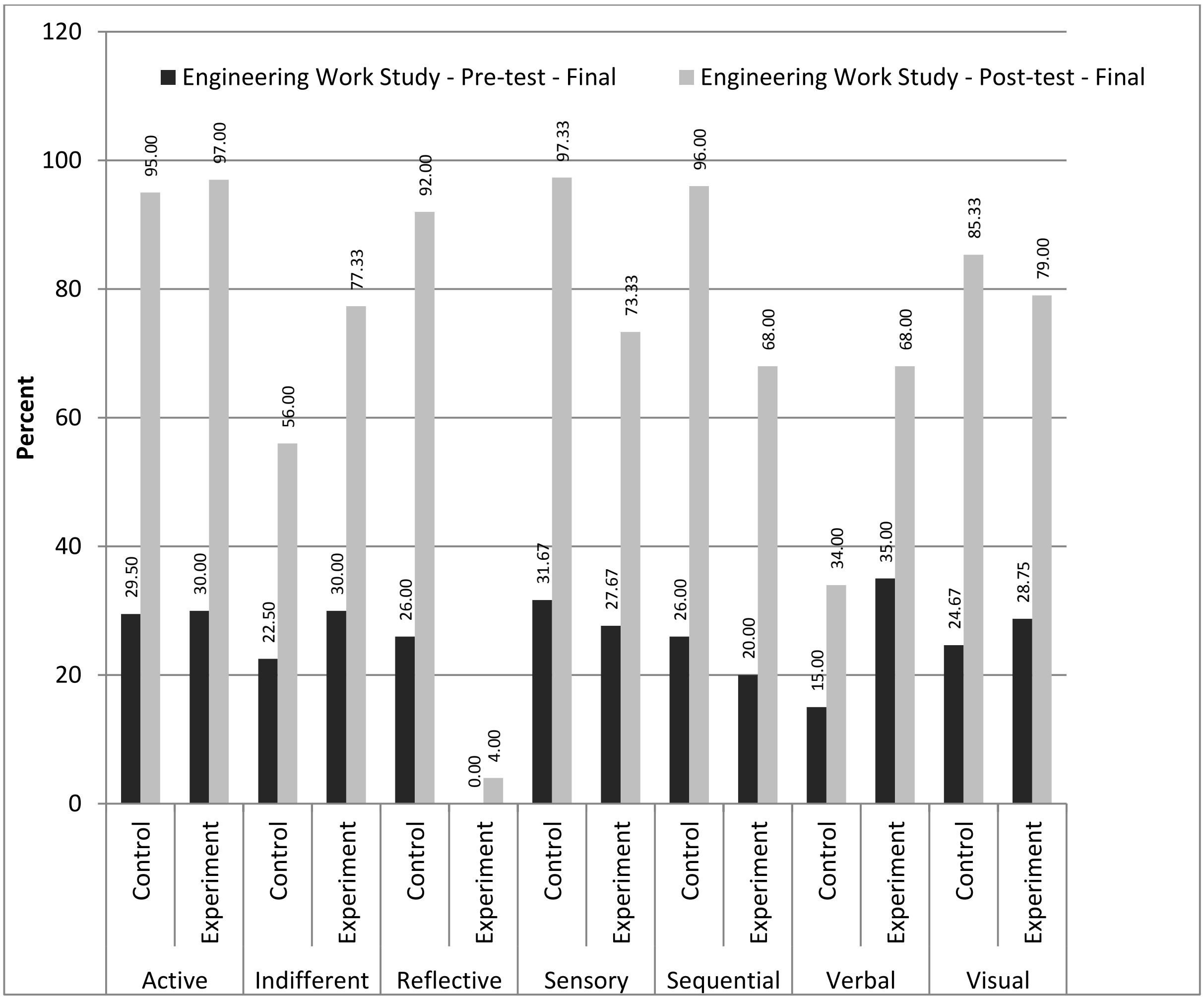

Figure 4.18: Pre-test and post-test results for the Engineering Work Study 1 group

4.6.1.3 Results of the Qualitative Techniques 1 group

The Qualitative Techniques 1 group did not actively take part in either the pre-test or the post-test, (Figure 4.19) due to various reasons supplied by the students such as preparing for main tests in other modules. This rendered the analysis of this data impossible.

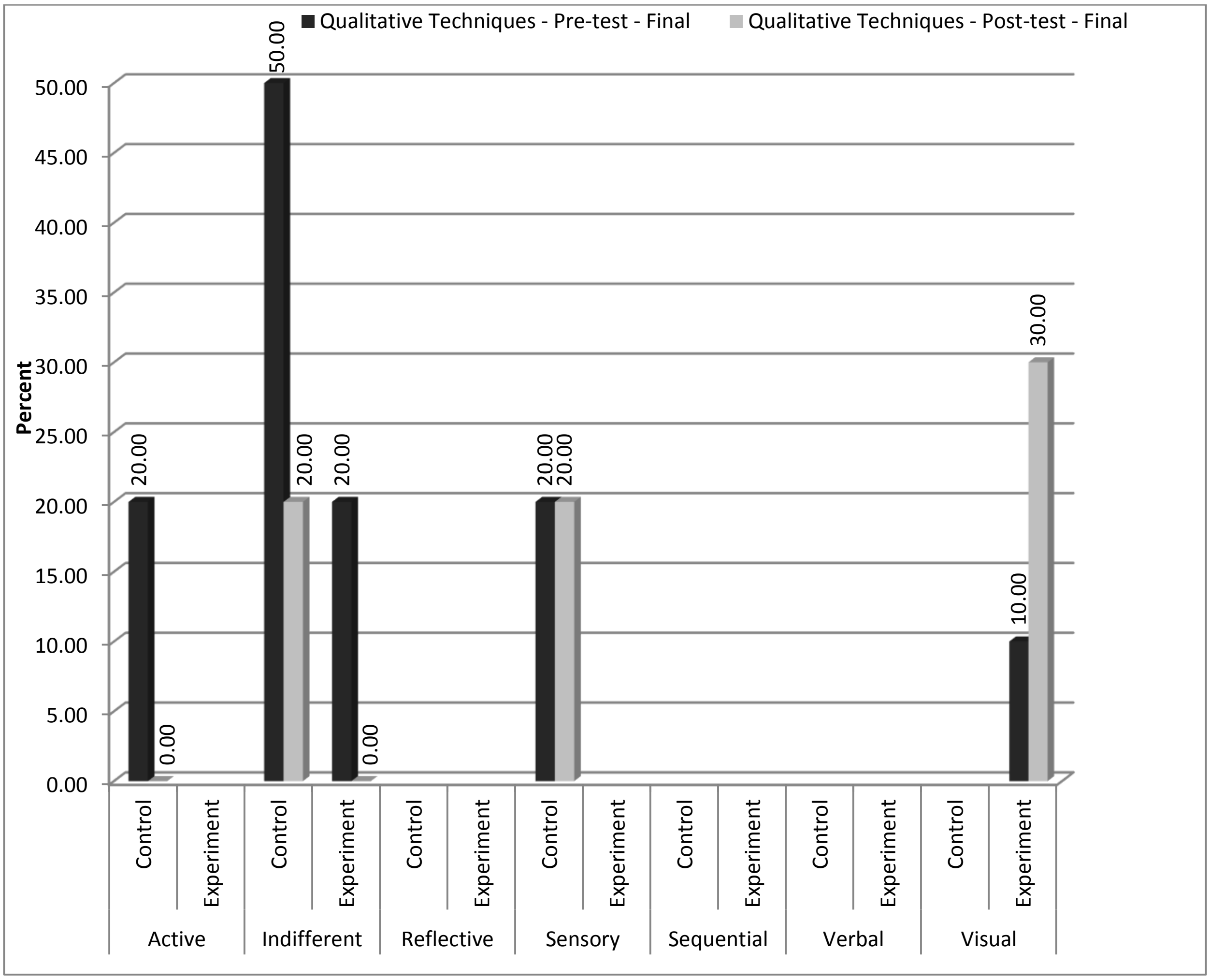

Figure 4.19: Pre-test and post-test results for the Qualitative Techniques 1 group

4.6.1.4 Results of the combined study level 1 students

The combined results of the modules on level 1 are presented in Figure 4.20. Although there were improved results in both the control and experimental groups, the active learners in the experimental group performed best in the post-test at 73%. Although the students were unaware of the fact that the same test would be used in both the pre-test and the post-test, they might have still recognised the questions; this explains the improvement in the control group results. The sensory learners' scores increased from 32% to 64% after the teaching interventions. The fact that reflective learners performed better during the pre-test suggests that the teaching interventions were a complete mismatch with the reflective learning style.

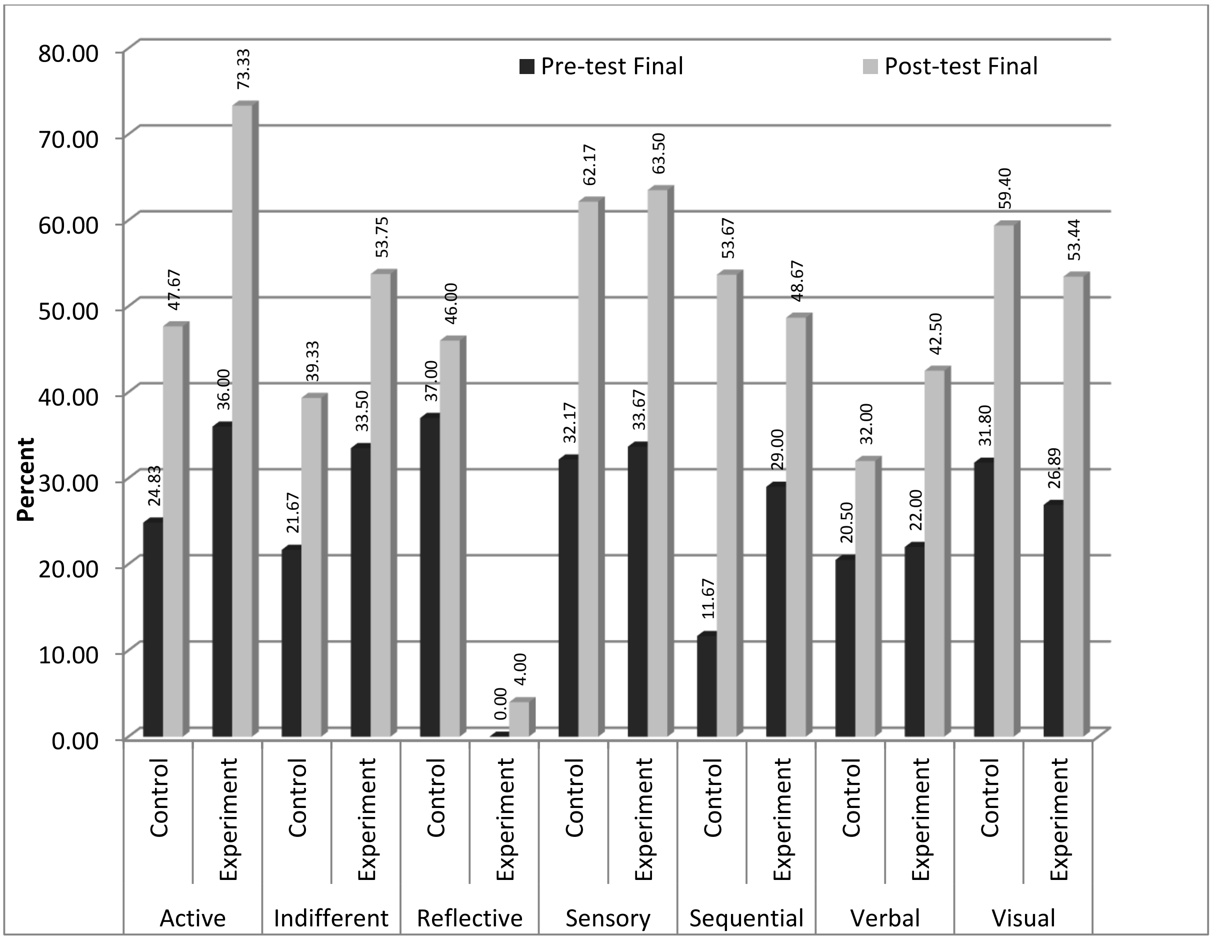

Figure 4.20: Combined results of the modules on level 1

The results (study level 1) of the t-test are presented in Table 4.12. The Sig (2 tailed) value for Engineering Work Study 1 is 0.000, which is lower than 0.05. It can thus be concluded that the change in the condition mean (post -test result) of Engineering Work Study 1 was influenced by the manipulation of the teaching method used.

The other two modules, QTES101 and PEIN102, on level one have a sig (2 tailed) which is higher than 0.05. This indicates that the difference in condition means (in this case, the results between the pre-test and the post-test) were likely by chance and not due to intervention in the teaching method.

Table 4.12: Paired Samples Test: influence of teaching methods on Level 1 modules

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Production Engineering - Pre-test Final - Production Engineering - Post-test Final	-5.552	26.681	4.955	-15.701	4.597	-1.121	28	.272
Pair 2	**Engineering Work Study - Pre-test - Final - Engineering Work Study - Post-test - Final**	**-50.552**	**20.653**	**3.835**	**-58.408**	**-42.696**	**-13.181**	**28**	**.000 ****
Pair 3	Qualitative Techniques - Pre-test - Final - Qualitative Techniques - Post-test – Final	5.000	25.100	10.247	-21.341	31.341	.488	5	.646

The mean test results for Engineering Work Study 1 in the post-test were greater than the mean test results of the pre-test. The mean test results increased from 25.62 to 76.17 (see Table 4.13). This indicates that intervention in the teaching method had a positive effect on student performance. The mean test results for Qualitative Techniques 1 decreased from 21.67 to 16.67. This could be due to the fact that not all the students took part in the study. The mean difference between the pre-test and the post test for Production Engineering 1 is not that large. The mean changed from 29.66 to 35.21. This indicates that teaching styles did not play a significant role in student performance.

Table 4.13: Paired sample statistics: influence of teaching styles on Level 1 modules

		Production Engineering - Pre-test Final	Production Engineering - Post-test Final	Engineering Work Study - Pre-test - Final	Engineering Work Study - Post-test - Final	Qualitative Techniques - Pre-test – Final	Qualitative Techniques - Post-test - Final
N	Valid	29	29	29	29	6	6
	Missing	5	5	5	5	28	28
Mean		29.66	35.21	**25.62**	**76.17**	21.67	16.67
Std. Deviation		19.081	24.072	11.855	25.898	14.720	18.619

Table 4.14 investigates whether there is a significant relationship between the scores (dependent variable) and the students' learning styles (independent variable). Since none of the p-values are less than 0.05, this implies that there are no significant relationships between student performance and students' preferred learning styles. That means that there is no one dominant learning style that will produce higher scores.

Table 4.14: Relationships between student scores and learning styles

			Sum of Squares	df	Mean Square	F	Sig.
Production Engineering - Pre-test Final * Student Learning style	Between Groups	(Combined)	1944.493	6	324.082	.920	.501
	Within Groups		7399.614	21	352.363		
	Total		9344.107	27			
Production Engineering - Post-test Final * Student Learning style	Between Groups	(Combined)	2646.750	6	441.125	.683	.665
	Within Groups		13563.107	21	645.862		
	Total		16209.857	27			
Engineering Work Study - Pre-test - Final * Student Learning style	Between Groups	(Combined)	498.881	6	83.147	.634	.702
	Within Groups		2756.083	21	131.242		
	Total		3254.964	27			

Engineering Work Study - Post-test - Final * Student Learning style	Between Groups	(Combined)	5424.867	6	904.144	1.637	.186
	Within Groups		11599.562	21	552.360		
	Total		17024.429	27			
Qualitative Techniques - Pre-test - Final * Student Learning style	Between Groups	(Combined)	633.333	3	211.111	.938	.553
	Within Groups		450.000	2	225.000		
	Total		1083.333	5			
Qualitative Techniques - Post-test - Final * Student Learning style	Between Groups	(Combined)	733.333	3	244.444	.489	.725
	Within Groups		1000.000	2	500.000		
	Total		1733.333	5			

4.6.2 Study level 2 student performance

From the results of the Kolmogorov-Smirnov test in Table 4.15, it is clear that the test distribution was normal and not skewed, by the fact that the students repeated the same test used for the pre-test in the post-test. All the Asymp sig (2-tailed results) were greater than the p-value of 0.05.

Table 4.15: Kolmogorov-Smirnov Test for Level 2 modules

		PEIN203 - Pre-test Final	PEIN203 - Pre-test Final	COST203 - Pre-test Final	COST203 - Post-test Final	EWOR203 - Pre-test Final	EWOR203 - Post-test Final
N		20	20	21	21	7	7
Normal Parameters[a,b]	Mean	36.40	49.55	69.10	44.62	58.57	20.57
	Std. Deviation	21.067	18.986	14.622	34.744	35.061	10.014
Most Extreme Differences	Absolute	.126	.267	.096	.234	.319	.173
	Positive	.126	.189	.076	.234	.170	.173
	Negative	-.097	-.267	-.096	-.196	-.319	-.168
Kolmogorov-Smirnov Z		.566	1.196	.440	1.071	.845	.457
Asymp. Sig. (2-tailed)		.906	.114	.990	.201	.473	.985

4.6.2.1 Results of the Production Engineering 2 group

It is clear from Figure 4.20 that the results for all learner types improved after the intervention, except for the active learners. Their post-test score dropped from 48% to 16%. The sensory students showed a slight increase from 60% to 63%, whereas the verbal experimental group had a significant increase from 35% to 63%. The reflective learners also had a significant change from 20% to 43%.

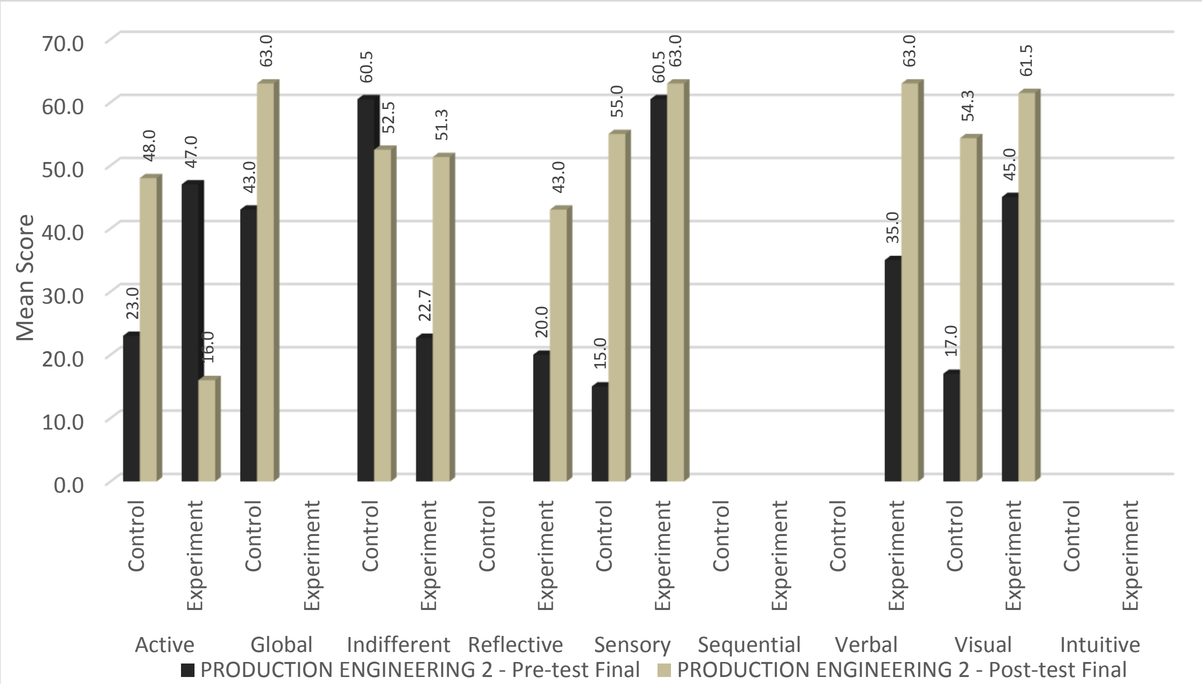

Figure 4.21: Pre-test and post-test results for the Production Engineering 2 group

4.6.2.2 Results of the Costing 2 group

From Figure 4.22 it is clear that the Costing 2 students in both the control and experimental groups performed much worse in the post-test than in the pre-test with the exception of the active and sensory group. The reflective learners dropped from 75% to 48% and the visual learners dropped from 76% to 60%. The active learners increased their score results from 59% to 63%, while the sensory learners increased their score results from 58.7 to 71.5%.

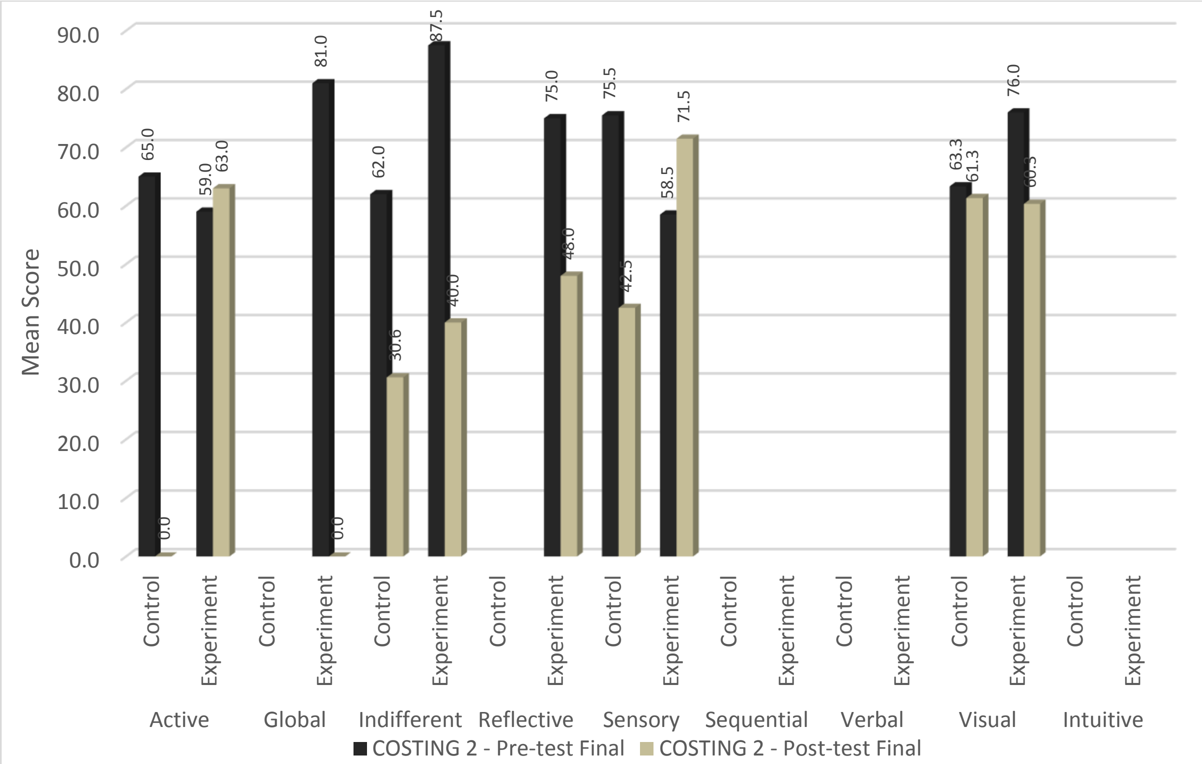

Figure 4.22: Pre-test and post-test results for the Costing 2 group

4.6.2.3 Results of the Engineering Work Study 2 group

The results of the Engineering Work Study 2 group in Figure 4.23 reflect that some students opted out of the tests. It is clear that all the students in the experimental group performed worse in the post-test, indicating that the students who wrote the tests, were not compatible with the intervention in the teaching method. The visual and verbal learners dropped from an average of 82% to 27% and 36%, respectively. The class interaction activity did not help students to perform better.

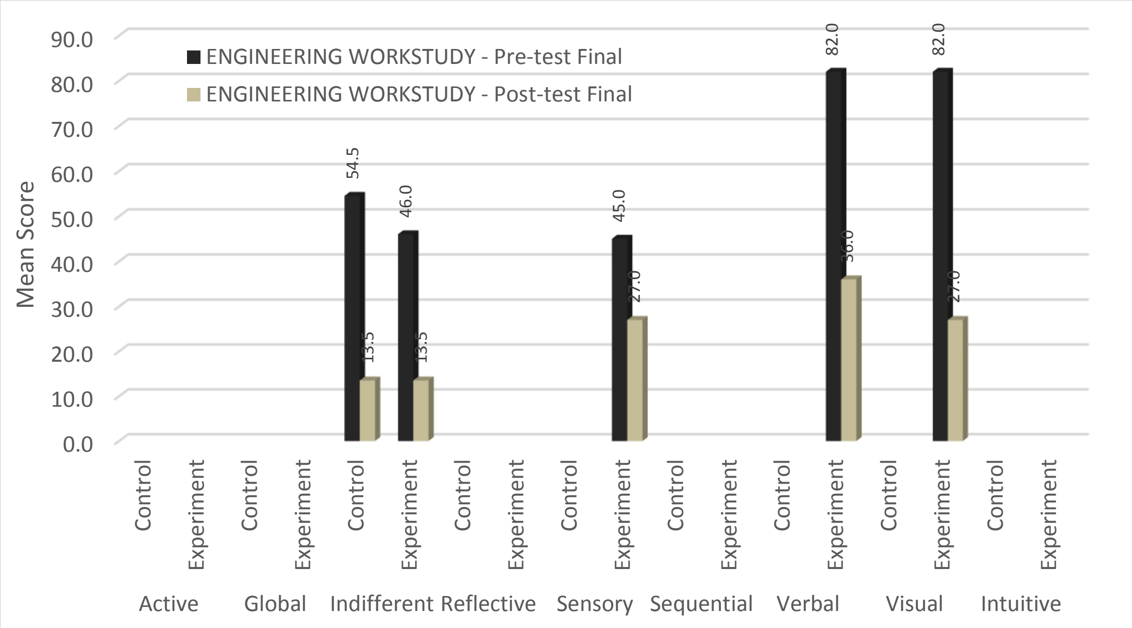

Figure 4.23: Pre-test and post-test results for the Engineering Work Study 2 group

4.6.2.4 Results of the combined study level 2 students

In Figure 4.24 it is evident that the interventions in the teaching styles did not result in improvements in student performance in level 2 as a whole. The post-test results are lower in all the learning style dimensions. This suggests that the wrong teaching method might have been used in all three modules in the level 2 student group. Interestingly, all the lecturers who teach at study level 2, made use of interactive class activities. This does not seem to have been effective in improving students' academic performance.

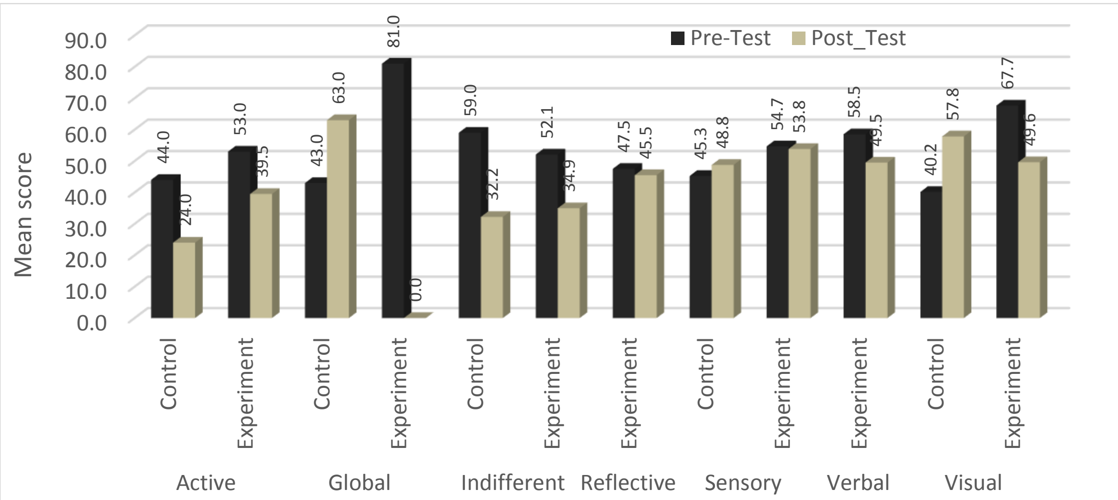

Figure 4.24: Combined results of the modules on level 2

To determine whether the change in scores was affected by the change in teaching style, a paired t-test was performed. The initial teaching profile was assessed using the pre-test scores and the changed teaching profile was correlated to the post-test score.

The results of the t-test for the modules in study level 2 can be seen in Table 4.16. The Sig (2 tailed) value for Engineering Work Study 2 is 0.026, while the sig value for Costing 2 is 0.014. Both are smaller than 0.05, leading to the conclusion that the change in the condition mean in these two modules was influenced by the manipulation of the teaching methods used.

Table 4.16: Paired Samples Test: influence of teaching methods on Level 2 modules

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PRODUCTION ENGINEERING 2 - Pre-test Final - PRODUCTION ENGINEERING 2 - Post-test Final	-13.150	29.548	6.607	-26.979	.679	-1.990	19	.061
Pair 2	**COSTING 2 - Pre-test Final - COSTING 2 - Post-test Final**	**24.476**	**41.893**	**9.142**	**5.407**	**43.546**	**2.677**	**20**	**.014*** **
Pair 3	**ENGINEERING WORKSTUDY - Pre-test Final - ENGINEERING WORKSTUDY - Post-test Final**	**38.000**	**34.132**	**12.901**	**6.433**	**69.567**	**2.946**	**6**	**.026*** **

The mean test results for Engineering Work Study 2 in the post-test were smaller than the mean test results of the pre-test at 58.57% and the post-test at 20.57%. The Costing 2 post-test results (44.62%) were much lower than the pre-test results (69.10%) (see Table 4.17). This indicates that the intervention did impact on student performance, but this time it had a negative effect. The teaching intervention used in both cases did not match the students' preferred learning styles.

Table 4.17: Paired Samples Statistics: influence of teaching styles on Level 2 modules

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRODUCTION ENGINEERING 2 - Pre-test Final	36.40	20	21.067	4.711
	PRODUCTION ENGINEERING 2 - Post-test Final	49.55	20	18.986	4.245
Pair 2	COSTING 2 - Pre-test Final	69.10	21	14.622	3.191
	COSTING 2 - Post-test Final	44.62	21	34.744	7.582
Pair 3	ENGINEERING WORKSTUDY - Pre-test Final	58.57	7	35.061	13.252
	ENGINEERING WORKSTUDY - Post-test Final	20.57	7	10.014	3.785

Table 4.18 investigates whether there is a significant relationship between the scores (dependent variable) and the students' learning styles (independent variable). Since none of the p-values are less than 0.05, this implies that there are no significant relationships. In other words, there is no one dominant learning style that will produce higher scores.

Table 4.18: Relationships between student scores and learning styles

		Sum of Squares	df	Mean Square	F	Sig.
PRODUCTION ENGINEERING 2 - Pre-test Final	Between Groups	984.533	6	164.089	.286	.933
	Within Groups	7448.267	13	572.944		
	Total	8432.800	19			
PRODUCTION ENGINEERING 2 - Post-test Final	Between Groups	3682.683	6	613.781	2.520	.077
	Within Groups	3166.267	13	243.559		
	Total	6848.950	19			
COSTING 2 - Pre-test Final	Between Groups	297.048	5	59.410	.224	.946
	Within Groups	3978.762	15	265.251		
	Total	4275.810	20			
COSTING 2 - Post-test Final	Between Groups	5436.190	5	1087.238	.872	.523
	Within Groups	18706.762	15	1247.117		
	Total	24142.952	20			
ENGINEERING	Between Groups	1558.964	3	519.655	.268	.846

WORKSTUDY - Pre-test Final	Within Groups	5816.750	3	1938.917		
	Total	7375.714	6			
ENGINEERING WORKSTUDY - Post-test Final	Between Groups	520.714	3	173.571	6.429	.080
	Within Groups	81.000	3	27.000		
	Total	601.714	6			

4.6.3 Study level 3 student performance

Not all of the participants in the level 3 group continued to participate in this study. It is therefore not included.

4.7 Summary

This chapter analysed the data collected for this study. The analysis of learning style types confirmed that IE students have a preference for active learning, visual learning, sensory learning and sequential learning. This is in line with studies conducted by various other researchers such as Van Aardt, Goede, Taylor, Kroeze and Pretorius (2010) and Mines (2013). It was found that gender and age have a slight influence on students' choices when answering the questions; however, study level did not play a significant role. The results of the pre-tests and post-tests for each level were also examined. It was noted that, while the students in the control group performed better during all the post-tests than in the pre-tests, those in the experimental group performed either better or worse in the post-tests. Possible reasons for these findings could include:

1. Although the students did not know that they would write the same test twice, they might have recognised the test during the post-test; therefore they were more familiar with it.
2. During the intervention phase, the students in the control group received the same lesson as before the pre-test phase. Once again, the students would remember better during the second phase because the work had been discussed previously. However, the students in the experimental group received the same lesson, but in a different manner. If the teaching

method did not match the students' preferred style of learning, they could have performed worse than the students in the control group.

A detailed discussion of the results follows in chapter 5.

CHAPTER 5: DISCUSSION, CONCLUSION AND RECCOMENDATIONS

5.1 Introduction

The major purpose of this study was to determine if learning styles and teaching methods have any effect on student performance, whether good or bad. It is hoped that the study will enable IE lecturers to better understand the type of educators they are and the extent to which their teaching styles can influence student learning and thus student performance. Chapter 4 reported on the findings made in relation to the objectives specified in chapter 1. This final chapter presents the conclusions, recommendations and suggestions for future research. The summary of the findings is organised around the study's objectives in order to answer the research question, namely, do the different learning styles of students and teaching methods of lecturers have an influence on student performance? The findings on the objectives, listed below, are discussed in the following sections:

- the preferred learning styles of students in the selected levels 1, 2, and 3 modules in IE at the DUT;
- lecturers' preferred teaching styles in the selected levels 1, 2, and 3 modules in IE at the DUT;
- the effect of lecturers' teaching styles and students' learning styles on student performance in the selected modules;
- student performance before and after adapting teaching styles in the selected modules in IE at the DUT.

5.2 Demographic information

Although not part of the objectives set out in the previous section, the researcher investigated the demographics of the IE students at DUT. It was found that IE at DUT is still dominated by male students and that only 40% of the student respondents were female.

The majority (85%) of the IE students at DUT are between the ages of 18 and 23, with the remainder being older than 23. This suggests that the majority of IE students commence their studies immediately after completing matric. Some of the 85% of students who did not meet the admission requirements the first time round enrolled at an FET college to upgrade their results. Only 15% of the students who took part in this study were older than 23. It is therefore difficult to determine if age has an effect on students' preferred learning styles. The following reasons may explain why students commence their studies at this age:

- students studied another course and decided to change to IE
- students were working and decided to enrich their skills by studying IE

The possible influences of age and gender on learning style preferences are discussed in the sections that follow.

5.3 Research objectives

5.3.1 Learning style preferences of IE students

Previous studies Felder and Silverman (1988); Van Aardt *et al.* (2010) and Mines (2013) found that engineering students' learning styles are active, sensory, visual and sequential. The current study confirmed that, irrespective of the engineering field, engineering students are active, sensory, visual and sequential learners.

This study also investigated if there are different learning style preferences across the different study levels at DUT. The learning style preferences for the students at study levels 1, 2 and 3 are as follows:

- Active learners: level 1 = 51%, level 2 = 56%, level 3 = 57%
- Sensory learners: level 1 = 66%, level 2 = 65%, level 3 = 63%
- Visual learners: level 1 = 61%, level 2 = 62%, level 3 = 69%
- Sequential learners: level 1 = 57%, level 2 = 57% level 3= 55%

It is evident that the students' preference for active and visual learning increased over the different study levels; the preference for sequential learning and sensory learning decreased in study level 3.

Although there was a slight indication that gender and age might have an influence on learning style preferences, it was not significant. Some of the questions were answered differently by female students. The following differences were highlighted:

Category 1: active vs reflective

83.8% of the female students are more willing to participate actively, but only 74.1% of their male counterparts said they are willing to contribute actively in group work. It is also noted that 91.9% of the female students made friends through group work, whereas only 62.5% of the male students felt that they make friends through group work. Another interesting finding is that 53.4% of male students prefer to study in a group and 46.6% prefer to study alone, whereas the females prefer to study alone at 67.8%.

Category 2: sensory vs intuitive

91.9% of the female students preferred to deal with facts and real life situations while only 75% of male students felt the same way. 91.9% of the females said that they check their work carefully when working with calculations, whereas only 69% of male students agreed with this statement.

Category 3: visual vs verbal

97.3% of the female students said that they found it easier to think of what they had done the previous day as a picture, compared with 84.5% of male students. Only 32.3% of the females preferred to use a map to go to a new place as opposed to 63.8% of males who would rather use a map than written instructions.

Category 4: global vs sequential

60.3% of the male students agreed that they need to understand all the parts before they can understand the whole, whereas females said that they need to understand the whole, and then they will see how the parts fit in.

Although these differences were identified in students' answers, they did not have a major effect on the overall preferred learning styles. If a bigger sample size of females was used to determine learning style preferences between males and females, the test results might change significantly. However, in the classroom environment, lecturers should be aware of the differences between male and female students when it comes to thinking and reasoning. Age did not play a role in determining students' preferred learning styles.

The following section discusses the teaching styles of the selected lecturers.

5.3.2 Teaching styles

It was found that the lecturers in the IE department have different teaching preferences. This is in contrast with the Felder and Silverman (1988) study that suggested that educators prefer traditional teaching, in which they do not expect any interaction with students; their role is to listen. The interviews with lecturers revealed that they realised that their students are all different and that they learn differently. They have therefore already started to adapt their teaching methods. Before the research was conducted in the IE department, lecturers were unaware of what type of educators they are. Lecturer 1 initially thought he was a facilitator but after completion of the interview and the questionnaire, the lecturer was rated a demonstrator. Lecturer 2 saw herself as a formal authority and this was confirmed. Lecturer 3 initially regarded himself as a demonstrator and after the study he was rated as a demonstrator combined with delegator and formal authority, Lecturer 4 indicated that he is a facilitator in his classes. At the end of his interview and after completion of the questionnaire it was confirmed that he is a facilitator and that formal authority was least used in his lecturing style. Lecturer 5 saw himself as a demonstrator, but after completion of his interview and the questionnaire he was rated a delegator. It is extremely important for lecturers to be aware of what teaching style they prefer as this will enable them to better understand how students perceive their lectures and why students perform the way they do.

The following sections discuss the students' results before and after the teaching intervention.

5.3.3 Student performance: study level 1

The results of the quasi experiment suggest that the lecturers' manner of teaching influences students' way of learning and directly affects how students perform in tests and exams. The influence can either be positive or negative.

5.3.3.1 Engineering Work Study 1

The lecturer for Engineering Work Study 1 was identified a demonstrator, whereas the Engineering Work Study 1 class had a very high preference for active learning and visual learning. During the first stage of the study, the lecturer only explained how to conduct a method study and did not demonstrate how to do it, as his preferred teaching style suggested. From the pre-test results in chapter 4 it is evident that the students performed poorly. The highest score was 35% in favour of the verbal students. The active and sensory students did worst in the test. As noted in the literature review, such students learn best by doing and observing. During the intervention, the lecturer decided to show a video on how to conduct method studies to the experimental group, and all the students had to conduct a method study afterwards in class. The post-test results indicated that all the students performed better. The students in the experimental group with a preference for active learning and visual learning showed definite improvement in their performance.

The Sig (2 tailed) value for Engineering Work Study 1 is 0.000, which is lower than 0.05. It is therefore concluded that the change in the condition mean (post-test result) of Engineering Work Study 1 was influenced by the manipulation of the teaching method used. The mean test results increased from 25.62 to 76.17

(see Table 4.6). This indicates that the intervention in the teaching method had a positive effect on student performance. In this case the teaching intervention chosen by the lecturer matched his preferred teaching style as well as his students' preferred learning styles.

5.3.3.2 Production Engineering 1

The lecturer for the Production Engineering 1 class is a formal type lecturer who makes use of visual material such as PowerPoint presentations. Before the intervention, the visual students performed overall the best, whereas the active students, indifferent students, and sequential and verbal students did not perform at all well. The lecturer then combined her PowerPoint presentation with a video on productivity. The active students and the visual students performed worse than they had performed before the intervention. The active students' score dropped from 48% to 26%. The sensory, sequential and indifferent students performed better after the intervention. However, the improvement for sensory students from a pre-test result of 39% to 53.67% is not that significant. These results indicate that the intervention used by the lecturer might not have been the most suitable for the learning style types found in her class.

5.3.3.3 Qualitative Techniques 1

The results of the Qualitative Techniques 1 students' performance were incomplete, due to students not attending the pre-test and the post-test.

5.3.4 Student performance: study level 2

5.3.4.1 Costing 2

The Costing 2 lecturer was identified as a facilitator. He prefers to get students involved from the start of his lessons, and currently uses PowerPoint presentations and the knowledge he gained in industry when teaching. During the pre-test all the learning style groups performed well and scored between 61% and 88%. After the lecturer changed his teaching method, most of the students performed worse. There was only a slight improvement in the experimental group of active learners and sensory learners.

This suggests that the lecturer's teaching intervention of more interactive discussions and peer reviews did not correspond with the students' preferred learning styles. It seems that IE students are not yet ready to be facilitated at such a high level. The Sig (2 tailed/0) value for Costing 2 is 0.014, which is much lower than p = 0.05. Unlike in Engineering Work Study 1 where the intervention in the teaching method had a positive effect on students' results, this teaching intervention had a negative effect on most of the students.

5.3.4.2 Engineering Work Study 2

Not all the students completed this study; therefore, the data is incomplete and it was not be possible to provide a true reflection of the effect the teaching intervention had on students.

5.2.4.3 Production Engineering 2

The lecturer is a demonstrator. It is clear from Figure 4.11 that the active learners in the Production Engineering 2 reflective group performed worse after the teaching intervention. The students' scores dropped from 47% to 16%. This implies that the intervention used by the lecturer did not correspond with these students' learning styles. The sensory students had a slight increase from 60% to 63%, whereas the verbal experimental group showed a significant increase from 35% to 63%. The reflective learners also had a significant change from 20% to 43%.

5.4 Limitations of the study

The main limitation experienced during the course of this study, was student strikes and unrest during 2013. Lectures were postponed due to unsafe conditions. This had a snowball effect because after lectures resumed, everybody was under pressure to complete the syllabus before the exams started. Dates for pre-tests and post-test were rescheduled, in some instances more than once, because lecturers felt that it was more important to complete their syllabus, taking into account the weeks lost due to the student unrest. Although the students were initially interested in taking part in the study, they lost interest and were more focused on performing well in tests “that matter”. Student would bunk lessons and tests dedicated to this study, in order to study for a test that would influence their year mark. It was for this reason that the data collected for study level 3 was inadequate and could not be included.

Another consequence of the shorter semester due to the unrest was that the lecturers did not really have adequate time to investigate their students’ preferred learning styles and to select an intervention that would suit the majority of the learning styles. The study results suggest that, while the lecturers chose a different teaching approach, they did not necessarily take students’ learning styles into consideration.

Although female learners did not have a significantly different preferred learning style, they did reveal different preferences in response to some of the questions in the ILS Questionnaire. The fact that a significant difference was not revealed could be due to the fact that the sample size of females was too small.

5.6 Conclusion and Recommendations

In conclusion, this study has shown that students registered for IE at DUT do in fact have different learning styles and that the lecturers in the IE department at DUT have their own preferences on how to conduct their lectures. Furthermore, the lecturers’ preferred teaching methods did not necessarily match the students’ preferred learning styles.

During the pre-test phase it was evident that the students whose learning styles matched the lecturers’ preferred method of teaching performed still better than the students who were not a match to the lecturers teaching method. Referring to figure 4.17, the visual and sensory learners have matched with the formal and visual teaching method of the lecturer and have performed better during the pre-test than the active, sequential and verbal learners. This occurrence is also noticed in the Pre-test results for Costing 2 and Engineering Work Study.

The remainder of the students did not fare well. From the post-test results, after lecturer intervention, it was evident that in some cases the whole class performed better. This implies that the lecturer chose an appropriate intervention that worked. In other cases, the students who performed well in the pre-test phase performed worse in the post-test phase. Students whose learning styles were closely related to the lecturer's teaching methods always performed better than when there was a mismatch between learning styles and teaching methods.

IE students' academic performance plays an important role in the throughput and graduation rates of students in the IE department. If student performance can be improved, this will have a positive effect on throughput and graduation rates. The majority of first year students are not well-prepared for tertiary education and they either drop out completely in their first year or do not perform well. The IE department needs to hold workshops for all first year IE students to discuss different learning methods. Students need to be made aware of the fact that it is okay to "study differently" from a fellow student. IE students should complete the ILS Questionnaire in order to determine their preferred learning styles. Students with similar preferences should be grouped together and receive some guidance on what learning methods they can use in order to improve their learning. This process will not happen overnight. Students need to be guided through this learning process in order to become comfortable with their preferred learning styles and understand how they can use this knowledge to their advantage.

Each lecturer in the department needs to identify his/her preferred teaching style and the methods s/he uses in his classroom. Each lecturer should compare their preferred teaching style with the learning styles of their students, and how it can be adapted to suit students. While it would be impossible to accommodate each and every student’s learning style preferences, lecturers should target the two most preferred styles in their classrooms. It might be useful to implement these recommendations as a pilot run and if it is a success, to introduce it to other engineering departments.

Below are a few examples of how to target different teaching styles in different IE classes:

- Active and reflective students: create ‘small breaks’ during a lesson, in order to give students time to think about what the lecturer was saying and to think of questions to ask. Lecturers could set problems to be solved by groups of no more than three students during class time. This would help to develop students’ thinking and problem solving skills.
- Sequential students: It is important to show students how the work they are learning in the lecturer’s course relates to other courses in the IE field. For example, lecturers could explain how time studies are linked to facilities layout and production engineering. The lecturer needs to encourage students to not ‘box’ each course on its own but to think about how courses relate to one another. The one cannot function without the other.
- Visual students. Flow-process charts can be explained by making use of the process involved in changing a tyre. Show the students how the flow-process chart is created. When explaining storage equipment in the facilities layout class, show images and videos on these types of equipment so that students can see how it looks and works.
- Sensory students: when teaching line-balancing, the lecturer could use simulation. Simulate a current scenario and show the students the productivity or efficiency of the facility. Re-simulate the scenario by making some physical changes to the layout and show the students the new results. The sensory students can now physically see how changes to a layout can impact on facility productivity and efficiency.

Awareness of teaching styles and learning styles across the Engineering Faculty could result in a continuous process of improvement in teaching and learning.

5.7 Future research

1. The researcher is interested in investigating the learning style preferences of graduate students in engineering. The researcher believes that graduate students will have different learning style preferences from those of undergraduate students, taking into account that graduate students have been actively involved in the working environment. The researcher is also interested in determining the factors that affect students' choices regarding their learning styles.
2. The researcher is also interested in expanding the research on undergraduate students to other faculties and departments at DUT. It would be interesting to compare the learning styles and teaching methods of disciplines other than engineering.

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Appendix A: Adapted ILS questionnaire

ILS Questionnaire for Industrial Engineering students

DURBAN UNIVERSITY OF TECHNOLOGY

Section A: Demographics

1. Gender
   a. Male ☐
   b. Female ☐

2. Age
   a. 18-23 years ☐
   b. 24 years and older ☐

Section B: Index of learning styles

Enter your answers to every question on the ILS scoring sheet. Please choose only one answer for each question. If both “a” and “b” seem to apply to you, choose the one that applies more frequently.

1. I understand something better after I
   a) try it out.
   b) think it through.

2. I would rather be considered
   a) realistic.
   b) innovative.

3. When I think about what I did yesterday, I am most likely to get
   a) a picture.
   b) words.

4. I tend to
   a) understand details of a subject but may be fuzzy about its overall structure.
   b) understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to

a) talk about it.
b) think about it.

6. If I were a teacher, I would rather teach a course
a) that deals with facts and real life situations.
b) that deals with ideas and theories.

7. I prefer to get new information in
a) pictures, diagrams, graphs, or maps.
b) written directions or verbal information.

8. Once I understand
a) all the parts, I understand the whole thing.
b) the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
a) jump in and contribute ideas.
b) sit back and listen.

10. I find it easier
a) to learn facts.
b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
a) look over the pictures and charts carefully.
b) focus on the written text.

12. When I solve math problems
a) I usually work my way to the solutions one step at a time.
b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
a) I have usually gotten to know many of the students.
b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
a) something that teaches me new facts or tells me how to do something.
b) something that gives me new ideas to think about.

15. I like teachers
a) who put a lot of diagrams on the board.
b) who spend a lot of time explaining.

16. When I'm analysing a story or a novel
a) I think of the incidents and try to put them together to figure out the themes.
b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
a) start working on the solution immediately.
b) try to fully understand the problem first.

18. I prefer the idea of
a) certainty.
b) theory.

19. I remember best
   a) what I see.
   b) what I hear.

20. It is more important to me that an instructor
   a) lay out the material in clear sequential steps.
   b) give me an overall picture and relate the material to other modules.

21. I prefer to study
   a) in a study group.
   b) alone.

22. I am more likely to be considered
   a) careful about the details of my work.
   b) creative about how to do my work.

23. When I get directions to a new place, I prefer
   a) a map.
   b) written instructions.

24. I learn
   a) at a fairly regular pace. If I study hard, I'll "get it."
   b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
   a) try things out.
   b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
   a) clearly say what they mean.
   b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
   a) the picture.
   b) what the instructor said about it.

28. When considering a body of information, I am more likely to
   a) focus on details and miss the big picture.
   b) try to understand the big picture before getting into the details.

29. I more easily remember
   a) something I have done.
   b) something I have thought a lot about.

30. When I have to perform a task, I prefer to
   a) master one way of doing it.
   b) come up with new ways of doing it.

31. When someone is showing me data, I prefer
   a) charts or graphs.
   b) text summarizing the results.

32. When writing a paper, I am more likely to
   a) work on (think about or write) the beginning of the paper and progress forward.
   b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
    a) have “group brainstorming” where everyone contributes ideas.
    b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
    a) sensible.
    b) imaginative.

35. When I meet people at a party, I am more likely to remember
    a) what they looked like.
    b) what they said about themselves.

36. When I am learning a new subject, I prefer to
    a) stay focused on that subject, learning as much about it as I can.
    b) try to make connections between that subject and related modules.

37. I am more likely to be considered
    a) outgoing.
    b) reserved.

38. I prefer courses that emphasize
    a) concrete material (facts, data).
    b) abstract material (concepts, theories).

39. For entertainment, I would rather
    a) watch television.
    b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
    a) somewhat helpful to me.
    b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
    a) appeals to me.
    b) does not appeal to me.

42. When I am doing long calculations,
    a) I tend to repeat all my steps and check my work carefully.
    b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
    a) easily and fairly accurately.
    b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
    a) think of the steps in the solution process.
    b) think of possible consequences or applications of the solution in a wide range of areas.

Appendix B: the interview guide used for structured interviews with lecturers

Questions for lecturer interviews

DUT DURBAN UNIVERSITY OF TECHNOLOGY

1. What courses do you lecture? Click the respective box next to displayed modules.

   Engineering Drawing ☐
   Production Engineering 1 ☐
   Auto CAD 1 ☐
   Costing 2 ☐
   Production Engineering 2 ☐
   Engineering Workstudy 2 ☐
   Automation 3 ☐
   Industrial Accounting 3 ☐
   Operational Research 3 ☐

2. Subject criteria

2.1 Engineering Drawing

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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<u>2.2 Production Engineering 1</u>

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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<u>2.3 Auto CAD 1</u>

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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2.4 Costing 2

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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2.5 Production Engineering 2

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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2.6 Engineering Workstudy 2

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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2.7 Automation 3

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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2.8 Industrial Accounting 3

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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2.9 Operational Research 3

Theory based only ☐

Theory and calculation based ☐

Theory and practice based ☐

Teaching style

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3. What type of teaching style do you think fits with you?
   Delegator (the educator place a lot of control and responsibility for learning on the individual learner or the group of students. the educator will give students the choice of designing and implementing their own learning projects.) ☐

   Facilitator (The educator focus on activities and student-centred learning. the educator will design learning situations/activities that require student processing and student collaboration.) ☐

   Formal authority (The educator gives information, and the student must receive it. The educator is not concerned to build relationships with their students or that students form any relationship with other students.) ☐

   Demonstrator (The educator acts as a role model to demonstrate skills and processes. They guide and coach the students to develop and apply these skills.) ☐

   Question 4 to 11 will be completed on the grid, supplied to you.

4. Do you find your teaching style:
   A. Lead to inflexibility for managing the concerns of students
   B. Make the students feel inadequate when they can't emulate your example
   C. A sequence of steps leading to mastery but which you orchestrate
   D. Leave students feeling anxious about their ability to meet your expectations

5. Which of the following do you like to use when evaluating student learning?
   A. Summative assessment
   B. Formative assessment
   C. Student self-assessment tests
   D. Peer assessment

6. Which of the following criteria do you make use to assess students?
   A. Student interaction in class activities

B. Open-ended problem solving
E. Performance based criteria
F. Problem solving and critical thinking

7. When planning lectures, do you have
   A. Formal lectures
   B. Role playing.
   C. Peer tutoring
   D. Brainstorming
   E. A combination of any of the above

   If you answered E: say which combination you make use of?

   ……………………………….

   Does this apply to all your classes?

   ....

   If No, how is it different?

   ....

   ……………………………………………………………………………………………

   ……………………………………………………………………………………………

8. When you teach face to face, does your instructional sessions include
   A. Lectures.
   B. Demonstrations
   C. Videos
   D. Class discussion/brainstorming.
   E. A combination of the above
   F. Other

   If you answered E, say which combination you make use of:………………………………….

   If you answered F, name it

   ....

9. Does your teaching style
   A. Focuses on clear expectations
   B. Emphasizes direct observation
   C. Allows students personal flexibility
   D. Helps students see themselves as independent learners

10. On what criteria are your assessments based?
    A. Your personal preferences
    B. Specific instructional models
    C. Sequence of steps leading to mastery but which you orchestrate.
    D. A student portfolio
    E. A learning log which has a self-assessment component.
    F. Problem solving based on research of course material.

11. Does your teaching style develop a rhythm which contains
    A. Four steps: content selection, presentation/reception, reflection, application.
    B. Three steps: selection, skill development, mastery performance.
    C. Five steps: creating awareness, collecting data, choosing innovation, implementing a plan, reviewing results.
    D. Twelve steps: ranging from pose and reflect on a problem, skill development exercises to interim evaluation, learner responses and development of solutions.
    E. Any combination of the above
    F. Other

    If you answered E, say which combination you make use of:…………………………………

    If you answered F, name it

    ....

Questionnaire Grid: Teaching styles

Question 3	A	B	C	D	E	F
Question 4	A	B	C	D	E	F
Question 5	A	B	C	D	E	F
Question 6	A	B	C	D	E	F
Question 7	A	B	C	D	E	F
Question 8	A	B	C	D	E	F
Question 9	A	B	C	D	E	F
Question 10	A	B	C	D	E	F

Teaching Style Types

Most A's: Formal Authority

Teachers who have a formal authority teaching style tend to focus on content. This style is generally teacher-centered, where the teacher feels responsible for providing and controlling the flow of the content and the student is expected to receive the content. One type of statement made by an instructor with this teaching style is "I am the flashlight for my students; I illuminate the content and materials so that my students can see the importance of the material and appreciate the discipline." Teachers with this teaching style are not as concerned with building relationships with their students nor is it as important that their students form relationships with other students. This type of teacher doesn't usually require much student participation in class. "Sage on the stage" model.

Most B's: Demonstrator or Personal Model

Teachers who have a demonstrator or personal model teaching style tend to run teacher-centered classes with an emphasis on demonstration and modeling. This type of teacher acts as a role model by demonstrating skills and processes and then as a coach/guide in helping students develops and apply these skills and knowledge. A teacher with this type of teaching style might comment: "I show my students how to properly do a task or work through a problem and then I'll help them master the task or problem solution. It's important that my students can independently solve similar problems by using and adapting demonstrated methods." Instructors with this teaching style are interested in encouraging student participation and adapting their presentation to include various learning styles. Students are expected to take some responsibility for learning what they need to know and for asking for help when they don't understand something.

Most C's: Facilitator

Teachers who have a facilitator model teaching style tend to focus on activities. This teaching style emphasizes student-centered learning and there is much more responsibility placed on the students to take the initiative for meeting the demands of various learning tasks. This type of teaching style works best for students who are comfortable with independent learning and who can actively participate and collaborate with other students. Teachers typically design group activities which necessitate active learning, student-to-student collaboration and problem solving. This type of teacher will often try to design learning situations and activities that require student processing and application of course content in creative and original ways.

Most D's: Delegator

Teachers who have a delegator teaching style tend to place much control and responsibility for learning on individuals or groups of students. This type of teacher will often give students a choice designing and implementing their own complex learning projects and will act in a consultative role. Students are often asked to work independently or in groups and must be able to maintain motivation and focus for complex projects. Students working in this type of setting learn about co-operation and how to interact socially.

Appendix C: Information letter to students

Information letter to DUT students

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITIUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

LETTER OF INFORMATION

Title of the research study:

Learning styles, teaching methods, and student performance in Industrial Engineering at a university of technology

Principal investigator/researchers: Hester Jackson

Supervisors: Prof P. Singh PhD

Co- supervisor: Prof T.N Andrew PhD

Brief Introduction and aim of this study:

The student success rate in the faculty of engineering and built environment is very low in comparison with none-engineering fields. My study focuses specifically on the student success rate in the department of Industrial Engineering (IE). A factor contributing in this can be that students have different learning styles. The aim of this study is to investigate the learning styles, teaching methods and student performance in Industrial Engineering (IE) at a selected university of technology, in this case DUT.

Outline of procedure

If you are currently registered for the national diploma: Industrial Engineering at Durban University of Technology (DUT), you are kindly requested to complete a questionnaire. It should take you about an hour. The questionnaire will be available online, making use of survey monkey. The computer laboratory of the Industrial Engineering department will be available for this purpose.

The questionnaire section consist out of 2 sections: Section A will include questions relating to student demographics and section B will ask questions that will determine students preferred learning styles.

Please note that participation to this study is voluntary and you are free to decline if you wish. However your participation is of great importance and will play a critical role in the outcome of this study.

Risk or discomfort to participants

You will not be subject to any risk or discomfort during the course of this investigation.

Benefits:

The results of this study could benefit the Engineering community in terms of identifying preferred learning styles of the students. There are no benefits to you personally for your participation.

Remuneration:

You will not receive any type of remuneration for your participation in this study.

Cost of the study:

Costs will be covered by the researcher's budget.

Confidentiality:

You will not be required to write or provide your name anywhere in the process of filling this questionnaire. Consent letters will be provided on line before you begin to answer the questionnaire. You will need to agree in order for the questionnaire to be activated. The information that you will provide, will be handled by the researcher, the researcher's supervisor and the statistician. Therefor the information will be kept safely for 15 years by the supervisor, before it is deleted.

Research related injury: None

Persons to contact in the event of any problems or queries:

Please contact the researcher (Hester Jackson) on 0722064928, or the researcher's supervisor (Prof P. Singh on 031 3736767 or the institutional research ethics administrator on 031 3732900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 3732382 or dvctip@dut.ac.za

Your sincerely

Mrs Hester Jackson

hesterj@dut.ac.za

Appendix D: Letter of consent: students

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

CONSENT

Statement of agreement to participate in the research study:

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

……………………	……..	…….	………….
Full name of participant	Date	Time	Signature

I, Hester Jackson hereby confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

………………………………….	……..	..………
Full name of researcher	Date	Signature
……………………………..	……..	…………….
Full name of witness	Date	Signature

Appendix E: Information letter to lecturers

Information letter to IE staff

INSTITIUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

LETTER OF INFORMATION

Title of the research study:

Learning styles, teaching methods, and student performance in Industrial Engineering at a university of technology

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Co- supervisor: Prof T.N. Andrew PhD

Brief Introduction and aim of this study:

The student success rate in the faculty of engineering and built environment is very low in comparison with none-engineering fields. My study focuses specifically on the student success rate in the department of Industrial Engineering (IE). A factor contributing in this can be that students have different learning styles. The aim of this study is to investigate the learning styles, teaching methods and student performance in Industrial Engineering (IE) at a selected university of technology, in this case DUT.

Outline of procedure

You are kindly requested to take part in a semi- structured interview which should be about 60 minutes long. You are provided with a list of questions that will serve to guide our interview.

Please note that participation to this study is voluntary and you are free to decline if you wish. However, your participation is of great importance and will play an important role in the outcome of this study.

Risk or discomfort to participants

You will not be subject to any risk or discomfort during the course of this investigation.

Benefits:

The results of this study could benefit the Engineering community in terms of identifying preferred learning styles of the students. There are no benefits to you personally for your participation.

Remuneration:

You will not receive any type of remuneration for your participation in this study.

Cost of the study:

Costs will be covered by the researcher's budget.

Confidentiality:

You will not be required to write or provide your name anywhere in the process of answering the questions for the interview. Consent letters will be provided before you begin to answer the interview questions. The information that you will provide, will be handled by the researcher, the researcher's supervisor and the statistician. Therefor the information will be kept safely for 15 years by the supervisor, before it is deleted.

Research related injury: None

Persons to contact in the event of any problems or queries:

Please contact the researcher (Hester Jackson) on 0722064928, or the researcher's supervisor (Prof P. Singh on 031 3736767 or the institutional research ethics administrator on 031 3732900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 3732382 or dvctip@dut.ac.za

Yours sincerely

Mrs Hester Jackson

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